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Memo No | Issue Date | Title                  |
--------|------------|------------------------|
1-1.09  | 04/22/2019 | General – Freeze-Thaw Areas |
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General – Freeze-Thaw Areas

Revision and Approval

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Background

This process establishes Structure Construction (S.C.) responsibilities and procedures for verifying that applicable concrete freeze-thaw preservation measures are incorporated in the finished construction project. Design details which have produced adequate structures in mild climates have resulted in expensive maintenance problems on structures which are subject to the freeze-thaw cycle, deicing chemicals, and chain wear.

Caltrans Bridge Memo to Designers (M.T.D.) 8-2, Protection against Deicing Chemicals and Freeze-Thaw Environment, Attachment 3, Freeze-Thaw Areas, identifies severe climate areas that can be exposed to freeze-thaw conditions. The severe climate areas are listed by County, State Route, and post-mile limits. M.T.D. 8-2 is used to verify that a project is in a severe weather area and requires additional design consideration, such as the use of corrosion resistant reinforcing steel, modifications to the concrete mix design, and curing methods. Structures located near severe weather areas may be exposed to deicing chemicals that are carried by vehicle traffic.

Prior to reviewing this Bridge Construction Memo (B.C.M.), it is essential to review the Contract Specifications 1-1.09, General – Freeze-Thaw, applicable to your specific project, that this B.C.M. is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this B.C.M.
Process Inputs

1. Trigger activity from process sequence for bridges, sign structures, buildings, walls, project development teams, or constructability reviews
2. Location of the project
3. Freeze-thaw requirements listed in the contract documents

Procedure

1. All work associated with this process is charged as Project-Direct – Construction, or Project-Direct – Preconstruction.
2. Inspection of field work for this process is:
   a. Benchmark as needed for verification of reinforcing steel freeze-thaw requirements.
   b. Continuous for concrete placement activities.
3. Before construction begins:
   a. Review Concrete Technology Manual for freeze thaw background information.
   b. Verify project locations and whether any are in a freeze-thaw area. If the project is not in a freeze-thaw area do not perform the following steps.
   c. Verify required freeze-thaw elements are included in the contract documents.
   d. Discuss any discrepancies with project locations and freeze-thaw areas with the Project Designer and prepare a change order if necessary.
   e. Discuss freeze-thaw requirements, such as epoxy coated reinforcement samples for Materials Engineering and Testing Services (M.E.T.S.), with the Contractor at the pre-construction conference.
   f. Verify all concrete mix designs for severe weather freeze-thaw areas meet contract requirements per B.C.M. 90-1.01C, Concrete – Submittals.
4. During construction:
   a. For epoxy-coated reinforcement:
      i. Inspect, handle, and store in accordance with the Special Provisions, B.C.M. 52-2.01A(3), Reinforcement – Epoxy-Coated Reinforcement and Epoxy-Coated Prefabricated Reinforcement, and the Construction Manual, Section 4-52, Reinforcement.
      ii. Verify epoxy-coated reinforcement has been approved by M.E.T.S.
iii. Provide minimum concrete cover as shown in contract documents.

b. For concrete:
   i. Verify delivered concrete meets the authorized concrete mix design submittal requirements (e.g., air entrainment).
   ii. Perform required freeze-thaw concrete field testing (air entrainment) in accordance with *Construction Manual, Table 6-1.17, Materials Acceptance Sampling and Testing Requirements: Concrete.*
   iii. Verify concrete curing method complies with contract documents (e.g., water method for concrete barriers).

c. For additional details needed in freeze-thaw environment (e.g., bent sealing under deck expansion joints, polyester concrete overlay, etc.), perform work in accordance with Special Provisions and applicable B.C.Ms.

d. Collect, review, and file certificates of compliance (e.g., concrete, epoxy-coated rebar).

e. Document all inspection and construction activities for freeze-thaw requirements in the Daily Reports per *B.C.M. C-4.04, Daily and Weekly Reports.*

f. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual *5-102, Organization of Project Documents.*

**Process Outputs**

1. Materials incorporated into the work meet the contract specifications for freeze-thaw. Certificates of compliance (e.g., concrete, epoxy-coated rebar):

2. Daily Reports: Document all inspection and construction activities for freeze-thaw requirements in the Daily Reports per *B.C.M. C-4.04, Daily and Weekly Reports*

**Attachments**

None
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4-1.07 Value Engineering

4-1.07A General

Construction Manual
Additional information is available in the Construction Manual, Section 3-405, Value Engineering.

4-1.07B Value Engineering Change Proposal

Resources, Review and Determination Procedure
Additional information is available in the:
- Structure Design Alert\(^1\) dated July 1, 2014.
- Project Delivery Directive, PD-13, Value Engineering Change Proposals.\(^2\)

The Division of Engineering Services (DES) is responsible for providing technical concurrence on structure related Value Engineering Change Proposals (VECPs). Acceptance of the VECP is a district/region responsibility. The Deputy District Director for Construction (DDDC) in each district makes the final determination if a VECP is acceptable based in part on the technical recommendation of DES.

It is critical that VECPs are thoroughly vetted and not rejected or accepted without full consideration. If a determination is made that a structure related VECP is:
- Acceptable to DES, that decision should be made at the lowest level possible and concurred at the level just above those making the decision.
- Unacceptable to DES, that decision must be validated by an appropriate team of DES Deputies (Structure Construction [SC], Structure Design [SD], and Material Engineering and Testing Services/Geotechnical Services [METS/GS]) before the determination is transmitted to the district.

Proposal Concept Stage
When the proposal concept is presented, the appropriate DES Representatives (Structure Representative, Structure Design Project Engineer, Bridge Construction Engineer (BCE), and SD Branch Chief) should participate in the meeting between the Contractor and the Engineer. To ensure an adequate understanding of the Proposal Concept, invite all parties from DES\(^3\) and Structure Maintenance & Investigations, to participate as appropriate. It is important that fatal flaws in the Proposal Concept be discussed early before the Contractor prepares a VECP.

The DES Representatives must confer and concur as to the DES decision for the Proposal Concept. If a Proposal Concept is found to be unacceptable (rejected), the next level (Area Construction Manager (ACM) and SD Office Chief) should review it. If they concur with the

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\(^1\) [http://onramp.dot.ca.gov/hq/des/sd/docs/structure_design_alerts/sda_20140701.pdf](http://onramp.dot.ca.gov/hq/des/sd/docs/structure_design_alerts/sda_20140701.pdf)


\(^3\) Appropriate DES parties could include Geotechnical Services, Earthquake Engineering, Structures Office Engineer (Specifications), Hydraulics, etc.
rejection, the *Proposal Concept* and VECP Analysis Report should be forwarded to the next level (DES Deputies) for review. The DES Deputy Division Chiefs for SC, SD, and METS/GS will make the determination for DES on whether the VECP *Proposal Concept* is unacceptable.

**Submit the DES decision in writing to the Resident Engineer.** The decision to proceed with the *Proposal Concept* should be made at the lowest level possible and concurred at the level just above those making the decision. The decision to accept a *Proposal Concept* must be documented on the *VECP Analysis Report*, for which a template is provided in Attachment No. 1.

For structure related items, the review times required by DES will vary depending upon the complexity of the *Proposal Concept*, as multiple functional units within DES will need to review and provide input on the VECP. Convey to the Resident Engineer the review times required by DES to the Resident Engineer for their discussion with the Contractor.

### VECP Investigation Stage

During the VECP investigation stage, the BCE will facilitate the review by all DES functional units and Structure Maintenance and Investigations to ensure all stakeholders have provided input and to ensure timely completion of the investigation.

The DES functional unit representatives should confer and concur as to the DES decision for the VECP. If the representatives find the VECP to be unacceptable, the next level (Area Construction Manager (ACM)/Office Chief) should review the VECP; if they concur with the rejection, the BCE should arrange for a meeting between the DES Deputy Division Chiefs for SD, SC, and METS/GS to review the VECP. *Prior to the meeting, provide the VECP Analysis Report to the Deputy Division Chiefs.*

The *VECP Analysis Report* will provide:
- All pertinent contract information along with a description of the VECP.
- Structures affected.
- Positive aspects of the VECP.
- Reasons the VECP should be rejected.
- The recommendation(s) of the Structure Representative and Project Engineer.

**Submit the DES decision, in writing, to the Resident Engineer.** The decision to proceed with the VECP should be made at the lowest level possible and concurred at the level just above those making the decision. **The decision must be documented in the *VECP Analysis Report***.

### Roles / Responsibility

**Structure Representative** – Collaborate with the Structure Design Project Engineer on the DES recommendation to the VECP.

---

4 SD, METS/GS, and Program/Project and Resource Management (PPRM)/Special Funded Projects

California Department of Transportation • Bridge Construction Records and Procedures Manual • August 2015
Structure Design Project Engineer – Evaluate the VECP for technical soundness and collaborate with the Structure Representative on the DES recommendation to the VECP.

Bridge Construction Engineer – Facilitate the review by all DES units to ensure timely completion. If needed, arrange for a meeting with the Deputy Division Chiefs from SC, SD, METS/GS and PPRM. Work with the ACM to review the Structure Representative’s and Project Engineer’s recommendation to the VECP.

Structure Design Branch Chief – With the BCE, review the Structure Representative’s and Project Engineer’s recommendation to the VECP.

Area Construction Manager – In cases of rejection of the VECP, verify that the VECP has been properly vetted. Confer with the SD Office Chief on the recommendations to the VECP. Meet with the Deputy Division Chiefs to review the cause for rejection. Confirm the recommendation from DES to the District, or return the VECP to the Structure Representative and Project Engineer for continued review.

Structure Design Office Chief – In cases of rejection to the VECP, verify that the VECP has been properly vetted. Confer with the ACM on the recommendations to the VECP. Meet with the Deputy Division Chiefs to review the cause for rejection. Confirm the recommendation to the District or return the VECP to the Structure Representative and Project Engineer for continued review and evaluation.

Division of Engineering Services Deputy Division Chief – In cases of rejection of the VECP, verify that the VECP has been properly vetted. Confirm the DES recommendation to the District or return the VECP to the Structure Representative and SD Project Engineer for continued review and evaluation.
The following is a sample *VECP Analysis Report* that can be used as a template:

**Structure Construction – Value Engineering Change Proposal Analysis (VECP) Report**

*Insert Date*

**Project Information**
- Dist-EA
- Dist-Co-Rte-PM
- Structure or bridge name
- Br. No.

**Description of VECP**
*Provide a description of the VECP*
- Reduce any cost of construction.
- Reduce construction activity duration.
- Reduce traffic congestion.
- Permit issues.
- Impact on other projects.
- Project impacts, including traffic, schedule, later stages.
- Peer reviews.
- Overall proposal merits.
- Review times required by the Department and other agencies.
- Etc.

**Structure(s) Affected:** *(Identify any structures that are affected)*

**Chronology:**
- Proposal Concept received: *(date)*
- Proposal Concept accepted or rejected: *(date)*
- VECP received: *(date)*
- VECP accepted or rejected: *(date)*
- Change Order issued: *(date)*
- Elapsed review time: _____ days

**Introduction:**

This report presents the results of the review for the *(insert type of review completed, i.e. Proposal Concept or VECP).*

**Discussion:**

Positive Aspects of the VECP – *List and clarify*
Reasons the VECP should be rejected – *This portion of the report would describe specific deficiencies found with the Proposal Concept or VECP that would be cause for rejection i.e.*

**Recommendation of the Structure Representative:**

**Authorization** – No exceptions were found with the VECP (*number or title of VECP or other unique identifier)*.

**Rejection:**

Structure Construction does not accept the VECP. The (*insert type of review completed, i.e. Proposal Concept or VECP*) for (*identify specific location*) of the (*Bridge name, Br. No.*), based upon the analysis that found the deficiencies listed above.

If you have any questions regarding this report, please contact Structure Representative at (XXX) XXX-XXXX.

Steve Street, P.E.
Structure Representative
Structure Construction
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  - Title: Control of Work – Contract Components
- **5-1.03**  
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  - Title: Control of Work – Property and Facility Preservation
- **5-1.37B**  
  - Issue Date: xx/xx/20xx  
  - Title: Control of Work – Maintenance and Protection – Load Limits
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  - Title: Control of Work – Final Inspection and Contract Acceptance
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Background

This process establishes Structure Construction (S.C.) responsibilities and procedures for assisting the Resident Engineer with administration of preservation of existing property and facilities.

This process addresses preservation, protection, and when applicable rearrangement of:

1. Highway improvements and facilities
2. Adjacent property
3. Waterways
4. Environmentally sensitive areas
5. Lands administered by other agencies
6. Railroads and railroad equipment
7. Nonhighway facilities, including utilities
8. Survey monuments
9. Department's instrumentation
10. Temporary work
11. Roadside vegetation not to be removed.
Prior to reviewing this Bridge Construction Memo (B.C.M.), it is essential to review the Contract Specification, Section 5-1.36, Control of Work – Property and Facility Preservation, applicable to your specific project, that this B.C.M. is based on, as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this B.C.M.

**Process Inputs**

1. Written notification of damage to existing utilities and other improvements
2. Written notification of unidentified utilities
3. Work plan for protecting railroad facilities
4. Work plan for protecting non-railroad facilities (if required)

**Procedure**

1. All work associated with this process is charged as [Project-Direct – Construction](#).
2. Inspection of field work for this process is:
   a. [Intermittent](#) during daily site visits to verify existing facilities remain in service.
3. Before construction begins:
   a. Coordinate with Resident Engineer the division of work for inspection and administration tasks, including:
      i. Initial, periodic, and final inspections
      ii. Agency requirements, communication, and coordination
      iii. Protection, relocation, and repair of existing facilities.
   b. Review contract documents to identify existing facilities.
   c. Conduct a visual inspection of the project limits to verify location of existing facilities and document facilities not identified in the contract documents
   d. Document with condition of the existing facilities; including photographs of the existing facilities. If necessary:
      i. Replace facilities that have deteriorated sufficiently beyond intended use.
      ii. Relocate or protect facilities to prevent damage.
   e. Document existing survey monuments and high-water marks as outlined in [Attachment 1](#), Preservation of Property.
   f. Record elevations of high-water marks if structures are widened, repaired, or replaced.
g. Based on field review and contract documents, notify the Contractor if a work plan showing the systems to be used to protect facilities is required.

h. Review railroad guidelines in B.C.M. 5-1.20C, Control of Work – Railroad Relations and Construction Manual, Section 3-520B, Railroad Property, regarding protecting railroad property, if applicable:
   i. Review and authorize work plan for protecting railroad facilities.
   i. Coordinate with other agencies with facilities to be relocated or protected as outlined in Construction Manual, Section 3-520, Property and Facility Preservation.

j. Coordinate with Resident Engineer to protect and relocate state owned facilities.

k. Verify utilities have been located prior to excavating.

l. Review and authorize work plan for protection devices furnished and installed by the contractor.

4. During construction:
   a. Conduct a visual inspection of the project limits to verify existing facilities remain in service and are in the same condition prior to the start of work.
   b. Verify suitable protection devices are in place to prevent property damage.
   c. Work with the Resident Engineer to coordinate with other agencies to provide protection or relocate facilities or objects.
   d. Coordinate with the railroad flagger to provide protection of railroad facilities.
   e. Notify the Resident Engineer if existing survey monuments require relocation.
   f. Upon written notification from the Contractor of damage to existing utilities or of unidentified utilities:
      i. Notify the Resident Engineer and coordinate response.
   g. Order the Contractor to make necessary repairs to return the facility to service.
   h. Document all inspection, construction, and quality assurance activities in the Daily Reports per B.C.M. C-4.04, Daily and Weekly Reports.

5. Following construction:
   a. Document existing facilities that remain in place and are in the same condition as prior to construction on the as-builds per Construction Manual, Section 5-104, As-Built Plans and B.C.M. 99-01000-1.10, Building Construction – As-Built Drawings.
   b. Replace high water marks.
c. Coordinate with the District to replace survey monuments and benchmarks.

d. Verify that the Contractor restores or repairs any facilities or improvement damaged by the Contractor’s operation.

e. File all correspondence and Daily Reports in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Successful completion of project
2. Existing facilities successfully preserved and protected
3. Daily Reports

**Attachments**

1. [Preservation of Property](#)
Preservation of Property

General Information

Structure Construction operations frequently occur in areas where there are existing utilities or other improvements which must be protected from damage and preserved or relocated. It is general practice to show utilities or other improvements on the plans, or list them in the Special Provisions. There are occasions, however, when utilities or improvements which exist in the construction area, are not shown on the plans or in the specifications, or are shown on the plans in a location other than where they are found in the field.

The Resident Engineer is responsible for the overall contract administrative duties associated with protecting and relocating utilities and improvements. All such items must be protected from damage or relocated in accordance with the following details.

Protecting Utilities and Improvements

The Standard Specifications require the Contractor to preserve and protect from damage, existing highway improvements or facilities, existing utility facilities, existing property improvements, etc., whether they are publicly or privately owned, and which are located within or adjacent to the highway right-of-way.

In connection with facilities and improvements, which are identified on the plans or in the Special Provisions, the Engineer has the authority to require the Contractor to furnish and install suitable protective devices to prevent property damage, and to require the Contractor to restore or repair any facility or improvement which may have been damaged by the Contractor's operations.

However, the Contractor's general responsibility includes only the installation of such devices as are necessary to protect against their operations. Any permanent protection which may be required, but which is not a part of the contract, must be authorized by a change order.

In the event, that the Contractor discovers underground facilities not identified on the plans or in the Special Provisions, the Contractor must immediately give the Engineer written notification of the existence of such facilities. Such facilities must be relocated or protected from damage, as directed by the Engineer, and the Contractor will be paid for such work as extra work.

Utility Relocation

The Construction Manual, Section 3-520, Property and Facility Preservation, covers this subject except for railroad work. All questions concerning permanent and/or temporary
Preservation of Property

relocation of railroad facilities, including related utilities such as telegraph and signal communication lines, are handled through the Division of Right of Way and Land Surveys, Railroad Coordination and Utility Relocation Office.

Relocation of Survey Monuments and Bench Marks

Caltrans is required by the Professional Land Surveyor's Act, Section 8771, Setting of Monuments in General; Monument Perpetuation, to arrange for the relocation of all monuments of record belonging to other governmental agencies if highway construction would otherwise result in their destruction.

Relocation of survey monuments and government bench marks will be handled by the District. The Structure Representative should notify the Resident Engineer when survey monuments are encountered and need to be relocated.

Existing High-Water Marks

Some existing structures have high water marks painted on them. If these structures are widened, repaired or replaced, the elevation of the previously painted high-water mark should be taken and recorded. If these high-water marks are lost during construction, they should be replaced at the completion of the work.
Control of Materials – Quality Assurance

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BCM 6-2, Control of Materials – Quality Assurance, has not been posted yet.

Until it is posted, information related to this topic is found in BCM 4-1.0, General Information; 4-2.0, Inspection and Release of Materials; 4-3.0, Sampling Materials; 4-3.1, Shipping Samples to the Materials Engineering and Testing Services (METS); 4-4.0, Testing Materials; 4-5.0, Record Keeping for Contractor Furnished Materials; 4-5.1, Category 31 Notice of Materials to be Used; 4-5.2, Category 32 Notice of Materials to be Inspected; 4-5.3, Category 33 Notice of Materials to be Furnished; 4-5.4, Category 37 Initial Tests and Acceptance Tests; 4-5.5, Category 39 Independent Assurance (Progress) and Final Tests; 4-5.6, Category 41 Reports of Inspection and Material; 4-5.7, Category 43 Concrete
Records; 4-5.8, Concrete Pour Records; 4-10.0, Miscellaneous Materials; 9-2.0, Certification of Materials; 4-5.9, Prequalification of Specified Strength Concrete.
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Legal Relationships and Responsibility to the Public – Occupational Safety and Health Standards – Excavation Safety

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BCM 7-1.02K(6)(a), Legal Relationships and Responsibility to the Public – Occupational Safety and Health Standards – Excavation Safety, has not been posted yet. Until it is posted, information related to this topic is found in BCM 122-1.0, Submitting Shoring Plans
Legal Relations and Responsibility to the Public – Laws – Labor Code – Occupational Safety and Health Standards – Scaffolding

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Contact SC Technical Team O for questions

Background

This process identifies Structure Construction (SC) responsibilities and procedures for construction of scaffolding, including submittal review and authorization when required by the contract documents.

It is important that SC personnel understand the requirements of the Cal/OSHA Construction Safety Orders (CSO) regarding the installation and use of scaffolding whenever the contractor uses scaffolding. Under certain circumstances, such as when scaffolding is suspended from a bridge, the contractor must perform an independent review of their scaffolding design prior to SC employees reviewing and authorizing the scaffolding submittal.

This process only applies to scaffolding constructed:

1. Over traffic
2. On, or suspended from a bridge
3. Within a distance equal to the scaffolding height plus 6 feet from the edge of a traveled way open to traffic
Scaffolding at sound walls, retaining walls, buildings, and other structures is administered per the *Contract Specifications*:

1. Section 7-1.02K(6)(a), *Legal Relations and Responsibility to the Public – General – Laws – Labor Codes – Occupation Safety and Health Standards – General*
2. Section 7-1.04, *Legal Relations and Responsibility to the Public – Public Safety*

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the *Contract Specifications*, Section 7-1.02K(6)(e), *Legal Relations and Responsibilities to the Public – General – Laws – Labor Code – Occupational Safety and Health Standards – Scaffolding*, that this BCM is based on as identified in the title block above. The information in the *Contract Specifications* typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Scaffolding submittal (shop drawings, calculations, and independent review calculations)

**Procedure**

1. All work associated with this process is charged as [Project Direct – Construction](#).
2. Inspection of field work for this process is:
   a. **Continuous** for scaffolding erection and removal over traffic.
   b. **Intermittent** for scaffolding erection and removal not over traffic.
   c. **Intermittent** for scaffolding maintenance.
3. Before construction begins:
   a. Review the contract documents prior to the preconstruction conference for requirements related to scaffolding:
      i. Verify the Special Provisions includes Section 7-1.02K(6)(e), *Scaffolding*. If it does not, a change order may be required. Consult with Structure Design to obtain revised contract specifications for the change order.
      ii. Prior to receiving the scaffolding submittal, discuss the following with the contractor:
         1. Means and methods
         2. Submittal requirements
      iii. Coordinate with the Resident Engineer (RE) to verify that the contractor has submitted the permit for erecting scaffolding in excess of 36 feet in
height, which is required before scaffolding erection can begin, per the *Construction Manual*, Section 2-102D, Resident Engineer.

b. For submittal review and authorization:
   
   i. Review and respond to the contractor within the specified review time.

   ii. Verify the requirements of the contract documents have been met:
       
       1. Confirm that the submittal contains an independent review that is stamped by a professional engineer.

   iii. Review the design for compliance with regulations in:
       
       1. [Cal/OSHA CSO, Article 22](#), *Scaffolds – Various Types*.

       2. [Cal/OSHA CSO, Article 23](#), *Suspended Scaffolds*.

       3. Confirm that the contractor’s calculations used capacities and loadings provided in the special provisions.

   iv. Verify that the field conditions:
       
       1. Are compatible with the scaffolding submittal

       2. Provides adequate staging area

       3. Are accessible per traffic handling requirements

   v. Authorize (or reject for resubmittal) the scaffolding submittal and send a copy of authorized scaffolding submittal to the SC Falsework Engineer.

   vi. Seek assistance from the Bridge Construction Engineer or SC Falsework Engineer, if necessary, to ensure timely and accurate review.

4. During Construction:

   a. Verify SC staff have a copy of the authorized scaffolding submittal.

   b. Verify construction activities are in accordance with the authorized scaffolding submittal. Notify the contractor and suspend work should a non-compliance condition arise, and inform the SR and RE.

   c. Monitor and verify loading conditions are in accordance with the authorized scaffolding submittal.

   d. Elevate issues related to scaffolding construction to the SR, RE, and/or Bridge Construction Engineer for resolutions.

   e. Document all inspection, construction, and quality assurance activities in the Daily Reports per [BCM C-7](#), *Daily and Weekly Reports*.

5. File all project documentation (materials acceptance documents, correspondence, Daily Reports, etc.) in the appropriate category in the project records as specified in the *Construction Manual*, Section 5-102, *Organization of Project Documents*. 

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Process Outputs

1. Authorized scaffolding submittal
2. Daily Reports

Attachments

None
Payment – Progress Payments

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BCM 9-1.16, *Payment – Progress Payments*, has not been posted yet.

Until it is posted, information related to this topic is found in BCM 5-1.0, *Preparing Quantity Calculations*
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Welding

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for the review and authorization of the following:

- General requirements for welding that apply to all structural welding as specified in the contract documents.
- Welding quality control (QC) plan
- Submittals and welding inspection for overhead sign structures, standards, and poles.

SC staff are involved in both structural and nonstructural welding, whether performed in a shop or in the field. Contract requirements for welding of:

- Structural steel members is covered under the Contract Specifications (CS), Section 55, Steel Structures and Section 75, Miscellaneous Metal.
- Reinforcement is covered under CS, Section 52, Reinforcement.
- All other welding applications are covered in their specific section of the CS, which includes Section 48, Temporary Structures; Section 49, Piling; Section 51, Concrete Structures; and Section 60, Existing Structures.
Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the CS, Section 11, Welding, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Contract work requiring welding
2. Welding Quality Control Plan (WQCP)
3. Welding Reports
4. Materials Engineering and Testing Services (METS) reports

**Procedure**

1. All work associated with this process is charged as [Project Direct – Construction](#).
2. Inspection of field work for this process is:
   a. *Intermittent* – for field welding
3. Before construction begins the Structure Representative (SR) or delegate must:
   a. Review the:
      i. Contract documents to prepare for and identify any potential constructability issues for welded components. For example, when reviewing the structure sheets, verify the details provide sufficient clearance for welding and the welding details are compatible.
      ii. Following welding and material codes specified in the contract documents, which can be accessed using the Engineering Workbench section of the Caltrans Transportation Library (Note – registration required):
         1. The American Society for Testing and Materials (ASTM)
         2. The American Welding Society (AWS) manuals
      iii. [METS Quality Assurance and Source Inspection (QASI) Manual](#), Section 11, Welding, for quality assurance (QA) inspection responsibilities and prewelding meeting information.
      iv. Project Code of Safe Practices (COSP) for safety considerations for welding and flame cutting. Revise the Project COSP if information needs to be modified for cutting or welding on existing steel containing lead based coating systems or stainless steel.
      v. [Caltrans Employee Safety Manual](#), Chapter 12, Personal Protective Equipment (PPE), and Chapter 15, Respiratory Protection Program.
vi. Attachment 1, Welding Terms.

b. Discuss constructability issues with Bridge Design (BD) Structure Project Engineer and the METS Material Representative (Mets Rep) for resolution.

c. Contact the BD Structure Project Engineer to determine if they need to attend the prewelding meeting or have information that you can cover at the prewelding meeting.

d. Contact the METS Rep to:
   i. Review the anticipated welding work, site conditions, and project work schedule.
   ii. Clarify any differences in the interpretation of the contract documents and welding requirements.

e. For work performed to CS, Section 11-2, Welding – Welding Quality Control:
   i. Contact the METS Rep to discuss the following regarding the prewelding meeting:
      1. The Structure Representative coordinates with the Resident Engineer and the METS Rep to hold the prewelding meeting with the Contractor.
      2. The METS Rep chairs the prewelding meeting per the QASI Manual, Section 11-A.03, Prewelding Meeting.
      3. The METS Rep provides the prewelding meeting agenda using the METS Handout for Pre-Welding Meeting Agenda Sample on the METS J2 drive which is customized for the project.
      4. Topics that will be discussed at the prewelding meeting, including topics the Structure Representative (SR) will address.
   ii. Review with the Contractor at the preconstruction conference, the scheduling of separate prewelding meetings.
   iii. Schedule and attend prewelding meetings with the Contractor, their QC manager, and representatives from each entity performing welding or inspection on the contract.
   iv. Receive the Welding Quality Control Plan (WQCP) and begin the process to:
      1. Review for completeness and forward to the METS Rep or review.
      2. Maintain a log to track review times of all the WQCPs.
      3. Authorize the WQCP pursuant to the METS Rep’s review:
         a. Stamp all sheets in the WQCP before returning to the Contractor for distribution to the work locations.
b. Receive the seven copies of the authorized WQCP from the Contractor to stamp and return.

c. Provide one copy of the authorized WQCP to the METS Rep.

f. For overhead sign structures, standards, and poles:
   i. Verify that the proposed fabrication shop is on the METS Authorized Facility Audit List.

   g. Verify that the fabrication facility possesses the necessary American Institute of Steel Construction Quality or other certifications as required by the contract.

   h. Obtain additional training or information on welding from the Bridge Construction Engineer as needed.

4. During construction the SR or delegate must:

   a. For shop welding:
      i. Contact the METS Rep to confirm that METS is verifying and documenting welding procedures.
      
      ii. Verify that inspection requests are being sent to METS Rep by the Contractor and/or fabricator.
      
      iii. Monitor the progress of fabrication and note any welding issues by:
          1. Reviewing METS inspection reports.
          2. Meeting with the METS Rep on issues involving non-conforming welds that cannot be resolved in the shop to:
              a. Determine the extent and background of the issue.
              b. Involve BD Structure Project Engineer for resolution or if a fit for purpose acceptance may need to be considered.
              c. Determine if the issue needs to be elevated to the Bridge Construction Engineer (BCE) for resolution.
      
          iv. Verify that shop welded products are paired with the proper release documents in the field.

      v. Contact the METS Rep:
          1. When any product released from the shop appears to be non-compliant.
          2. To schedule and perform additional QA inspection.
          3. To request, review, authorize a mitigation plan from the Contractor.

      vi. Receive welding reports from the Contractor and:
1. Forward a copy to the METS Rep for review.
2. Monitor review times to stay within the allotted 15-day timeframe.
3. Authorize or reject welding reports based upon guidance from the METS Rep.

b. For field welding performed to CS, Section 11-2, *Welding – Welding Quality Control*:

   i. Before field welding:
      2. Verify the Contractor has submitted timely inspection request forms.
      3. Verify the Contractor has provided suitable access for the weld activity (scaffold, ventilation, shoring, etc.)

   ii. During field welding:
      1. Verify that all Procedure Qualification Record (PQR), Welder Certification test have been performed and witnessed by the METS Rep.
      2. Document certified welding inspector (CWI), crew, resources, and production rates.
         a. Verify that the CWI is on site during welding operations.
      3. Verify the QC manager submits the Welding Reports within seven (7) days after any welding is performed.
      4. Receive, review, and authorize, with assistance from the METS Rep, repair plans not already addressed in the WQCP for any weld defects.
      5. Forward nonconformance reports to the Contractor and follow up with:
         a. Reviewing the response/resolution with the METS Rep and/or BD Structure Project Engineer.
         b. Documenting closure of issue.
      6. Verify with the METS Rep that testing methods and frequencies are compliant per *QASI Manual*.

   iii. After field welding:
      1. Receive welding reports from the Contractor:
         a. Forward a copy to the METS Rep for review.
         b. Monitor review times to stay within the allotted timeframe, which differs for steel field welded pipe piling, bar reinforcement in CIP.
concrete piling, and overhead sign structures, standards, and poles. Refer to the Contract Specifications:


c. Authorize or reject welding report(s) per contract requirements and guidance from the METS Rep before encasing welds in concrete.

d. Other than steel pipe piling and reinforcement in CIP concrete, the Contractor may elect to encase welds in concrete at their own risk prior to receiving authorization.

c. For field welding not performed to CS, Section 11-2, Welding – Welding Quality Control, like joint seal assemblies:

  i. Before field welding:
     1. Consult with the METS Rep on the inspection and acceptance process by the QA inspector.
     2. Verify scheduling and timing of inspections.
     3. Verify that the Contractor’s QC inspector meets the requirements of AWS D1.1.

  ii. During field welding:
     1. Verify that the Contractor’s QC inspector is present during welding.
     2. Work with the METS Rep to verify that welder qualifications, welding processes, and QC inspection are being spot checked by the QA inspector as discussed before field welding.
     3. Review QC inspection documentation in conjunction with the METS Rep.

d. Welding work must be identified as part of the project Fire Prevention Plan, Hot Work.

e. Public safety must be considered and maintained during all welding operations and testing, using the following:

   1. Visual barriers required to protect pedestrians during welding, which includes a glare shield or welding screens.
   2. Additional work zone protections where non-destructive test methods like radiography requires a minimum clear distance.

f. Verify the Contractor’s Stormwater Pollution Prevention Plan (SWPPP) follows:
   b. **WM-5**, Solid Waste Management.

2. Proper maintenance during all welding operations, including to:
   a. Collect all welding slag and rod for proper disposal.
   b. Provide adequate containment to prevent falling weld debris.
   g. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per **BCM C-7**, Daily and Weekly Reports.

5. Following construction, the SR must:
   a. Confirm all nonconformance reports are resolved and documented before accepting the project.
   b. Provide as-builts and include location of all splices per **BCM C-6**, Required Documents to be Submitted During Construction.

6. File all project documentation (correspondence, materials acceptance documentation, Daily Reports, etc.) in the appropriate category in the project records as specified in the *Construction Manual*, Section 5-102, Organization of Project Documents.

### Process Outputs

1. Daily Reports
2. Authorized WQCP and repair procedures
3. As-Builts

### Attachments

*Attachment 1. Welding Terms*
Welding Terms

The following is a list of definitions commonly used in "Welding Quality Control" documents. Current and additional definitions can be found in American National Standards Institute/American Welding Society (ANSI/AWS) “Standard Welding Terms and Definitions”.

Certified Welding Inspector (CWI) for State Projects – Inspector certified in accordance with AWS QC1. For State projects the Quality Control Inspector will be a CWI.

FCAW – Flux Cored Arc Welding – An arc welding process utilizing a tubular electrode with the flux contained within the core. The electrode is supplied on a reel and is fed continuously to the welder’s gun automatically.

FLUX – A material used to hinder or prevent the formation of oxides and other undesirable substances in molten metal and on solid metal surfaces, and to dissolve or otherwise facilitate the removal of such substances.

GMAW – Gas metal arc welding utilizes a bare or a flux-cored electrode. Gas from an external source is used for shielding. Normally a shop welding process. Often referred to as MIG welding.

Nonconformance Report – A written report originated by OQASI (Office of Quality Assurance & Source Inspection) which addresses a deficiency being performed and the contract documents not being fulfilled. The report will describe the problem, the location, the Quality Control Inspector response, the proposed solution, and OQASI recommendation.

Nondestructive Testing (NDT) – Testing or an inspection method which does not damage the element being tested (e.g., Radiographic (RT), Ultrasonic (UT), Visual (VT), Magnetic Particle (MT), Liquid Penetrant (PT).

Procedure Qualification Record (PQR) – Documentation indicating testing was performed to qualify a WPS.

Quality Assurance (QA) – This oversight is the prerogative of the Engineer and will be performed by a state representative.

Quality Assurance Inspector (QA Inspector) – The duly designated person who acts for and on behalf of the Engineer. This person is from OQASI and will inspect the welding operation and write a welding report for the State.

Quality Control (QC) – Responsibility of the Contractor. As a minimum, the Contractor shall perform inspection and testing prior to welding, during welding and after welding.
as specified in the contract documents and additionally as necessary to ensure that materials and workmanship conform to the requirements of the contract documents.

**Quality Control Inspector (QC Inspector)** – The person duly designated by the contractor, to perform inspection, testing, and address welding issues on the project. This person shall be responsible to the Contractor for the quality control acceptance or rejection of materials, workmanship, and shall be currently certified as AWS Certified Welding Inspector (CWI) in conformance with the requirements in AWS QC1, “Standard and Guide for Qualification of Welding Inspectors.”

**Quality Control Manager (QCM)** – A representative, employed by the prime contractor, who is responsible directly to the Contractor for the quality of all field welding performed. This includes the materials and workmanship. The QCM reviews, approves, and submits all QC documents to the Engineer.

**Quality Control Plan (QCP) or Welding Quality Control Plan (WQCP)** – A plan submitted by the Contractor to the State for each item of welding work to be performed. This plan contains all welding documents required by the contract (refer to the Special Provisions and QCP 1). No welding can begin until this plan is reviewed by OQASI and approved by the Structure Representative.

**QCP-1, QCP-5 and QCP-7** – These forms are used by OQASI and the Structure Representative, as checklists to ensure the contractor’s Quality Control Plan or Fracture Control Plan are complete.

**SAW** – An arc welding process utilizing a solid wire electrode that is fed automatically to the welding head from a reel. A granular flux is automatically deposited from a dispenser onto the molten weld deposit (normally a shop welding process).

**Resistance Butt Welding (Flash Butt Welding)** – A welding process in which the necessary heat is derived from an arc, or a series of arcs established between the bars being welded prior to pressure being applied to join the ends together.

**SMAW** - Shielded Metal Arc Weld – An arc welding process utilizing a solid electrode with an outer flux coating.

**Welding Procedure Specifications (WPS)** – A document providing the required welding variables for a specific application to assure repeatability by properly trained welders and welding operators.

**Welder’s Qualification** – Welders must be certified for type and position of weld and weld process. If not certified, tests can be performed to qualify the welders. Welders must be certified and approved by OQASI before welding on State projects.
Welding Terms

Welding Quality Control Plan (WQCP) – See QCP above.
Welding – General

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BCM 11-1, *Welding – General*, will not be posted as originally planned.

Welding – Welding Quality Control

Revision and Approval

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BCM 11-2, *Welding – Welding Quality Control*, will not be posted as originally planned.

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MEMO NO.   ISSUE DATE         TITLE
12-4       08/30/2019         Temporary Traffic Control – Maintaining Traffic
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Temporary Traffic Control – Maintaining Traffic

Revision and Approval

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for assisting the Resident Engineer (R.E.) with authorization of traffic control submittals and maintaining traffic during contract structure work.

Structure Construction staff may assist the R.E. with temporary traffic control activities during structure work at the RE’s request, provided SC resources permit.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the contract specifications 12-4, Temporary Traffic Control – Maintaining Traffic, that this BCM is based on as identified in the title block above. The information in the contract specification(s) typically will not be repeated in the text of this BCM.

Process Inputs

1. Contractor lane closure request
2. Traffic handling plans required in contract documents
3. Contractor submitted required or requested contingency plans for maintaining traffic.
**Procedure**

1. All work associated with this process is charged as: (1) **Project-Direct – Construction**, (2) **Project-Direct – Preconstruction**.

2. Inspection of field work for this process is:
   a. **Intermittent**

3. All SC staff are expected to be familiar with *Construction Manual (CM), Chapter 2-2, Traffic*.

4. Before construction begins:
   a. Review structure work plan submittals for conformance with traffic control requirements of the contract documents. Discuss with the district RE:
      i. Potential impact of structure work affecting traffic.
      ii. Traffic work windows and structure work done within them.
      iii. Determine if contingency plans are required per the Special Provisions or a plan needs to be requested. Review and provide input to the RE for authorization.
      iv. Determine if impact to traffic for structures work can be reduced.
   b. RE handles all necessary notices to all local agencies regarding temporary traffic control unless other arrangements are made.
   c. Inform the RE of proposed closing of structures to traffic so the RE can inform District Traffic Management Center (TMC) and **HQ Permits**.
   d. Assist RE with coordinating traffic handling needs between interested parties (SC, contractor, District TMC, CHP, District Construction Safety Coordinator (CSC), District Public Information office, public, etc.)
   e. Review maintaining traffic requirements for structure operations, pay attention to the following:
      i. Authorized traffic handling plans when required.
      ii. Authorized contingency plan when required for structure work. Refer to **CM 4-1203C(1b), Contingency Plans for Closures**.
      iii. Discuss the responsibilities and procedures per **CM Chapter 2-204, Responsibilities and Procedures**. Ensure field staff obtain all necessary contact information prior to night work starting, including:
         1. Resident Engineer.
         2. State Representative on Projects Administrated by Others.
         3. District Construction Safety Coordinator (CSC).
5. Construction Engineer.
6. Bridge Construction Engineer.

iv. Authorized Falsework submittal (All BCMs in Bridge Construction Records and Procedures Manual, Section 120, Falsework):
   1. If traffic and/or pedestrian openings are specified, refer to BCM C-4.14, Notice of Change of Clearance or Permit Rating, prior to erection of falsework over the roadway.
   2. Pedestrian openings are in compliance with the Temporary Pedestrian Facilities Handbook
   3. Verify construction operations can be completed within specified traffic closure windows.
   4. Verify that the contractor has a contingency plan for unanticipated events.

v. Authorized Guying Plan:
   1. Do not authorize connection of guying cables to traffic control k-rail.

vi. For large crane picks refer to relevant Construction Procedure Directives (CPD), which currently includes CPD 01-11, Hoisting Operations near Public Traffic and Pedestrians:
   1. Placement of pre-fabricated rebar cages (e.g., CIDH concrete piling, column).
   2. Hoisting over or next to live traffic.
   3. Critical crane picks.
   4. Overhead wires.

vii. Authorized Bridge Removal Plan:
   1. Construction operations can be completed within specified traffic closure window and a contingency plan is in place for unanticipated events

5. During construction, collaborate with RE on traffic control roles and responsibilities. Based on that discussion:
   a. For structure operation, verify the contractor submitted lane closure request and that closure request have been authorized.
   b. Before the start of structure operations, coordinate with District RE to verify required traffic control is in place and has been checked (drive through):
      i. Discuss with the RE any local agency requirements.
c. Monitor SC field activities for compliance with contract requirements and authorized submittals.

d. Verify the contractor maintains temporary traffic control devices through the construction work zone, as needed, refer to CA MUTCD Part 6, Maintaining Traffic Control For example:
   
i. K-rails must conform to Standard Specifications (SS), Section 12-3.20, Type K Temporary Railing, as well as other requirements of the Contract Documents (white paint, bolted connections, etc.).
   
ii. Gawk screens must conform to 2018 SS, Section 12-3.21, Temporary Traffic Screens.

e. Minimize public inconvenience:
   
i. Monitor contractor’s means and methods conform to the responsibilities specified in 2018 SS, Section 7-1.03, Legal Relations and Responsibility to the Public – Public Convenience.
   
f. Public safety:
   
i. Ensure contractor’s means and methods conform to the responsibilities specified in 2018 SS, Section 7-1.04, Legal Relations and Responsibility to the Public – Public Safety.
   
g. Prior to ending traffic control, measure applicable horizontal and vertical clearances for conformance:
   
i. Prior to reopening a road after construction that impairs vertical or horizontal clearances, measure the widths and heights for conformance:
      
1. Horizontal traffic openings are measured from toe to toe of temporary railings. Vertical traffic openings measurements are the minimum vertical clearance across the entire traveled way.
   
2. Record the measurements in the Daily Report and promptly forward to all affected parties per BCM C-4.14, Notice of Change of Structure Clearance or Permit Rating.
   
ii. Verify the contractor allows sufficient time within the work shift to perform required job site cleanup (operate sweeper trucks for sediment control) in conformance with authorized plans (e.g., work plan, Water Pollution Control Plan (WPCP)/Storm Water Pollution Prevention Plan (SWPPP), etc.).
   
   h. The structure representative will inform the RE when structures are opened and closed to traffic.
i. Record when structures are opened or closed to traffic in the Daily Reports and SC Weekly Newsletter. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the reports per BCM C-4.04, Daily and Weekly Reports.

6. Safety:
   a. Keep the RE informed of any unsafe conditions or problem areas.
   b. Take immediate action to address field deficiencies in traffic control with contractor. Record notes and photos in Daily Report.
   c. Coordinate with District RE to request CHP enforcement (COZEEP) as needed.
   d. Night work:
      i. Use approved night work attire and personal protection equipment at all times during any night shift.
      ii. Operate Caltrans vehicle (amber flashing lights, etc.) in accordance with Construction Manual, Chapter 2-2 (and Caltrans Code of Safe Practices)
      iii. Verify that contractor’s work lights do not create conditions hazardous to the public, per 2018 SS, Section 7-1.04, Public Safety.

Process Outputs

1. Daily Reports and SR newsletters
2. Safe traffic handling through and around construction zones with minimized public inconvenience

Attachments

None
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Temporary Facilities – Temporary Pedestrian Facilities

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Background

This process establishes Structure Construction (SC) roles and responsibilities for temporary pedestrian facilities constructed by the Contractor to facilitate structure work.

Structure Construction reviews submittals and administers construction and maintenance of temporary pedestrian facilities to allow for safe passage of pedestrians through structure construction work zones.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review contract specifications, Section 16-2.02, Temporary Facilities – Temporary Pedestrian Facilities, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Authorized temporary structure shop drawings with pedestrian opening
2. Temporary pedestrian facility shop drawings
3. Authorized bridge removal work plan
Procedure

1. All work associated with this process is charged as Project-Direct – Construction.

2. Inspection of field work for this process is:
   a. Benchmark during construction and maintenance.

3. Before construction begins:
   b. Complete temporary pedestrian facilities on-line training per relevant Construction Procedure Directive (CPD), which currently includes CPD 17-1, Permanent Pedestrian Facilities Inspection Training (every 3 years).
   c. Discuss the locations and requirements for temporary pedestrian facilities during the preconstruction conference. There are temporary pedestrian facilities that:
      i. Do not require shop drawings, but instead require the contractor to install them in compliance with the Temporary Pedestrian Facilities Handbook or the Contract Plans.
      ii. Require shop drawing:
         1. Temporary pedestrian facilities with a protective overhead covering.
   d. Review temporary structure shop drawings and bridge removal plans with pedestrian openings.
   e. Review and authorize temporary pedestrian facility submittals from the Contractor:
      i. For submittal involving railroad, discuss additional requirements with SC Falsework Engineer and obtain railroad approval prior to authorization.

4. During Construction:
   a. Inspect and verify construction of the temporary pedestrian facility is in conformance with the contract documents, Temporary Pedestrian Facilities Handbook, and authorized shop drawings.
      i. This process is for temporary pedestrian facilities. The Temporary Pedestrian Facilities Handbook emphasizes the importance of accommodating pedestrians with disabilities through and around work zones. Thus, the contractor must specify measures that will be taken to
correct any non-conformance while the temporary facility is in use. Any
non-conformance must be remedied immediately.

b. Document all inspection, construction, and quality assurance activities,
pertinent to this BCM, in the Daily Reports per BCM C-4.04, Daily and Weekly
Reports.

c. Review form C.E.M.-2311 Temporary Pedestrian Access Route Contractor
Compliance Report, prior to occupancy.

d. Review weekly inspections form C.E.M.-2312 Temporary Pedestrian Access
Route Contractor Weekly Report.

Process Outputs

1. Authorized temporary pedestrian facility submittals:

2. Temporary Structure Analysis Report if required:

3. Temporary Pedestrian Access Route Contractor Compliance Report (form
C.E.M.-2311):

4. Temporary Pedestrian Access Route Contractor Weekly Report (form C.E.M.-
2312):

Attachments

None
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Earthwork – General – Construction – Unsuitable Material

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Background
This process establishes Structure Construction (SC) responsibilities and procedures for identifying, removing, and replacing unsuitable material found below structure excavation limits.

Process Inputs
1. Discovery of unsuitable material.

Procedure
1. All work associated with this process should be charged to the Project-Direct - Construction, unless otherwise directed.
2. Field work for this process is:
   a. Benchmark inspection for structure excavation.
3. Discovery of unsuitable material by inspection or notification from Contractor.
4. Perform a field review and material testing (if necessary) to gather data.
5. Review contract documents.
6. Contact resources in SC and the Division of Engineering Services (DES).
7. Determine available options and select course of action.
8. Inform District and Contractor.
9. Issue a Change Order if needed.
10. Document discovery, work affected, and action taken in the daily reports per BCM C-4.04, Daily and Weekly Reports, and other correspondence.
**Process Outputs**

1. Response to notification of unsuitable material.
2. Daily reports.
3. Change Order and any plan revisions.

**Attachments**
Earthwork – General – Construction – Buried Man-Made Objects

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and administration of buried man-made objects removed from the work area by the Contractor.

Caltrans cannot hold the Contractor responsible for objects buried underground prior to purchase of Caltrans right-of-way, or not located on existing As-built drawings.

Process Inputs

1. Notice of buried man-made objects from Contractor.

Procedure

- All work associated with this process should be charged to the Project-Direct-Construction, unless otherwise directed.

1. Field work for this process is:
   a. Benchmark inspection for structure excavation.

2. Upon receipt of Contractor’s notice of buried man-made object:
   a. Investigate.
   b. Determine response.

3. If object appears to be hazardous¹:
   a. Secure area.
   b. Notify District Hazardous Waste Coordinator and Resident Engineer (RE).

4. Inform RE and Contractor of your findings:

¹ 2015 Standard Specifications, Section 14-11.02, Discovery of Unanticipated Asbestos and Hazardous Substances.
a. Support RE in development of Change Order if warranted.
   - Estimated cost to remove.
   - Anticipated delay to critical path.

b. Notify Bridge Construction Engineer as required by local protocols.

c. Provide Notice to Proceed, if warranted.

5. Document work performed to remove the buried man-made object.

6. If warranted, write a Change Order for work performed.

**Process Outputs**

1. Documentation to RE to support Change Order if warranted.
2. Direction to contractor from RE to remove buried man-made object.
3. Documentation of work performed to remove buried man-made object.

**Attachments**
Earthwork – Structure Excavation and Backfill – General – Summary

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Contact SC Technical Team K for questions

Background

This process establishes Structure Construction (SC) responsibilities and procedures for:

- Identifying structure excavation and structure backfill types and quantities, and contractor notification of any footing or seal course revisions.
- Payment and any quantity changes and adjustments that may be necessary for structure excavation and backfill and procedures specific to spread footing elevations and changes in seal course quantity.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 19-3.01A, Earthwork – Structure Excavation and Backfill – General – Summary that this BCM is based on as identified in the title block above. The information in the contract specification(s) typically will not be repeated in the text of this BCM.

Process Inputs

1. Contract work requiring structure excavation and/or backfill
2. Contract documents, specifically contract pay items and quantities related to structure backfill and structure excavation
3. Contractor inquiry about quantities for structure excavation and backfill contract items
4. Existing field conditions
5. As-built plans of existing facilities (if applicable)
6. Foundation Report in the Informational Handout

Procedure

1. All work associated with this process is charged as Project Direct Construction.
2. Inspection of field work for this process is:
   a. Intermittent for structure excavation
   b. Benchmark for placement of structure backfill
   c. Intermittent for sampling and testing of material and compaction measurement
3. Before construction begins:
   a. Review the contract documents, Resident Engineer (R.E.) Pending file, foundation reports, as-built plans.
   b. Review the site to verify and document existing field conditions, taking note in particular of any nearby or conflicting utilities. Obtain photo and/or video documentation of the existing site conditions and include relevant notes for the project files.
   c. Verify the sum of the quantities listed for each structure matches the Bid Item Quantity.
   d. Verify if the excavation and backfill quantity is already included in the payment for some structure and culvert items.
   e. If pay limits are not shown on the contract plans, calculate the quantities for structure excavation and structure backfill as required per other contract documents. Use of quantities (if available) in the R.E. Pending file is usually sufficient for estimating quantity payments.
   f. Review the Contract Specifications, Section 19-3.04, Earthwork – Structure Excavation and Backfill – Payment, regarding that the planned footing elevations and seal course thickness are approximate. Additional information on seal courses is contained in the Foundation Manual:
      i. Chapter 3, Contract Administration, Section 3-3, Change Orders
      ii. Chapter 12, Cofferdams and Seal Courses:
         1. Section 12-4, Seal Course
2. Section 12-4.3, *Thickness of Seal Course*

3. Section 12-6, *Engineer’s Responsibility*

g. Advise the contractor in writing about ordering material prematurely. Refer to the first sample letter titled, *Bottom of Footing Elevation Sample Letter*, in *Attachment 1*, *Sample Letters to the Contractor Regarding Spread Footings and Seal Courses*.

h. As necessary or based on the contractor’s inquiry, hold a meeting with the contractor to confirm their understanding of what is required for each type of structure excavation and backfill, and what is included in the payment; document agreements in a letter to the contractor.

   i. Write a Change Order (C.O.) if warranted based on a quantity check.

i. When the contract plans include a spread footing and/or seal course, the Structure Representative issues a letter to the contractor containing the following as appropriate:

   i. A reminder stating that per the *Contract Specifications*, Section 51-1.03C(1), *Concrete Structures – General – Construction – Preparations – General*, the “Bottom of footing elevations shown are approximate.”

   ii. A reminder that, per the contract, the engineer determines whether seal courses shown on the plans must be used as shown, changed in thickness, or eliminated, depending upon the water conditions existing at the time.

   iii. A statement that the engineer will establish final footing elevations, and/or determine the need for seal courses at the earliest time possible consistent with progress of the work, and that the contractor will be informed in writing of the engineer’s decision.

   iv. A closing statement to caution the contractor that should they elect to do any work or order any materials before receiving the engineer’s decision regarding spread footing elevations, pile footing elevations where seal courses are involved, and revision or elimination of the seal course; they do so at their own risk and assume the responsibility for the cost of alterations to such work or materials in the event that revisions are required.

j. For sample letters, See *Attachment 1*, *Sample Letters to the Contractor Regarding Spread Footings and Seal Courses*.

4. During construction:

   a. Evaluate the conditions at the time of excavation and the foundation material being excavated to determine final footing elevation and/or the use of seal course.
b. Request assistance from the Bridge Design Project Engineer and Geotechnical Services Geoprofessional, if needed, to evaluate the need for:

i. Bottom of footing elevation changes:
   1. If a bottom of footing elevation change is determined to be necessary, request revised plan sheets so a C.O. may be issued.

ii. Use of a seal course, need for a change in planned thickness, or its elimination:
   1. Determine the need for seal course use or a quantity and/or changes to planed seal course thickness.

c. As soon as a determination can be made, follow up with a letter to the contractor confirming:

i. The bottom of footing elevation to be used, and if applicable, the revised elevation.

ii. If a seal course is needed and/or if the thickness has changed.

iii. See Attachment 1 for sample letters regarding the confirmation of the spread footing elevation and seal course thickness.

d. Write a C.O. when item quantities need to be increased, reduced, or deleted for changes to the footing elevation and/or the use of a seal course.

e. Verify and track the contractor’s quantity of structure excavation and placement of backfill per the contract documents including C.O. work.

f. Make monthly progress payment of quantities consistent with the actual amount excavated or the backfill placed per the contract documents including C.O. work.

i. When there is a discrepancy between the actual and planned item quantities for either structure excavation or backfill, remember that these items are generally Final Pay quantities:

   1. Thus, unless there is an ordered change by the engineer, the Final Pay quantity listed in the Bid Book/Special Provisions is the amount paid regardless of discrepancies.

   2. When there is an ordered change, only that quantity is used in the C.O. for payment, regardless of potential discrepancy between the C.O. and actual quantity.

   3. Be aware of thresholds for limits of unit price adjustment and C.O. work if necessary when adjusting the footing elevation or seal course thicknesses.
g. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Following construction:
   a. Document all changes on the as-built plans.

6. File all materials acceptance documentation and Daily Reports in the appropriate category in the project records as specified in the Construction Manual, 5-102, Organization of Project Documents.

**Process Outputs**

1. Written agreement on types and quantities of structure excavation and backfill
2. Monthly progress payments
3. Letter to the contractor advising final spread footing and/or seal course
4. Letter to contractor confirming need for seal course and/or footing elevation revision
5. Change Orders if needed

**Attachments**

Attachment 1, Sample Letters to the Contractor Regarding Spread Footings and Seal Courses
Sample Letters to the Contractor Regarding Spread Footings and Seal Courses

This attachment includes the following four sample letters to assist the Structure Representative when writing letters to the contractor:

- **Figure 1.** Bottom of Footing Elevation Sample Letter
- **Figure 2.** Bridge Footing and Seal Course Concrete Revisions Sample Letter
- **Figure 3.** Final Footing Elevation Determination – Bent XX Sample Letter
- **Figure 4.** Final Seal Course Use Determination Sample Letter

When writing letters to a contractor always start with the current template from the Director’s Office.
<Current Date>

File: XX-XXXXXX
District-County-Route-RX/X
Project ID: XXXXXXXXXX
Fed No. XXXXXXXX-XXXX

<Mr. Contractor>
Project Manager
ABC USA
123 South 3rd Street
Fresno, CA 93726

Subject: Bottom of Footing Elevation

Dear <Mr. Contractor>:

This letter is to bring your attention to some important guidance information in the contract specifications about field revisions of the elevation of bottom of footings. You are reminded that Section 51-1.03C(1) of the 2018 Standard Specifications states that “Bottom of footing elevations shown are approximate” and “The Engineer may order changes in footing dimensions or elevations.”

The Engineer will establish the final bottom of footing elevations at the earliest time possible consistent with the progress of work, and you will be informed in writing of the Engineer’s decision. This is change order work. CO #XX will be issued to address this change.

You are reminded that should you elect to do any work or order any materials before receiving the Engineer’s decision regarding bottom of footing elevations you do so at your own risk and assume the responsibility for the cost of alterations to such work or materials in the event that revisions are required.

If you have any questions, feel free to call me at XXX-XXX-XXXX.

Sincerely,
NAME
Structures Representative
For
Resident Engineer
Attachments:
(none)
c. RE file
   Job file

Figure 1. Bottom of Footing Elevation Sample Letter
Re: Bridge Footing and Seal Course Concrete Revisions

Dear <Mr. Contractor>,

This letter is to direct your attention to some important guidance information in the contract specifications regarding field revisions of the footing elevation and seal course thickness, and the potential elimination of the seal course.

Section 51-1.03C(1) of the 2018 Standard Specifications states the bottom of footing elevations are approximate and the Engineer may order changes to the footing dimensions or elevations.

The Engineer will also determine whether seal courses shown on the plans must be used as shown, changed in thickness, or entirely eliminated, depending upon the water conditions existing at the time. Refer to Section 51-1.03D(3) of the 2018 Standard Specifications.

The Engineer will establish final footing elevations, and/or determine the need for seal courses at the earliest time possible consistent with progress of the work. This is change order work. CO #XX will be issued to address this change.

You will be informed in writing of the Engineer’s decision.

Should the you elect to do any work or order any materials before receiving the Engineer’s decision regarding footing elevations, or pile footing elevations where seal

“Provide a safe and reliable transportation network that serves all people and respects the environment”
courses are involved, and revision or elimination of the seal course is required, you do so at your own risk and assume the responsibility for the cost of alterations to such work or materials in the event that revisions are required.

If you have any questions, feel free to call me at XXX-XXX-XXXX.

Sincerely,

<NAME>
Structures Representative
For
Resident Engineer
Attachments:
(none)

c. RE file
   Job file

Figure 2. Bridge Footing and Seal Course Concrete Revisions Sample Letter
Subject: Final Footing Elevation Determination – Bent XX

Dear <Mr. Contractor>:

As a follow up to Bridge Letter XX-XXX “of Bottom of Footing Elevation”, upon a determination of field conditions and contract provisions, there will be no changes to the elevations and/or dimensions to the footing of Bridge XXXXXX(Br #xx-xxxx), at Bent XX. You are to proceed to construct the bridge bottom of footing with elevations and limits as specified per contract plans and specifications.

[OR]

As a follow up to Bridge Letter XX-XXX “of Bottom of Footing Elevation”, upon a determination of field conditions and contract provisions, the bottom of footing elevation will be lowered two (2) feet to elevation 245.0, for Bridge XXXXXX(Br #xx-xxxx), at Bent XX.

A change order is forthcoming to adjust the final pay quantities for Structural Concrete, Bridge Footing and Bar Reinforcing Steel (Bridge) for this change.

If you have any questions, feel free to call me at XXX-XXX-XXXX.

Sincerely,
<NAME>
Structures Representative
For
Resident Engineer
Attachments:
(none)

c. RE file
   Job file

Figure 3. Final Footing Elevation Determination – Bent XX Sample Letter
Subject: Final Seal Course Use Determination

Dear <Mr. Contractor>:

As a follow up to Bridge Letter XX-XXX “Bridge Footing and Seal Course Concrete Revisions” and upon a determination of field conditions and contract provisions, the seal course thickness for Bridge XXXXXX(Br #xx-xxxx), Bent XX, must be reduced from a plan thickness of 4’ to 3’. There are no revisions to the bottom of footing elevation or its dimensions.

If you have any questions, feel free to call me at XXX-XXX-XXXX.

Sincerely,

NAME
Structures Representative
For
Resident Engineer

Attachments:
(none)
c. RE file
Job file

Figure 4. Final Seal Course Use Determination Sample Letter
Earthwork – Structure Excavation and Backfill – Submittals

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<td>Steve Altman</td>
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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of earthwork submittals, including:

- Shop drawings for cofferdams.
- Shop drawings for soldier pile walls.
- Collaborative review of shop drawings for ground anchors and soil nail walls with Structure Design.
- Controlled low-strength material.
- Stability test results for ground anchors and soil nail walls.

Process Inputs

1. Contractor’s submittal(s).

Procedure

1. All work associated with this process should be charged to the Project-Direct-Construction, unless otherwise directed.

2. Receive submittal; check that submittal meets the requirements of the contract documents.

3. For excavations utilizing temporary structures:
   b. When authorizing or rejecting shop drawings, send a Temporary Structure Plan Analysis Report per BCM C-4.12, Shop Drawing Review of Temporary Structures. Attachment No. 1 is a sample authorization letter for a shoring plan.
c. When temporary shoring structures are installed as part of an Encroachment Permit, conform to the Division of Traffic Operations’ Memorandum titled: *Temporary Ground Anchor (Tieback) Encroachments*, dated July 26, 2017. See Attachment No. 2.

4. For soldier pile walls:
   a. Review the shop drawings for contract compliance per BCM 5-1.23, *Control of Work – Submittals* and the Standard Specifications (SS)¹.

5. For ground anchor and soil nail walls:
   a. Coordinate the review with the project designer per the *Foundation Manual, Chapter 11, Ground Anchors & Soil Nails*, and *Memo to Designers 5-14, Review of Shop Drawings for Ground Anchors*, or *Memo to Designers 5-18 Attachment A, Soil Nail Working Drawings Review Process (Interim)*.
   
   b. Authorize or reject the shop drawings based on the project designer’s recommendation.

6. For Stability Test results:
   a. Review the submittal for the specified wall zone.
   b. Determine whether the exposed excavated face maintains integrity per the SS².

7. For Controlled Low Strength Material:
   a. Typically this is District work. If this is structure work, review the mix design in accordance with the requirements of the contract documents.

8. Notify the Contractor of authorization or rejection of all submittals in writing.

**Process Outputs**


**Attachments**

Attachment No. 1: Sample Authorization Letter.

Attachment No. 2: Temporary Ground Anchor Encroachments Memo.

---

¹ 2015 SS, Section 5-1.23B(2), *Shop Drawings*.
² 2015 SS, Section 19-3.01D(2), *Stability Test for Ground Anchor and Soil Nail Walls*.
July 20, 2016

Mr. Hold M. Back  
Temporary Works Engineer  
Design-Right Engineers  
1344 Lucky Lane  
Sacramento, CA, 95816

Dear Mr. Back:

Shoring Plan Analysis Report

Project Information:

- 02-XXXXX4
- 02-XXX-70-50.6/51.7
- Spring Forward Overhead (Widen)
- Br. No. 09-9000

Type of Structure Reviewed: Shoring Plan for Bents 2 and 3 – Option 2

Chronology:

- Plans were received: 5/3/16
- Review completed: 7/17/16
- Elapsed review time: 75 days

Introduction:

This report presents the results of an independent engineering review of Opt. 2 of the proposed shoring for Bents 2 and 3 for Spring Forward Overhead (Widen).

Discussion:

Authorization: No exceptions were found.

Conclusion:

“Provide a safe, sustainable, integrated and efficient transportation system to enhance California’s economy and livability”
Mr. Hold M. Back  
July 20, 2016  
Page 2

The shoring plan for Bents 2 and 3, Opt. 2, for Spring Forward Overhead, 09-9000, is authorized based upon an independent engineering analysis and found acceptable and is authorized to the extent provided in the Standard Specifications, Section 5-1.23, Submittals.

The contractor’s attention should be directed to their responsibilities pursuant to the Standard Specifications, Section 5-1.23, Submittals, and Standard Specifications 7-1.04, Public Safety as well as the Construction Safety Orders.

The shoring at Bents 2 and 3 must be constructed to conform to the shoring working drawings and the materials used must be of the quality necessary to sustain the stresses required by the shoring design and the workmanship must be of such quality that the shoring will support the loads imposed without excessive settlement and take up beyond that shown on the shoring drawings.

If you have any questions, please contact me at (555) 555-7334.

Sincerely,

IVE WATCHING  
Structure Representative for Ron Road, Resident Engineer

C: My Boss, Area Bridge Construction Engineer  
Head Guru, Caltrans Temporary Structures Engineer  
Engineering Service Center

"Provide a safe, sustainable, integrated and efficient transportation system  
to enhance California’s economy and livability"
MEMORANDUM

To: DISTRICT DIRECTORS
    DEPUTY DISTRICT DIRECTORS
    Traffic Operations

From: AMARJEET S. BENIPAL
    Acting Chief
    Division of Traffic Operations

Date: July 26, 2017

REQUEST FOR AN ENCRYCACHMENT POLICY EXCEPTION

Temporarily encroachment requests must be authorized through the encroachment policy exception process. In addition, an executed Right of Way/Airspace Use Agreement (UA) is required between the applicant/developer and Caltrans to compensate for use of airspace and/or property.

Request for an Encroachment Policy Exception

The applicant must justify the need and character of the encroachment policy exception, as described in PDPM Chapter 17, Section 3. In addition, the applicant must provide the District Encroachment Permits (EP) Office the following documents:

1. Documentation demonstrating that there are no other feasible, alternative designs that do not encroach into state highway right-of-way.

2. A minimum of six complete sets of plans. A 3-D computer model with all dimensions identified (X, Y and Z) and the model can be in any format (.dgn etc.). The plans must include all construction details including those of the temporary shoring wall. The visual 3-D computer model must identify all existing subsurface highway infrastructure and

Subject: TEMPORARY GROUND ANCHOR (TIEBACK) ENCROACHMENTS

This memorandum provides guidance and processing requirements for non-highway-related temporary ground anchor (tieback) requests.

A temporary tieback is defined as a tieback that is de-tensioned when it is no longer needed for structural support and abandoned within the state highway right-of-way after project completion. A permanent tieback is defined as a tieback that remains in tension and is used for structural support after project completion. Permanent tiebacks that are not part of a state highway improvement project are prohibited on all state highway rights-of-way.

From: JENNIFER LOWDEN
    Chief
    Division of Right of Way and Land Surveys

To: TIMOTHY CRAGGS
    Chief
    Division of Design

From: MICHAEL D. KEEVER
    Chief
    Division of Engineering Services

DEPARTMENT OF TRANSPORTATION

State of California

utilities within state highway right-of-way, relative to all objects proposed to be placed. The plans must delineate all proposed objects relative to the state highway right-of-way and roadway features.

3. A geotechnical report and recommendations, which must include applicable elements similar to those in the Foundation Reports for Earth Retaining Systems. For access to Caltrans guidance on Foundation Reports for Earth Retaining Systems, refer to: http://www.dot.ca.gov/hq/esc/geotech/geo_manual/page/FR_ERS_June2017.pdf

4. Structural plans and design calculations. Tiebacks must be installed in compliance with current Caltrans practices for temporary tiebacks.

5. Drainage plans showing existing and proposed drainage facilities within the vicinity of the tiebacks and existing Caltrans facilities.

6. Assessment of potential impacts and risks of all proposed objects to the existing highway infrastructure (including utilities) within state highway right-of-way.

**Processing Requirements**

The District EP Office must not issue an encroachment permit for temporary tiebacks without an approved encroachment policy exception, executed UA, and recommendation from all reviewers.

Unlike most encroachment permits involving a UA, the District EP Office will lead the review of temporary tieback permit requests. The District EP Office will circulate the application package to functional units including but not limited to the District Division of Design, District Division of Right of Way, Division of Engineering Services (Structure Policy and Innovation and Geotechnical Services) and Division of Maintenance - Structure Maintenance and Investigations, for their review, processing, and recommendation. Tieback installations must be placed in such a manner as to avoid affecting highway traffic operations, maintenance, or obstructing removal of the tieback for any future transportation improvements in the state highway right-of-way.

After obtaining electronic and paper as-built plans from the Division of Engineering Services-Structure Construction (with locations of de-tensioned tiebacks provided by permittee and authorized by the Structure Construction), the District EP Office will forward a copy of the electronic as-built plans to the District Utility Engineering Work Group.

The District Right of Way units understand the maximum 60-day time constraints of issuing an encroachment permit, and are responsible for preparing, coordinating, and expeditiously executing a UA. For temporary tieback requests, the Right of Way Program will develop a UA for temporary site use and will charge the Fair Market lease rate. Entering into a UA and the payment of the Fair Market lease rate addresses the private use of state highway right-of-way. It also addresses the Federal Highway Administration (FHWA) regulations relating to...
management of airspace on interstate highways for non-highway purposes, which are included in title 23 Code of Federal Regulations sections 710.403 and 710.405.

For encroachments on interstate highways, the Headquarters Division of Design, Office of Project Support, will facilitate the FHWA review and consideration for approval.

The attached Temporary Ground Anchors (Tiebacks) Special Provisions must be included with all encroachment permits to install temporary tiebacks within the state highway right-of-way.

The Office of Structure Construction will perform inspections of installation and management of temporary tiebacks. The Structure Representative will: confirm ground anchors are de-tensioned and physically detached from the shoring wall; confirm there are no impacts to state structures, utilities, drainage, or other features as a result of installation of the temporary excavation support and grouting; verify the as-built plans represent the actual locations of ground anchor and appurtenance installations that will remain in the state highway right-of-way.

For questions regarding this memorandum or the attachment, you may contact:

1. Yin-Ping Li, Chief, Office of Encroachment Permits and Engineering Support, Division of Traffic Operations at (916) 654-5548, or by e-mail at Yin-Ping.Li@dot.ca.gov
2. Carol Hanson, Chief, Office of Real Property Services, Division of Right of Way at (916) 654-3536, or by e-mail at Carol.Hanson@dot.ca.gov
3. Linda Fong, Chief, Office of Project Support, Division of Design at (916) 653-8559, or by e-mail at Linda.Fong@dot.ca.gov
4. Susan Hida, Chief, Office of State Bridge Engineer Support, Division of Engineering Services at (916) 227-8738, or by e-mail at Susan.Hida@dot.ca.gov

Attachment:
Temporary Ground Anchors (Tiebacks) Special Provisions

Malcolm Dougherty, Director
Kome Ajise, Chief Deputy Director
Karla Sutliff, Deputy Director, Project Delivery
Steve Takigawa, Deputy Director, Maintenance and Operations
Rachel Falsetti, Chief, Division of Construction
Matthew Schmitz, Director, Project Delivery, Federal Highway Administration
Thomas A. Ostrom, Deputy Division Chief, Structure Policy and Innovation, Division of Engineering Services
Daniel H. Spear, Acting Deputy Division Chief, Geotechnical Services, Division of Engineering Services
Steve Altman, Deputy Division Chief, Structure Construction, Division of Engineering Services
Susan Hida, Chief, Office of State Bridge Engineer Support, Division of Engineering Services
DISTRICT DIRECTORS, et al.
July 26, 2017
Page 4 of 4

Carol L. Hanson, Chief, Office of Real Property Services, Division of Right of Way and Land Surveys
Linda Fong, Chief, Office of Project Support, Division of Design
Yin-Ping Li, Chief, Office of Encroachment Permits and Engineering Support, Division of Traffic Operations
District Encroachment Permit Engineers

"Provide a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability"
1. The tiebacks must be de-tensioned and physically detached from the shoring wall once the permittee’s foundation construction is complete. No future access to the tiebacks will be allowed once they have been detached.

2. Tieback installations shall not be placed in such a manner to impact traffic operations, maintenance, or obstruct any future transportation improvements in the state right-of-way.

3. Permanent tiebacks are prohibited. Tiebacks shall not be used to support the completed structure.

4. The shoring wall shall not be located within the state highway right-of-way.

5. The shoring wall shall be monitored during construction to determine any lateral movement.

6. The temporary wall must not create perched ground water that affects the foundation strength of state structures and facilities.

7. Should any underground facilities or utilities be encountered during the installation of the tiebacks, work must stop and the Caltrans representative shall be immediately notified. Work will not continue until Caltrans agrees to an alternate strategy (including the possible need to redesign) or other mitigation.

8. Deformation impacting state structures, roadways, utilities, drainage, or other features as a result of installation of the temporary excavation support and grouting, is not permitted. Should unanticipated deformation or other impacts occur, the Caltrans representative shall be immediately notified, and work will cease until Caltrans agrees to an alternate strategy (including the possible need to redesign) or other mitigation.

9. Upon completion of the installation and subsequent de-tensioning of the tiebacks, the permittee must submit as-built plans, prepared in accordance with Caltrans’ CADD Users Manual, of all objects installed and to be abandoned in state highway right-of-way and submit as-built plans to Structure Construction for their authorization.
Earthwork – Structure Excavation and Backfill – Quality Assurance – Stability Test for Ground Anchor and Soil Nail Walls

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for administration of soil stability testing performed by the contractor for ground anchor and soil nail walls.

Soil stability testing is required for excavation lift heights greater than 5 feet or an exposure duration longer than 1 work shift.

Submittals pertaining to soil stability testing are reviewed and authorized per the Contract Specifications, Section 19-3.01C, Earthwork – Structure Excavation and Backfill – Submittals.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 19-3.01D(2), Earthwork – Structure Excavation and Backfill – Quality Assurance – Stability Test for Ground Anchor and Soil Nail Walls, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.
Process Inputs

1. Authorized shop drawings

Procedure

1. All work associated with this process is charged as Project-Direct – Construction.

2. Inspection of field work for this process is:
   a. Intermittent for inspection of soil stability testing.

3. Before construction begins:
   b. Discuss soil stability testing requirements and the contingency plan with the contractor.
   c. For example photographs and information of ground anchors and soil nail walls, review the 2019 Winter Training presentations:
      i. Q. Ground Anchors and Soil Nails General
      ii. R. Ground Anchors
      iii. S. Soil Nails
         These are large files and may take a while to load.

4. During construction:
   a. Verify soil stability testing is performed per authorized submittals and contract requirements.
   b. If soil stability test requirements are met, authorize wall excavation height and exposure time limits:
      i. Notify the contractor in writing of test results.
   c. If during excavation for soil stability testing the soil conditions are different than anticipated, contact the project’s Geotechnical Designer and Structure Designer. The design could be impacted, either increasing or reducing the reinforcement needed or modifying the wall limits.
   d. If the exposed excavated face does not maintain its integrity:
      i. Direct the contractor to stabilize the excavated face as described in the authorized shop drawings.
ii. Discuss with the contractor whether additional soil stability tests will be performed or if modifications to the authorized excavation submittals need to be made.

iii. Consult with the Geotechnical Designer and Structure Designer.


e. Document all inspection, construction and quality assurance activities, pertinent to the BCM, in the daily reports per BCM C-4.04, *Daily and Weekly Reports*.

5. Following an authorized stability test:

a. Be aware that face instability may occur at any time during wall construction and thus must be monitored. Instability must be addressed per BCM 19-3.03K, Earthwork – Structure Excavation and Backfill – Construction – Ground Anchor and Soil Nail Walls.

6. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual 5-102, *Organization of Project Documents*.

**Process Outputs**

1. Authorized Soil Stability Test results
2. Daily Reports

**Attachments**

Attachment 1, *Excavated Exposed Face Instability*
Excavated Exposed Face Instability

Following are examples of excavated wall faces that did not maintain integrity and stability.

Figure 1. Native sandy silt material that will not maintain a vertical stable cut.

Figure 2. Another example of wall face instability due to sandy material.
Excavated Exposed Face Instability

Figure 3. Material that stands initially, may slough over time as the soil loses moisture. Thus, even apparently good soil material may slough.

Figures 4 through 9 depict a time lapse event that led to a wall failure. Work occurred on a Friday shift culminating in a wall collapse Monday morning.

Figure 4. Improper berm and native sandy material sloughing on Friday from behind the previously constructed 2 layer/rows of soil nails.
Excavated Exposed Face Instability

Figure 5. As work progressed through the day and afternoon more material sloughs from behind the wall due to construction activity and loss of moisture.

Figure 6. Picture from inside and behind shotcrete to illustrate the amount of material loss. Note the exposed soil nail from the previously completed row above.
Excavated Exposed Face Instability

Wall Instability Leading To Wall Failure

Figures 4 through 6 depicts what contributed to the wall failure that is depicted in Figures 7 through 9 that was observed the following Monday morning.

Figure 7. Wall collapsed due to progressive loss of material from behind the wall, noted in the previous pictures. Notice the deteriorated berm and loss of material.

Figure 8. With the loss of the supporting soil behind the wall, the wall failed similar to a beam in bending. The top portion of the wall buckled outward and broke.
Excavated Exposed Face Instability

Figure 9. Illustrating the magnitude of material loss due to wall face instability and potential safety hazard for the travelling public. The berm being placed is to stabilize the failed section to prevent further collapse.
Earthwork – Structure Excavation and Backfill – Construction – Structure Excavation

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for structure excavation work, for typical excavations, soldier pile walls, pier columns, and cofferdams, including the construction of protective systems required per BCM 7-1.02K(6)(b), Legal Relations and Responsibility to the Public - Occupational Safety and Health Standards – Excavation Safety. The end of this process concludes with the acceptance of completed structure excavations.

Additional unique requirements related to this process are detailed in:


It is important for SC personnel to have all necessary authorized submittals required for worker and facility protection prior to the start of structure excavation work to best assure the safe performance of structure excavation.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the contract specifications 19-3.03B, Earthwork – Structure Excavation and Backfill – Construction – Structure Excavation, that this BCM is based on as identified in the title.
The information in the contract specifications typically will not be repeated in the text of this BCM.

**Process Inputs**

1. The start of structure excavation work.
2. The contractor’s Underground Service Alert (USA) notice to begin excavation.

**Procedure**

1. All work associated with this process is charged as [Project-Direct – Construction](#).
2. Field work for this process is:
   a. **Intermittent** inspection for structure excavation work and installation of protective systems.
   b. **Continuous** inspection for structure excavation work and installation of protective systems if public safety or preservation of property is a concern, or when a change order (C.O.) is required for buried man-made objects or unsuitable material.
3. Before construction begins:
   b. Review the Geotechnical Design Report (GDR) and/or the Final Foundation Report (FFR), which includes foundation recommendations, settlement requirements, and the Geotechnical Services contact.
   c. Review the Resident Engineer (RE) pending file for the:
      1. Engineer’s Estimate quantity calculations for anomalies.
      2. Project Risk Register for excavation risks such as buried man-made objects or unsuitable material.
   d. Discuss with the contractor:
      i. Timely notification of Underground Service Alert (USA). Request a copy.
      ii. The competent person(s) for excavation as defined in Title 8 CCR Subchapter 4, *Construction Safety Orders, Article 6. Excavations*. See Subsection 1541, *General Requirements*, (b)(1)(C) for a definition of “the competent person” responsible for monitoring excavation operations.
iii. The requirements of the contract documents; particularly unique issues such as vibration restrictions and handling of contaminated (or potentially contaminated) soil.

iv. Timely request of quantity adjustments (if needed) prior to performing extra work.

4. During construction:
   a. For all structure excavation work:
      i. Inspect and evaluate structure excavation work in progress:
         1. Verify the field conditions match the authorized submittals assumptions and the contractor’s method or materials are as planned.
         2. Verify soil types/classifications encountered during structure excavation work match the assumed conditions in the authorized earthwork submittals and/or Contract Documents using:
            a. Inspection tools such as a pocket penetrometer or Torvane (BCM 122-3.0) can be useful for verifying soil conditions.
            b. Geotechnical Services to assist with the classification of the in-situ materials if needed.
            c. Additional information contained in the *Trenching and Shoring Manual*, Sections 2.2.3, *Soil Classification*; 3.1, *Soil Identification, Classification, Description and Presentation*, and Appendix A, excerpts of *California Occupational Safety and Health Standards for Excavations* (see Soil Classification on page A-19).
   
      ii. Verify that the contractor’s competent person is inspecting the site in accordance with the Construction Safety Orders and the authorized excavation plan.
      iii. Require resubmittal for any deviations encountered during structure excavation work of the authorized submittals, including assumed soil types/classifications.
iv. Determine whether the depth of the structure excavation needs to be changed from that shown in the contract documents. See BCM 19-3.01A, Earthwork - Structure Excavation and Backfill – Summary, and BCM 51-1.03C-D, Concrete Structures - General - Preparation and Placing Concrete. Authorize change order work if needed. See BCM 19-1.03B, Earthwork – General – Construction – Unsuitable Material:

1. Contact Geotechnical Services as needed for assistance in determining the soil at the planned footing elevations or with identification of unsuitable materials.

v. Accept structure excavation work, upon satisfactory inspection of foundation material at planned footing elevation, by letter to the contractor.

b. For Soldier Pile Walls:

i. Confirm excavation and construction of soldier pile walls meets the requirements of the contract documents and the authorized shop drawings.

ii. Evaluate whether boulders that interfere with lagging need to be removed and authorize change order work if needed.

c. For Pier Columns:

i. Review requirements for excavation work for pier columns contained within the contract Special Provisions.

ii. Confirm excavation and bracing used to support the pier column excavation meet the requirements of the contract documents. See Foundation Manual, Chapter 10, Pier Columns.

d. For Cofferdams:

i. Confirm construction of the cofferdam meets the requirements of the contract documents and the authorized shop drawings.


5. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the daily reports per BCM C-4.04, Daily and Weekly Reports.

6. File all test results and daily reports in the appropriate category in the project records as specified in the Construction Manual 5-102, Organization of Project Documents.
Process Outputs

1. Daily Reports
2. Authorized change order work (BCM C-4.09)
3. Accepted structure excavations

Attachments

None
Earthwork – Structure Excavation and Backfill – Construction – Structure Excavation – Water Control and Foundation Treatment

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for removing and control of water as well as foundation treatment during structure excavation operations.

Removal of water may be performed using well point systems, pumping systems, cofferdams, concrete seal courses, or a combination of these methods. Control of water removed is addressed in the Contract Specifications, Section 13-4, Water Pollution Control – Job Site Management, and BCM A-1, Communicating SC Staff Responsibilities, Attachment 2, SC Staff Responsibilities for Performing Standard Construction Activities.

Foundation treatment includes work necessary to mitigate foundation material disturbed by the Contractor as well as mitigating undisturbed foundation material that is unsuitable for the planned use.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 19-3.03B(5), Earthwork – Structure Excavation and Backfill – Construction – Structure Excavation – Water Control and Foundation
Treatment, that this BCM is based on as identified in the title block above. The information in the Contract Specifications (CS) typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Contract documents requiring use of a seal course.
2. Dewatering and discharge work plan if needed.
3. Original foundation material in the excavation is unsuitable, requiring a change order.

**Procedure**

1. All work associated with the process should be charged to Project Direct Construction, unless otherwise directed.
2. Inspection of field work for this process is:
   a. **Benchmark** for structure excavation, removing and control of water, and foundation treatment.
   b. **Intermittent** for change order work.
3. Before construction begins, the Structure Representative (SR) or delegate must:
   a. Review the contract documents, including the foundation report and Permits, Licenses, Agreements and Certifications (PLACs), for seal course and dewatering requirements.
   b. Review the jobsite and contract documents for groundwater table information. Refer to BCM 19-3.01A, Earthwork – Structure Excavation and Backfill – General – Summary, for letters to be written to the Contractor ahead of the anticipated work. Preliminary seal course thickness calculations (Foundation Manual, Appendix I, Coffers and Seal Courses) should be done based on anticipated water levels and compared to the planned thickness.
   c. Review with the Resident Engineer the Contractor’s dewatering and discharge work plan per CS, Section 13-4, Water Pollution Control – Job Site Management, and the Foundation Manual, Chapter 4, Footing Foundations, Section 4-7.3, Wet Excavations.
      i. If dewatering is not in the authorized Stormwater Pollution Prevention Plan/Water Pollution Control Program (SWPPP/WPCP), an amendment to that document will be required per the CS, Section 13-2, Water Pollution Control – Water Pollution Control Program, or the CS, Section 13-3, Water Pollution Control – Stormwater Pollution Prevention Plan.
ii. When the dewatering and discharge work plan includes a cofferdam, remind the Contractor to comply with the CS, Section 19-3.01C(2), *Earthwork – Structure Excavation and Backfill – General – Submittals – Cofferdams.*

4. During construction, the SR or delegate must:
   a. Review daily the dewatering operations to verify work is performed per the authorized SWPPP/WPCP or amendments to the SWPPP/WPCP if applicable, including sampling and testing of water when required. Advise the Contractor and the Resident Engineer of the results.
   c. When a seal course is shown on the contract documents:
      i. Determine whether a seal course is required according to Foundation Manual, Chapter 12, Cofferdams and Seal Courses, Section 12-6 Engineer’s Responsibility.
         1. Eliminate the seal course by change order if not needed.
      ii. Verify the required thickness of the seal course. Refer to the Foundation Manual, Section 12-4.3, Thickness of Seal Course.
   d. When seal course is not shown on the contract documents and the Contractor chooses to use a seal course in the dewatering and disposal work plan:
      i. Review and authorize the Contractor’s work plans for construction of the seal course. Refer to the Foundation Manual, Chapter 12, Cofferdams and Seal Courses, Section 12-5, Contractor’s Responsibility.
      ii. All work to construct the seal course must comply with CS, Section 19-3.01C(2), *Earthwork – Structure Excavation and Backfill – General – Submittals – Cofferdams.*
   e. For foundations not supported on piles:
      i. Review the suitability of the foundation material:
         1. For original foundation material rendered unsuitable by the Contractor’s means and methods for excavation, verify the Contractor takes action to restore the foundation per the Foundation Manual, Section 4-8, Foundation Problems and Solutions.
         2. For undisturbed original foundation material found to be unsuitable, prepare a change order to specify a foundation treatment. See BCM 19-1.03B, *Earthwork – General – Construction – Unsuitable Material,*
for additional information on this process. When preparing the change order:

a. Discuss methods for foundation treatment with Geotechnical Services Geoprofessional.

b. Review the *Foundation Manual*, Section 4-8, *Foundation Problems and Solutions*.

c. Document all inspection, construction, and quality assurance activities in the daily reports per *BCM C-7, Daily and Weekly Reports*.

d. Document dimensions and thickness of seal courses and any foundation treatments in the as-built project plans. See *Foundation Manual*, Appendix *K3, Cofferdam and Seal Course Construction Checklist*, Section IX, *Project Completion/As-Builts*.

e. Authorize payment in accordance with contract documents and guidance in *BCM 19-3.01A, Earthwork – Structure Excavation and Backfill – General – Summary*.

f. Full compensation for seal course concrete not shown on the plans for excavations, unless ordered by the engineer, is considered to be included in the price paid for structure excavation or the contract price paid for the item of work requiring excavation, and no separate payment is made.

5. Following construction, the SR or delegate must:

a. Document any unusual conditions and corrective actions in the *Form SC-6303, Report of Completion – Bridges*.

6. File all project documentation (correspondence, materials, acceptance documentation, daily reports, etc.) in the appropriate category in the project records as specified in the *Construction Manual*, Chapter 5, *Section 5-102, Organization of Project Documents*.

**Process Outputs**

1. Authorized dewatering and disposal work plan, if needed
2. Foundation treatment change order, if needed
3. As-built project plans
4. Daily reports

**Attachments**

None
Earthwork – Structure Excavation and Backfill – Construction – Structure Backfill

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for construction of structure backfill work, including accepting completed structure backfill, and the construction of structure backfill work for Soldier Pile walls.

Additional unique requirements for structure backfill are detailed in:

- Construction Manual, Chapter 6, Sampling and Testing
- Construction Manual, Chapter 4, Construction Details, Section 68, Subsurface Drains

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 19-3.03E, Earthwork – Structure Excavation and Backfill – Construction – Structure Backfill, that this BCM is based on as identified in the title block above. The information in the contract specification(s) typically will not be repeated in the text of this BCM.

Process Inputs

1. Authorized backfill material
2. Contractor work schedule for this item of work
Procedure

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:
   a. Intermittent for structure backfill material placement.

3. Before construction begins:
   a. Discuss drainage, backfill, and testing operations with the contractor.
   b. Prior to placing structure backfill material, verify concrete finish is completed, compressive strength attained, and the drainage system is in place per Construction Manual, Chapter 4, Construction Details, Section 68, Subsurface Drains.
   c. Arrange for gradation and cleanliness tests with the District Materials testers per Construction Manual, Section 6-107, Materials Acceptance Sampling and Testing.
      i. Accept or reject proposed structure backfill material in accordance with test results and Contract Specifications, Section 19-3.02, Earthwork – Structure Excavation and Backfill – Materials.
   d. Verify structure backfill material is onsite and available for backfill operations.
   e. Verify the drainage system is in place per the Construction Manual, Chapter 4, Construction Details, Section 68, Subsurface Drains.
   f. Check weep hole locations and elevations. If weep holes are placed at wrong elevations and/or missing, core through the concrete and place at proper locations.
   g. Authorize start of backfill operations when all the above is satisfactory.

4. During construction:
   a. Verify the contractor's structure backfill placement operation complies with excavation safety requirements per BCM 7-1.02K(6)(b), Legal Relations and Responsibility to the Public – Occupational Safety and Health Standards – Excavation Safety.
   b. Verify that backfill material and the contractor operation is appropriate to provide the required compaction. For example, excessively wet material may cause pumping (heaving of material) and improper compaction equipment may not achieve uniform compaction.
   c. Confirm placement of temporary bumpers per BCM 51-1.03E, Concrete Structures – General – Miscellaneous Construction.
   d. Monitor structure backfill placement progress such that:
i. Unequal loading is not induced on the structure, as required to bring backfill up uniformly on all sides of structures or drainage facilities. (Example: both sides of a pier wall concurrently.)

ii. Compaction testing is performed at intervals to validate method used is meeting the specifications. Arrange for compaction, gradation, and cleanliness tests with the District Materials Testers per the Construction Manual, Section 6-107, Materials Acceptance Sampling and Testing.

iii. Accept or reject structure backfill in accordance with test results.

e. Enter results in Backfill Log and file Materials Test reports Form SC-3701, Test Results Summary, in the project records. Record remediation efforts for failing tests on this log and the Daily Report.

f. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

g. Measure and pay for work in accordance with Contraction Specifications, Section 19-3.04, Earthwork – Structure Excavation and Backfill – Payment, and BCM 19-3.01A, Earthwork – Structure Excavation and Backfill – General – Summary. Provide monthly payment estimate based on estimates of work completed with passing compaction. For earthwork unit price calculations, refer to existing BCM C-4.07, Preparation of Progress Payment Documents.

5. Mechanically Stabilized Embankment walls will have additional backfill inspection, sampling, and testing requirements. Refer to BCM 47-2, Earth Retaining Systems – Mechanically Stabilized Embankment.

6. File all materials acceptance documentation and Daily Reports in the appropriate category in the project records as specified in the Construction Manual 5-102, Organization of Project Documents.

**Process Outputs**

1. Materials test reports
2. Daily Reports
3. Monthly Estimate Sheets

**Attachments**

None
Earthwork – Structure Excavation and Backfill – Construction – Ground Anchor and Soil Nail Walls

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for construction of structure excavation work for ground anchor and soil nail walls.

Excavation of ground anchor and soil nail walls is typically performed in layers from the top down. Soil stability testing, if performed, is completed per the Contract Specifications, Section 19-3.01D(2), Earthwork – Structure Excavation and Backfill – General – Quality Assurance – Stability Test for Ground Anchor and Soil Nail Walls.

Proper execution of structure excavations is critical for safety, and it is important for SC personnel to have all necessary authorized submittals required for worker and facility protection prior to the start of structure excavation work.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 19-3.03K, Ground Anchor and Soil Nail Walls, that this BCM is based on as identified in the title block above. The information included in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Authorized shop drawings for ground anchor and soil nail wall excavations
2. Authorized soil stability test as performed per Contract Specifications, Section 19-3.01D(2), Earthwork – General – Quality Assurance – Stability Test for Ground Anchor and Soil Nail Walls

3. Record of Underground Service Alert Ticket

**Procedure**

1. All work associated with this process is charged as Project Direct Construction.

2. Inspection of field work for this process is:
   a. **Intermittent** for ground anchor and soil nail wall excavation.

3. Before construction begins:
   a. Review the authorized contractor submittals, such as excavation shop drawings and soil stability test results, when applicable.
   b. Review the contract documents, and the Foundation Manual, Appendix K-6, Ground Anchor Wall Construction Checklist, Section VIII. Construction, and Appendix K-7, Soil Nail Wall Construction Checklist (as applicable).
   c. Place copies of the checklists above in the field book for reference during wall construction operations.
   d. Discuss the following with the contractor, the:
      i. Excavation safety and contractor’s responsibility to protect employees in excavations per Cal/OSHA Title 8 of the California Code of Regulations.
      ii. Requirement for underground service alert and providing record of notice.
      iv. Contractor’s competent person name and discuss required inspections per Cal/OSHA CSO § 1541, General Requirements.
      v. Contingency plans for stabilization of unstable excavation face and procedures for review and authorization of remedial measures.

4. During construction:
   a. Verify that the contractor is following authorized shop drawings for ground anchor and soil nail wall excavations and the requirements of the contract documents.
   b. Utilize the Foundation Manual, Appendix K-6, Ground Anchor Wall Construction Checklist, Section VIII. Construction, or Appendix K-7, Soil Nail Wall Construction Checklist, as applicable.
c. Visually observe excavated face and slopes for stability. Document observation in the Daily Report. Be aware that instability can occur at any time during wall construction:

   i. The conditions below may contribute to instability:
      1. Water at the wall face/visible seepage
      2. Vibration caused by nearby activities (pile driving, train, etc.)
      3. Soil layers sloping (dipping) into the excavation

   ii. If the exposed excavated face does not maintain its integrity:
      1. Immediately notify the contractor and the Structure Representative (SR) if there is observed instability. Stop construction in unstable areas and direct the contractor to stabilize the excavation face. Use the authorized contingency plan if applicable.
      2. Discuss conditions with the contractor and the SR:
         a. The SR may request additional assistance from Geotechnical Services Geoprofessional to confirm conditions and discuss findings with the contractor.
         b. Discuss with the contractor whether modifications to the authorized excavation submittals will need to be made; including additional soil stability tests and submit for engineer’s review.
      3. Discuss with the contractor whether modifications to the authorized excavation submittals will need to be made; including additional soil stability tests and submit for engineer’s review.

   iii. If the observed soil conditions of the excavated face and slope appear to be better than those assumed by the authorized shop drawings:
      1. Discuss conditions with the contractor and the SR:
         a. The SR may request additional assistance from Geotech to confirm conditions and discuss findings with the contractor.
      2. The contractor may submit for review revisions to the authorized shop drawings to take advantage of the observed conditions.

   d. Document all inspection, construction, and quality assurance activities in the Daily Reports per BCM C-7, Daily and Weekly Reports.
   e. File all project documentation (correspondence, materials acceptance documentation, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

Daily Reports
Attachments

None
Earthwork – Rock Excavation

Revision and Approval

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<td>01-21-2022</td>
<td>Original Issue</td>
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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, materials, and construction for presplitting, blasting, and controlled blasting of excavation in rock.

When rock excavation is performed as part of Roadway Excavation and Structure Excavation, SC assists the Resident Engineer with the review and authorization of submittals, quality assurance, materials, and construction for the structure portion of the work.

Structure excavation performed under this process is typically accomplished using controlled blasting.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 19-4, Earthwork – Rock Excavation, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Contract work that requires rock excavation

2. Submittals required by the Contract Specifications for controlled blasting (including, but not limited to qualifications for the blaster-in-charge, blast monitoring consultant, and blasting consultant, which are part of the contractor's Quality Control (QC) responsibilities.)
Procedure

1. All work associated with this process is charged as Project Direct-Construction.

2. Inspection of field work for this process is:
   a. **Intermittent** for drilling holes and other preparatory pre-blast work.
   b. **Continuous** for setting charges and blasting.

3. Before construction begins:
   a. At the preconstruction conference, discuss contractor’s proposal for controlled blasting.
   b. Following the preconstruction conference, coordinate with the Resident Engineer to determine if planned blasting affects SC item work, and determine coverage of the blasting as follows:
      i. If blasting involves structures work, SC Staff will review and authorize (or reject for resubmittal) the submittals for controlled blasting and perform inspection and record keeping of the blasting operations.
      ii. If blasting involves District work, coordinate with the Resident Engineer to determine who will be responsible for work coverage as described above (SC or District) and document the agreements in the Division of Work Memo per **BCM C-3.04**, *Division of Project Work*.

   c. Review and authorize (or reject for resubmittal) the following required submittals before controlled blasting begins:
      i. **Blasting safety plan:**
         1. Required for all proposed controlled blasting operations. One blasting safety plan may be appropriate for each controlled blast. The blasting safety plan must clearly specify if it is used for each controlled blast.
         2. Coordinate review with the District Construction Safety Coordinator (CSC).
         4. Verify compliance with all applicable Construction Safety Orders as well as *Construction Manual*, Section 4-1902B, *Blasting*.

   ii. **Controlled Blasting Plan and Preblast Survey:**
      1. Required for each controlled blast.
         a. An updated Preblast Survey is required if blasting activities are suspended for 45 days or more.
2. Coordinate review with GS Geoprofessional and District CSC. Verify that proposed blasting will not adversely affect structure foundation materials.

3. Verify compliance with all applicable Construction Safety Orders as well as Construction Manual Section 4-1902B, Blasting.

d. Verify that the contractor provides written notice to the occupants of nearby buildings as required by the contract documents.

4. During construction:
   a. Review authorized controlled blasting submittals.
   b. Document that the contractor provides written notice (7 days minimum) to the occupants of nearby buildings.
   c. Conduct pre-blast meeting(s) and review blasting operations and safety protocols. The blaster-in-charge controls the jobsite during all controlled blasting operations.
      i. Do not perform blasts within 1,200 feet of concrete placed within the previous 72 hours.
   d. Monitor controlled blasting operations for conformance to authorized submittals. If determined for any reason that a dispute or potential claim might occur due to blasting operations, take video recording(s) of blast(s).
   e. Notify the Resident Engineer and stakeholders and be prepared to act to secure the jobsite and surrounding areas in the event of a misfire.
   f. If the blasting causes flyrock, suspend blasting activities and ensure the contractor submits a revised controlled blasting plan as required by the contract documents.
   g. SC/CT to perform our own independent video of blast. The Public Information Officer will normally perform this when requested.
   h. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.
      i. After each blasting activity review the post-blast report submittal which is required within 48 hours for each controlled blast:
         i. The post-blast report includes the vibration and noise monitoring reports, and the blasting complaint reports and the contractor’s video of blast.
         ii. Verify compliance with authorized blasting safety plan and Controlled Blasting Plan.
         iii. If necessary, ensure revision and resubmittal of blasting safety plan and/or controlled blasting plan to address issues identified in post-blast reports.
5. Following construction:
   a. Review post-blasting submittals:
      i. The post-blast survey, which is required within 15 days after completing
         blasting activities.
      ii. Video submitted along with Post-blast Survey Recordings

6. File all Controlled Blasting submittals and Daily Reports in the appropriate
category in the project records as specified in the Construction Manual, 5-102,
Organization of Project Documents.

**Process Outputs**

1. Authorized controlled blasting submittals
2. Documented Post-blast Reports (from the contractor)
3. Daily Reports

**Attachments**

None
Earthwork – Embankment Construction – Settlement Periods and Surcharges

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<td>Original Issue</td>
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Background

This process establishes Structure Construction (SC) responsibilities and procedures for monitoring settlement periods and surcharges, including the installation of settlement monitoring devices.

Settlement periods and surcharges are established in the contract documents but can be lengthened or shortened by SC staff as needed. Settlement monitoring devices are generally required in the contract documents when anticipated settlements are large. If settlement monitoring devices are not required but are needed; they should be ordered by the engineer as change order work.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the contract specifications 19-6.03D, Earthwork – Embankment Construction – Settlement Periods and Surcharges, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Project Supplemental Information: Information Handout
2. R.E. Pending File
3. Foundation Manual; Chapter 4, Footing Foundations, Section 5, Ground Improvement/Soil Modification
Procedure

1. All work associated with this process is charged as: Project-Direct – Construction

2. Inspection of field work for this process is:
   a. Intermittent during platform installation.
   b. Benchmark during settlement period.

3. Before embankment construction begins:
   a. Review contract documents, R.E. pending file, the Geotechnical Design Report and/or the Final Foundation Report, which includes foundation recommendations, settlement requirements, and the Geotechnical Services contact:
      i. If settlement monitoring devices are not specified in the contract’s Special Provisions, confirm with the geotechnical designer that settlement monitoring devices are not needed.
      ii. When settlement monitoring devices are specified, inform the geotechnical designer that the project has started and the schedule for the monitoring devices:
         1. If large settlements are expected, consideration for its potential effect on nearby (adjacent) infrastructure should be evaluated; i.e. damage to existing or new construction. Discuss this with the geotechnical designer.
   b. Discuss with the contractor the placement and requirement to not disturb the settlement hubs:
      i. If the settlement hubs or settlement platform is damaged or disturbed it must be remedied promptly. The settlement period may need to be extended for the time between the last measurement and the reestablishment of the monitoring.
   c. Discuss required embankment construction restrictions, settlement period, surcharges (if applicable), and required settlement monitoring devices with the contractor.
   d. When settlement monitoring devices not specified in the contract are ordered, issue a change order for settlement platform construction in a timely manner.

4. During embankment construction:
   a. Coordinate with District Survey Branch, if necessary, to establish settlement hubs and a bench mark sufficiently away from the work to be unaffected by the embankment settlement.
b. Coordinate installation of settlement monitoring devices, if required, with the Foundation Testing and Instrumentation Branch and the contractor according to California Test (CT) 112, Method for Installation and Use of Embankment Settlement Devices.

5. During embankment settlement period:
   a. As soon as the embankment (and surcharge, if applicable) is complete, install settlement monitoring hubs. Usually, four (4) hubs is enough but larger than standard areas require additional hubs.
   b. Verify that the contractor installed protection for monitoring the settlement hubs and equipment. Regularly check that they are not disturbed.
   c. Record settlement accurately at prescribed intervals to monitor progress and provide information to the geotechnical designer:
      i. When settlement monitoring devices are used, record and monitor per CT 112 for settlement monitoring devices.
   d. Coordinate with the geotechnical designer to determine when the settlement period is complete:
      i. Notify the contractor in writing immediately:
      ii. When settlement monitoring data indicates the period should be extended, notify the contractor in writing immediately when the decision is made.
      iii. Notify the RE of settlement period completion and changes for coordination with the contractor’s Critical Path Method updates.
   e. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

6. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual 5-102, Organization of Project Documents.

7. For additional information, refer to the Foundation Manual, Chapter 4, Footing Foundations, Section 4-5, Ground Improvement/Soil Modification.

**Process Outputs**

1. Record of settlement device readings
2. Letter(s) to the contractor
3. Change Order for settlement platform installation if needed
4. Daily Reports
Attachments

None
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## Memo No | Issue Date | Title
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20-2.13 | 04/30/2021 | Landscape – Irrigation – Supply Line on Structures |
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Landscape – Irrigation – Supply Line on Structures

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for authorization of submittals, quality assurance, materials, and construction of water supply lines through bridges and on the exterior of concrete structures.

Review and installation of water supply lines is generally administered by the Resident Engineer. SC staff assist the Resident Engineer with field inspection as agreed upon when water supply lines run through bridges or are to be attached to concrete structures, pipe casing installation, welding, flexible expansion connectors, payment and coordination with Buy America requirements. SC verifies the hangers and brackets that attach the water supply line to the structure are consistent with contract requirements and that the structure is not damaged during the installation. Water supply line connections at abutments and hinges deserve special attention as flexible joints present more risk to water supply line integrity.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 20-2.13, Landscape – Irrigation – Supply Line on Structures, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Water supply line submittals including:
a. Submittal for temporary casing supports at abutments
b. Submittal for hanger details for permanent water line attachments on bridge concrete surfaces
c. Submittal of manufacturer data for material incorporated in work

**Procedure**

1. All work associated with this process is charged as [Project-Direct – Construction](#).
2. Inspection of field work for this process is:
   a. [Intermittent for installation of the water supply line](#).
3. Before construction begins:
   a. Review the:
      i. Contract documents to verify the details are constructable on the exterior of the structure or through it.
      ii. As-built plans and field conditions for conflicts. See [Attachment 1](#), *[Potential Issues to Look for When Reviewing As-Built Drawings and Field Conditions](#)*.
   b. Discuss with the RE the installation work schedule.
   c. Consult with the District Landscape Architect (as needed).
   d. Verify that material submittals meet specified material requirements and the Buy America requirement.
   e. Authorize or reject submittals by notifying the contractor in writing including:
      i. For welded steel casing, the SR authorizes shop drawings for the temporary support of casings at the abutments per Standard Specifications (SS) 20-2.13A(2)(c), *Landscape – Supply Line on Structures – Materials – Installation*, and BCM 70-7, *Miscellaneous Drainage Facilities – Casings for Bridges*.
      ii. Collaborate with the Structure Designer and District Landscape Architect for review and authorization of the submittal for:
         1. More than 4 Inch supply line through the Structure Design Documents Unit.
         2. Less than 4-inch supply line the review is by SC field personnel.
      iii. Update the project submittal log.
   f. Prior to installation, review the *Construction Manual*, Section 6-2, *Acceptance of Manufactured or Fabricated Materials and Products*, to determine if
materials are released by Materials Engineering and Testing Services (METS) or field released by SC. If field released:

i. Materials are accepted by Certificate of Compliance.

ii. Materials accepted are on Authorized Material List.

4. During construction:

a. Verify work is completed in accordance with the contract documents, authorized submittals, and manufacturer’s recommendations.

b. Verify flexible connections are installed per plans and are functional.

c. Prior to placing concrete, verify:

i. Water supply line pipe hanger attachments for alignment and consistency with the requirements of the contract documents.

ii. Pipe casings are installed in abutments and bent caps in accordance with the contract documents.

d. For existing structures:

i. Verify no damage to reinforcement or prestressing from water supply line pipe hanger bracket anchors.

ii. Verify drilling will not damage the structure.

e. Prior to accepting work:

i. Verify passing pressure test; consider:
   1. Contacting the District Landscape Architect for assistance (as needed).
   2. Early pressure testing, which is recommended in case leak repair is needed.

f. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the daily reports per BCM C-4.04, Daily and Weekly Reports.

g. Record any changes to the as-built plans.

h. File Certificate of Compliance for field released material with Form CEM-4102, Materials Inspected and Released on Job.

5. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual 5-102, Organization of Project Documents.
Process Outputs

1. Authorized submittals
2. Materials certification documentation
3. Daily Reports
4. As-built plans

Attachments

Attachment 1, Potential Issues to Look for When Reviewing As-Built Drawings and Field Conditions
Potential Issues to Look for When Reviewing As-Built Drawings and Field Conditions

Review as-built drawings and field conditions for conflicts. Examples of conflicts to identify are as follows:

1. For post tensioning:
   a. Take note of the path of prestress tendons in existing bridges for conflict with any connections to be drilled into existing girders.

2. For clearance to bridge mounted signs:
   a. Be aware of any bridge mounted signs and make sure the layout for the supply line allows for adequate space for mounting hardware and clearance to avoid any reduction of visibility and vertical clearance for signage.

3. For intermediate diaphragms:
   a. Note the existence of any intermediate diaphragms on existing bridges that can interfere with the layout of the supply line.

4. For existing bridges with a shallow superstructure:
   a. Be aware of how a shallow superstructure depth can limit space for both the layout as well as required edge distances for mounting hardware.

5. For field quality of existing concrete:
   a. Inspect the bridge in the field to assess the quality of the concrete to which the supply line will be attached. The quality and age of the concrete can greatly affect the effectiveness of mounting hardware. Low quality/very old concrete can spall unexpectedly when drilled into.
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Ground Anchors and Soil Nails – General

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of general submittals for ground anchor and soil nail walls.

This process also includes research investigation when required by the contract documents.

Review and authorization of shop drawings for ground anchor walls are coordinated with Structure Design per MTD 5-14, Review of Shop Drawings for Ground Anchors.

Review and authorization of shop drawings for soil nail walls are coordinated with Structure Design per MTD 5-18, Attachment A, Soil Nail Working Drawings Review Process.

Test data submittals are required for all performance and proof-tested ground anchors, and all verification, proof, and supplemental-tested soil nails. Specific load testing procedures are in BCM 46-2, Ground Anchors, and BCM 46-3, Soil Nails.

Process Inputs

1. Contractor submittals:
   a. Shop drawings for ground anchors and soil nails:
      i. Test data
      ii. Grout mix design
      iii. Certified calibration charts for each jack and gauge
   b. Shop Drawings for ground anchor and soil nail wall excavations
   c. Form CEM 3101, Notice of Materials to be Used
d. Storm Water Pollution Prevention Plan (SWPPP) or Water Pollution Control Program (WPCP)

e. Test samples for strand coating and encapsulation corrosion-inhibiting grease

**Procedure**

1. All work associated with this process is charged as [Project-Direct – Construction](#).

2. Inspection of field work for this process is:
   a. **Benchmark** for review and authorization of submittals.

3. Before construction begins:
   a. Discuss steps for submission, review, and authorization of ground anchor or soil nail shop drawings with the Contractor.
   b. Verify the Contractor submitted shop drawings to the Structure Design (SD), Documents Unit.
   c. Coordinate ground anchor and soil nail shop drawing review responsibilities with the Designer:
      i. For ground anchors, review [MTD 5-14, Review of Shop Drawings for Ground Anchors](#).
      ii. For soil nails, review [MTD 5-18, Attachment A, Soil Nail Working Drawings Review Process](#).
   d. Check status of submitted shop drawings using [Tracker Web](#).
   e. Receive unchecked shop drawings from the Documents Unit.
   f. Review unchecked shop drawings and provide comments to the Designer:
      i. See [Foundation Manual, Section 11-2, Sub Horizontal Ground Anchors](#), and [Section 11-5, Soil Nails](#).
      ii. See [Foundation Manual, Appendix K-6, Ground Anchor Wall Construction Checklist](#), and [Appendix K-7, Soil Nail Wall Construction Checklist](#).
   g. Receive authorization or rejection of shop drawings from SD Document Unit, notify the Contractor in writing.
   h. Review [Form CEM-3101, Notice of Materials to be Used](#). Ensure all Soil Nail/ Ground Anchor materials are listed. Notify the Contractor of discrepancies.
   i. Review Storm Water Pollution Prevention Plan (SWPPP) or Water Pollution Control Program (WPCP) for grout control and drilling dust containment.
   j. When research investigation is specified, coordinate:
      i. Research equipment installation procedures with the Division of Engineering Services (DES) Design team and the Contractor.
4. During construction:
   a. For load testing, review test data submitted for each completed ground anchor or soil
      nail test as work progresses.
   b. For revised shop drawings, see step 3 above.
   c. Document all inspections, construction, and quality assurance activities in the Daily
      Reports per BCM C-4.04, Daily and Weekly Reports.

5. Following construction:
   a. File all submittals in the project records as specified in the Construction Manual.
   b. Record information necessary for Final Completion Records:
      i. Any As-built changes
      ii. Project Final Report

**Process Outputs**

1. Authorized shop drawings
2. Installed research equipment
3. Daily Reports
4. Project Final Records

**Attachments**

None
Ground Anchors

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of quality assurance testing, materials, and construction of ground anchors.

Review and authorization of specific submittals for ground anchors is usually performed in conjunction with the general submittals identified in BCM 46-1, Ground Anchors and Soil Nails – General.

Process Inputs

1. Authorized shop drawings per BCM 46-1, Ground Anchors and Soil Nails – General.
2. Revised shop drawings when necessary

Procedure

1. All work associated with this process is charged as Project-Direct – Construction.
2. Inspection of field work for this process is:
   a. Intermittent for Material Field release.
   b. Intermittent for drilling holes for ground anchors.
   c. Continuous for insertion, and grouting of ground anchors.
3. Before construction begins:
   a. Review authorized shop drawings.
   b. Coordinate material inspection for ground anchor with Materials Engineering and Testing Services (METS):
c. Coordinate a pre-operation meeting with the Contractor to discuss the construction of ground anchors. Consider inviting the METS Representative, Geotechnical Engineer, and Structure Design Engineer to the pre-operation meeting.

d. Verify the Contractor submitted certified calibration chart for each jack and gauge system proposed for use by the Contractor.

e. Review *Foundation Manual, Section 11-2, Sub Horizontal Ground Anchors.*


4. During construction:

a. Verify construction methods are in accordance with contract documents:
   i. Water and grout control methods
   ii. Drilling methods and contingencies for caving and hard drilling.
   iii. Ground anchor or soil nail installation methods:
      1. Use of centralizers
      2. Installation adjacent to traffic if applicable
      3. Grouting methods and contingencies for secondary grouting

b. Verify ground anchor materials delivered to the job site have been released for construction:
   i. Match orange tags to *Form TL-29, Report of Inspection of Material.*

c. For load testing:
   i. Review certified calibration chart for each jack and gauge system proposed for use by the Contractor and verify contract requirements are met.
   ii. Verify jacking equipment and movement measuring system are stable.
   iii. Verify load increments are held for the specified time frames and measurements taken per the requirements of the contract documents.
   iv. Request and review test data in accordance with the requirements of the contract documents.

d. Accept or reject ground anchors based on the results of load testing:
   i. For rejected ground anchors, do not allow a retest until post-grouting has been performed.
   ii. For rejected ground anchors where post-grouting does not result in a passing load test, consult the Structure Design Engineer and Geotechnical Engineer for possible solutions.
e.  When research investigation is specified, coordinate research equipment installation with the Contractor’s operations.

f.  Document all inspections, construction, and quality assurance activities in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

5.  Following construction:

   a.  File all submittals in the project records as specified in the Construction Manual.

   b.  Record information necessary for Final Completion Records:

       i.  Any As-built changes

       ii.  Project Final Report

**Process Outputs**

1.  As-built shop drawings

2.  Reports and testing results for accepted Ground Anchors (material and function)

3.  Daily Reports

4.  Project Final Records

**Attachments**

None
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Soil Nails

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of quality assurance testing, materials, and construction of soil nails.

Review and authorization of specific submittals for soil nails is usually performed in conjunction with the general submittals identified in BCM 46-1, Ground Anchors and Soil Nails – General.

Process Inputs

1. Authorized shop drawings per BCM 46-1, Ground Anchors and Soil Nails – General
2. Test boring report and revised shop drawings when necessary

Procedure

1. All work associated with this process is charged as Project-Direct – Construction.
2. Inspection of field work for this process is:
   a. Intermittent for Material Field release.
   b. Intermittent for drilling holes for soil nails.
   c. Continuous for insertion, and grouting of soil nails.
3. Before construction begins:
   a. Review authorized shop drawings.
   b. Coordinate material inspection for soil nails with Materials Engineering and Testing Services (METS).
c. Coordinate a pre-operation meeting with the Contractor to discuss the construction of soil nails. Consider inviting the METS Representative, Geotechnical Engineer, and Structure Design Engineer to the pre-operation meeting.

d. Verify the Contractor submitted a certified calibration chart for each jack and gauge system proposed for use.


4. During construction:

a. Verify construction methods are in accordance with contract documents:
   i. Water and grout control methods
   ii. Drilling methods and contingencies for caving and hard drilling
   iii. Ground anchor or soil nail installation methods:
      1. Use of centralizers
      2. Installation adjacent to traffic if applicable
      3. Grouting methods and contingencies for secondary grouting

b. Verify soil nail materials delivered to the job site have been released for construction:
   i. Match orange tags to *Form TL-29, Report of Inspection of Material.*

c. For load testing:
   i. Review certified calibration chart for each jack and gauge system proposed for use by the Contractor and verify contract requirements are met.
   ii. Verify jacking equipment and movement measuring system are stable.
   iii. Verify load increments are held for the specified time frames and measurements taken per the requirements of the contract documents.
   iv. Request and review test data in accordance with the requirements of the contract documents.

d. Accept or reject soil nails based on the results of load testing:
   i. For soil nails rejected during verification testing:
      1. Consult with the designers to determine the cause of failure.
      2. If the cause of failure is the Contractor’s installation methods, require revised shop drawings per the requirements of the contract documents.
      3. If the cause of failure is inadequate length of the soil nail, write a Change Order to:
         a. Revise soil nail lengths or design pullout resistance values.
b. Require horizontal borings and test boring report submittal.

ii. For soil nails rejected during proof testing:
   1. Require revised shop drawings per the requirements of the contract documents.

iii. For soil nails rejected during supplemental testing:
   1. Apply the deduction specified in the contract documents to the soil nails represented by the supplemental test.

iv. For pullout failure, the Contractor must submit the pullout failure load with test data.

e. Document all inspection, construction, and quality assurance activities in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

5. Following construction:
   a. File all submittals in the project records as specified in the Construction Manual.
   b. Record information necessary for Final Completion Records:
      i. Any As-built changes
      ii. Project Final Report

**Process Outputs**

1. Reports and testing results for accepted soil nails (material & function)
2. Contract Change Order when specified
3. Daily Reports

**Attachments**

None
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**MEMO NO | ISSUE DATE | TITLE**
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47-2 | 12/20/2018 | Earth Retaining Systems – Mechanically Stabilized Embankment |
47-6 | 12/20/2018 | Earth Retaining Systems – Alternative Earth Retaining Systems |
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Earth Retaining Systems – Mechanically Stabilized Embankment

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Background

This process establishes Structure Construction (SC) responsibilities and procedures to administer mechanically stabilized embankments (MSE), including:

1. Review and authorization of submittals.
3. Quality assurance during construction.

This process applies to MSE. The contract documents may permit the Contractor to propose use of an alternative earth retaining system instead of the MSE shown in the contract documents. If the Contractor proposes to use an alternative earth retaining system, refer to the Standard Specifications (SS)\(^1\).

Process Inputs

1. Shop Drawings.
2. Foundation Report.
3. Test Data for button head wire couplers.
5. Excavation plans, if needed.

Procedure

1. All work associated with this process is charged as Project-Direct – Construction.

\(^1\) 2018 SS, Section 47-6, Earth Retaining Systems – Alternative Earth Retaining Systems.
2. Inspection of field work for this process is:
   a. Intermittent for placement of leveling pads, soil reinforcement, filter fabric, face panels, and structure backfill.

3. Before construction begins:
   a. Review MSE submittals. Request assistance from Structure Designer, Geotechnical Services and METS if necessary.
   b. Review the layout plans and verify the top of wall elevations versus the District grid grades, drainage plans, and underground utility plans. Verify the locations of the soil reinforcement to ensure no conflict with utilities.
   c. Review Construction Considerations section of the Foundation Report and contact report author if there are any questions or unusual geotechnical requirements, such as settlement monitoring, surcharge, etc.
   d. Check contract documents for Surcharge Loading and monitoring requirements.
   e. Set up a pre-construction meeting with the Contractor to discuss MSE construction. Invite representatives from METS, Structure Design (SD), Geotechnical Services, MSE wall specialist, District Construction, and the Materials Lab as needed.
   f. Review and authorize the final texture of the sample facing panel and concrete mix design. The sample panel must be stored for later comparison to the finished product.
   g. Remind the Contractor to submit the construction staking request for the wall layout line, beginning of the wall, end of the wall, and respective elevations. Coordinate review of District related items with the Resident Engineer (RE).
   h. Confirm with the Contractor the schedule of material procurement and sampling.
   i. Review and authorize the erection procedures. Confirm with the Contractor on adequate equipment to lift and set panels.
   j. Review and authorize the excavation plan, if required. See BCM 7-1.02K(6)(b), Legal Relations and Responsibility to the Public – Occupational Safety and Health Standards – Excavation Safety.

4. During construction:
   a. Verify sloping or shoring installation if required.
   b. Provide QA to verify that the leveling pad is constructed properly. Verify the wall layout line (LOL) is per plan.
   c. Verify proper material storage and handling. Geosynthetic reinforcement, polyurethane foam, and filter fabric must be stored away from sunlight.
   d. Upon delivery of materials onsite:
      i. Check for inspection release tags (Form TL-0624, Inspection Release Tag) and match with Form TL-0029, Report of Inspection of Material.
ii. Take photos of release tags that are applied directly onto the system elements, such as, stenciled on panels or etched into concrete block.

iii. Document quantities.

iv. Check for Certificates of Compliance and Buy America Certification.

v. Check for damage incurred during the delivery and request a repair plan from the contractor as needed.

e. Verify proper material storage and handling. Geosynthetic reinforcement, polyurethane foam, and filter fabric must be stored away from sunlight.

f. Sample and test the backfill material for gradation and quality requirements listed in the contract documents. The District Materials Laboratory typically performs gradation, plasticity index (PI), and sand equivalent (SE) tests. Corrosive tests (i.e., chlorides, sulfates, and resistivity) are performed by the Sacramento METS Laboratory. Obtain a copy of test results from the RE.

g. Inspect all materials incorporated into the work prior to placement. Once constructed, it is difficult to remove and replace. Check concrete elements for cracks, spalls, surface irregularities, dimensions, and misaligned connections. Check for broken (popped) welds or damage to the galvanized coating on the metallic elements. Check for damage and correct alignment of the machine direction of geosynthetic reinforcement.

h. Verify the vertical wall layout line (LOL) is referenced and at the right batter to account for the backfill displacement. Monitor wall alignment and vertical displacement. Check against Standard Specifications\(^2\) and the authorized drawings and notify the Contractor promptly so timely corrections are made.

i. Verify all joints are protected with engineering filter fabrics prior to backfilling.

j. Verify the Contractor installs the drainage system, if required, per plan before backfilling. Coordinate with the RE.

k. Coordinate QA backfill and compaction testing with the District Materials Lab.

l. Verify that backfilling is done with proper equipment to avoid damage to the panels:

   i. Do not allow sheepsfoot rollers for compaction of select granular backfill within the limits of the soil reinforcement. Handheld or hand-guided compacting equipment must be used within three feet of the facing panels.

m. Verify facing layout is in proper configuration and at proper spacing prior to backfilling. Verify bearing pads in vertical panel joints or space bars are placed between two adjacent panels to maintain the spacing of the interlocked panels.

n. Verify the Contractor correctly connects and uses the correct configuration of soil
reinforcement to the facing. The soil reinforcement may vary throughout the length of
the wall. It is of utmost importance that the panel type and soil reinforcement
coincide with the requirements shown on the authorized plans.

o. Verify soil reinforcement is placed in the proper alignment and on the level surface,
2-inches higher to avoid down drag by the compaction of the backfill.
   i. Soil reinforcement must be installed perpendicular to the back of the panel, unless
      otherwise noted.
   ii. Verify the condition of the soil reinforcement and tension prior to backfilling.
   iii. Verify top layer of soil reinforcement is aligned with the profile grade of the top
        of panels, and when necessary slopes down to avoid a negative super elevation.

p. Verify that all inspection wires are in place according to the contract documents:
   i. Verify the locations of wires are centered in the opening of the panels.
   ii. Verify that the threaded ends of the wires are clean and covered per details.
   iii. Verify that the panel openings are completed with caps or fill per details.

q. Verify the Contractor grades the backfill to slope away from the wall face at the end
   of each shift to keep surface run off away from the panels if a significant rain event is
   anticipated. Surface water, if not controlled, will migrate the fines from the structure
   backfill into the pervious material, possibly causing excessive backfill settlement.

r. Confirm top of wall profile elevations match the cross section and super elevations of
   the roadway section. Do not allow the Contractor to drive equipment directly on soil
   reinforcement.

s. Once any anticipated settlement is complete, the concrete coping can be formed and
   placed.

t. Verify all reinforcing steel for the coping, and the slab and barrier when required
   before concrete placement.

u. If the Contractor elects to form coping or barrier slabs by attaching the formwork
   (including, for example, overhang braces) to MSE panels, request the contractor to
   submit forming plans that show their form system in detail, including calculations,
   signed by an engineer registered in California.
   i. Verify that the Contractor has obtained MSE wall designer’s concurrence to
      attach formwork.
   ii. Verify that the form attachment to the MSE panels has adequate bearing capacity.
   iii. Do not allow installation of supporting bolts through the panel joints. There have
        been instances where the overhang forms collapsed because there is not enough
        bearing area to support the load.
v. Document all inspection, construction, and quality assurance activities in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

5. Following Construction:
   a. File all submittals in the project records as specified in the Construction Manual.
   b. Record information necessary for Required Documents:
      i. Any as-built changes.

**Process Outputs**

1. Authorized test reports.
2. Written notification of submittal authorization.
3. Daily Reports.

**Attachments**

*Attachment 1*, Mechanically Stabilized Embankment Retaining Wall Construction Checklist.
Mechanically Stabilized Embankment
Construction Checklist

I. SOURCES OF INFORMATION

- *Bridge Design Specifications*, Section 5, *Retaining Walls*.
- *Bridge Design Aids* – Chapter 3-8, *Mechanically Stabilized Embankments*.
- Earth Retaining Systems Committee web page at https://des.onramp.dot.ca.gov/structure-policy-innovation/earth-retaining-systems

II. PROPRIETARY EARTH RETAINING SYSTEMS

The contract Special Provisions usually gives the contractor the option of choosing one of the proprietary systems listed in the Department’s current list of pre-qualified earth retaining systems. These systems are alternatives to the fully detailed State system shown on the contract plans. The pre-qualified list can be accessed from the SC home page under “Field Resources.”

III. POTENTIAL PROBLEMS

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<tr>
<td><strong>Wall Distortion:</strong></td>
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<tr>
<td>• Differential settlement that causes panels to contact each other resulting in chipping or spalling.</td>
<td>• Weak or improper bearing material.</td>
</tr>
<tr>
<td>• Low spot in the wall profile.</td>
<td>• Inadequate compaction and/or poor-quality foundation material.</td>
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<td>• Overall wall leaning.</td>
<td>• Leveling pad not constructed per the tolerances specified in the approved shop plans.</td>
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<tr>
<td><strong>Wall Leaning Out (away from backfill).</strong></td>
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</tr>
<tr>
<td>• Backfill material pushed against back of wall before being compacted on the strips.</td>
<td>• Panels not battered sufficiently.</td>
</tr>
<tr>
<td>• Excessive or vibratory compaction on uniform fine sand (more than 60% passing a No. 40 sieve).</td>
<td>• Large backfill placing and/or compaction equipment working within the 3’ zone from the back of the wall.</td>
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<td>• Backfill material dumped too close to the free end of reinforcing strips, then spread towards back of wall, causing bulge in strips and pushing panels out.</td>
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<tr>
<td>Observation</td>
<td>Potential Cause</td>
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<tr>
<td>Wall Leaning In (towards backfill).</td>
<td>• Excessive batter set in panels for select granular backfill material being used.</td>
</tr>
<tr>
<td></td>
<td>• Inadequate compaction of backfill.</td>
</tr>
<tr>
<td></td>
<td>• Panels excessively battered.</td>
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<tr>
<td></td>
<td>• Improper Compaction of lower backfill levels.</td>
</tr>
<tr>
<td></td>
<td>• Settlement of the original ground behind the wall.</td>
</tr>
<tr>
<td>Localized differential distortion between adjacent panels that causes points of inflection and excessively wide joints.</td>
<td>• Adjacent panels set at different battered angles.</td>
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Earth Retaining Systems – Alternative Earth Retaining Systems

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Background

This process establishes Structure Construction (SC) responsibilities and procedures to administer Alternative Earth Retaining Systems (AERS), including:

1. Review and authorization of submittals.
3. Quality assurance during construction.

Alternative earth retaining systems (AERS) are listed on the Authorized Material List (AML), and may be used when specified in the contract documents. Shop drawings for alternative earth retaining systems are reviewed and authorized by the Designer. SC staff and the Earth Retaining Systems technical specialist in Structure Policy and Innovation (SP&I) assist with the review as described in MTD 5-16, Review of Working Drawings for Proprietary Earth Retaining Systems.

The AERS shall comply with contract documents specific to the type of AERS submitted:


Process Inputs

1. AERS submittals and shop drawings.
2. Foundation Report.
4. Excavation plans, if needed.

**Procedure**

1. All work associated with this process is charged as [Project-Direct – Construction](#).
2. Inspection of field work for this process is:
   a. Intermittent.
3. Before construction begins:
   a. Verify that the Contractor submits the alternative earth retaining systems (AERS) shop drawings to Structure Design (SD) Document Unit.
      i. Only one type of wall shall be used at each wall location.
      ii. Shop drawings shall include the manufacturer’s installation manual, system specific information such as design parameters, materials notes, construction procedures, erection sequencing, tensioning or spacing details, etc.
      iii. When the submitted shop drawings are authorized with minor corrections, ensure that the Contractor incorporates the minor corrections into the final construction.
   b. For technical assistance during AERS shop drawing review and construction may be provided by:
      i. Structure Designer.
      ii. METS Representative.
      iii. DES Structure Policy & Innovation – MSE Senior Technical Specialist.
      iv. Geotechnical Services.
      v. Manufacturer Representative.
   c. Coordinate with RE:
      i. Notify RE Documents Unit may mail authorized Shop Drawings to RE.
      ii. Request RE review shop drawings for conflicts with roadway plans, utilities, drainage, etc.
      iii. Request RE forward all AERS related District QA testing to SR.
   d. SR will review the AERS shop drawings:
      i. Verify proposed system is authorized for use.
      ii. Review Standard Specification:


   iv. Review Construction Considerations Section of the Foundation Report and contact report author if there are any questions or unusual geotechnical requirements, such as settlement monitoring, surcharge, etc.


   vi. Verify top of wall elevations versus the district grid grades, drainage plans, and underground utility plans. Coordinate review of district related items with RE.

   vii. Verify the locations of structural elements for any potential conflict with utilities. Coordinate review of district related items with RE.

   viii. Verify the bottom of facing elevations are at or below the project plans.

   ix. Provide shop drawing review comments to Structure Designer. The Structure Designer Authorizes shop drawings.

   e. Receive rejection or authorization of the AERS shop drawings from the Documents Unit. Document Unit forwards authorization/rejection to contractor. Verify Contractor was notified.

   f. Set up a pre-construction meeting with the Contractor to discuss Alternative ERS construction. Invite representatives from METS, SD, Geotechnical Services, ERS specialist, District Construction, and Materials Lab. Remind Contractor of requirement for onsite Qualified Manufacturers Representative during first 10 vertical feet of erection and backfill and submittal of Form 3101, *Notice of Materials to be Used*.

   g. Remind the Contractor to submit the construction staking request for the authorized system, including: wall layout line, beginning of wall, end of wall, and respective elevations.

   h. Confirm with the Contractor the schedule of material procurement and sampling.

   i. Review and authorize the final texture of the sample facing panel and concrete mix design. The sample panel must be stored for later comparison to the finished product.

   j. Review and authorize the erection procedures. Confirm with the Contractor on adequate equipment to lift and set panels.

4. During construction:
a. Meet and work with the qualified representative of the alternative system manufacturer
b. Upon delivery of materials onsite:
   i. Check for inspection release tags (Form TL-0624, Inspection Release Tag) and match with Form TL-0029, Report of Inspection of Material.
   ii. Take photos of source inspection release information that are applied directly onto the system elements such as stenciled on panels or etched into concrete block.
   iii. Document Quantities
   iv. Check for Certificates of Compliance and Buy America Certification.
   v. Verify proper material storage and handling.
   vi. Check for damage incurred during the delivery and if request a repair plan from the contractor as needed.
c. Verify sloping or shoring installation specific to the authorized AERS.
d. Verify the Contractor installs drainage system, if required, per authorized plans before backfilling. Coordinate with RE.
e. Coordinate QA backfill and compaction testing with District Materials Staff.
f. Verify that backfilling is done with proper equipment to avoid damage to the structural elements.
g. Verify the Contractor grades the backfill to slope away from the wall face at the end of each shift to keep surface run off away from the facing if a significant rain event is anticipated. Surface water, if not controlled, will migrate the fines from the structure backfill into the pervious material, possibly causing excessive backfill settlement.
h. Verify wall cap profile elevations to match the cross section and super elevations of the roadway section.

5. Document all inspection, construction, and quality assurance activities in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

6. Following Construction:
   a. File all submittals in the project records as specified in the Construction Manual.
   b. Record information necessary for Required Documents:
      i. Any as-built changes.

**Process Outputs**

1. Complete project records for each wall that is an alternative ERS (including materials certifications and test results).
2. As-built plans and shop drawings.
3. Daily Reports.

Attachments

None.
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Temporary Structures – Falsework

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Background

This process establishes Structure Construction (SC) responsibilities for review and authorization of submittals, quality assurance, and construction of falsework, including foundations, erection, removal, and lighting.

Construction of falsework in accordance with the authorized shop drawings is a critical operation. Performing a thorough analysis, authorizing shop drawings, and guaranteeing erection, maintenance, and removal of falsework is executed in a safe controlled manner ensures public and worker safety.

Prior to reviewing this BCM, it is essential to review Contract Specifications, Section 48-2, Temporary Structures – Falsework, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. The contractor’s falsework submittal including but not limited to shop drawings and calculations

Procedure

1. All work associated with this process is charged as Project-Direct – Construction.
2. Inspection of field work for this process is:
   a. Benchmark inspection for maintenance of in-place falsework.
b. **Intermittent** inspection of falsework construction, erection, and removal.

c. **Continuous** inspection for falsework erection and removal at traffic openings and during concrete placement operations for falsework.

3. For detailed photographs of falsework elements and additional information that supplements the information in the *Falsework Manual*, review the:

   a. **Winter Training** presentations on Falsework
   
   b. **Field Engineer Training**, Section 5a, *Falsework*
   
   c. **Falsework Academy** online training

4. Before construction begins:


   b. Review critical dimensions and traffic control measures as follows:

      i. Verify calculated vertical and horizontal clearances.

      ii. Notify the Resident Engineer (RE) and Traffic Operations of temporary restrictions of vertical or horizontal clearances in advance per BCM C-4.14, *Notice of Change of Structure Clearance or Permit Rating*.

      iii. Coordinate installation of traffic control measures with the RE.

   c. Review planned falsework foundation locations and determine soil bearing capacity with consideration of the items below:

      i. Determine if soil load testing is needed per the *Falsework Manual*, Section 8-4, *Soil Load Test and Soil Bearing Values*.

      ii. Verify conflicts with existing above or below ground utilities or structures.

   d. Lay out as-built location of falsework bents on 4-scale drawings per BCM C-4.15, *Bridge Deck Contours and Geometrics*.

   e. Calculate falsework stringer camber per the *Falsework Manual*, Section 4-2.04, *Camber*.

   f. Submit camber strip dimensions to the contractor.

   g. Coordinate the following considerations for falsework erection and removal schedules with the RE:

      i. Traffic control and work windows

      ii. Project schedule

      iii. Power source for falsework lighting
iv. Environmental commitments

h. Coordinate railroad inspection and flagging if applicable.

i. Confirm the contractor has obtained a permit from the California Division of Occupational Safety and Health Administration of Industrial Relations (Cal/OSHA) per the requirements of the Construction Safety Orders, Article 341, Permit Requirements, for falsework more than 3 stories in height.

j. Discuss falsework erection and removal items below with the contractor:

i. Verify falsework erection and removal sequence discussed matches that shown on the authorized falsework shop drawings.

ii. Discuss coordination of falsework erection, temporary pedestrian facility construction, and falsework lighting installation with the contractor.

iii. Discuss temporary pedestrian facility construction and the requirements found in the Temporary Pedestrian Access Routes Handbook.

iv. Requirements for the temporary structure engineer who signed the authorized shop drawings to be present during adjustment activities and certifying the system prior to loading.

k. Inspect falsework materials as they are delivered to the job site. Reject any falsework materials that are defective or will not support the loads to be imposed per Falsework Manual, Chapter 9, Inspection.

l. Study the authorized falsework shop drawings and assess locations and types of welds to be performed on the project falsework. Address items below:

i. Determine welds that require inspection, including visual inspection in accordance with the American Welding Society, Structural Welding Code – Steel (AWS D1.1) or American Welding Society, Structural Welding Code – Steel Reinforcing Bars (AWS D1.4) for welding rebar.

ii. Determine welds that require non-destructive testing (NDT) for:
   1. Welded splices
   2. Other welds requiring NDT in accordance with specified standards

iii. Review welding requirements in the Contract Specifications, Section 48-2, Temporary Structures – Falsework.

iv. Review certification for falsework members with welded splices for conformance with contract requirements.

m. Review Falsework Manual, Chapter 9, Inspection.

5. During construction:
a. Prior to erecting the falsework members delivered to the jobsite with previously welded splices. Verify welded splices matches the welding certification for the falsework members.

b. For field welded falsework members with welded splices address the following:
   i. Prior to placing concrete on the falsework, verify the welds comply with the letter of certification.
   ii. Document all welding quality assurance activities in the Daily Reports.

c. Verify that the locations selected by the contractor for testing represents each weld and any repair made to a previously welded splice.

d. Verify welder certification per AWS D1.1 or AWS D1.4 as applicable.

e. During falsework erection:
   i. Verify falsework erection, temporary pedestrian facilities construction, and falsework lighting installation are sequenced in accordance with authorized submittals.
   ii. Verify all temporary bracing is placed as falsework bents are erected.
   iii. Verify permanent bracing is installed prior to placing falsework above stringers.
   iv. Inspect falsework members as they are incorporated into the work per Falsework Manual, Chapter 9, Inspection, including the following:
      1. Verify materials are placed according to the authorized shop drawings.
      2. Verify actual dimensions match dimensions shown on the authorized shop drawings.
      3. Verify camber strips are correctly placed on falsework stringers.
   v. Discuss any field changes to falsework that deviate from the authorized falsework shop drawings per Falsework Manual, Section 9-3.22, Field Changes. If field changes are needed:
      1. Request revised falsework shop drawings from the contractor.
      2. Review and authorize falsework shop drawing revisions per BCM C-4.12, Shop Drawing Review of Temporary Structures.
   vi. For falsework traffic openings, prior to resumption of traffic through the opening:
      1. Coordinate traffic control measures with the RE.
      2. Verify all traffic control measures are in place.
3. Verify all required bracing and lighting for falsework openings are in place.

4. Field measure the vertical and horizontal clearances and notify the RE and Traffic Operations of the actual impaired clearance dimensions per BCM C-4.14, *Notice of Change of Structure Clearance or Permit Rating*.

vii. Confirm falsework soffit grading has been performed by the contractor per *Falsework Manual*, Chapter 9, *Inspection*, Section 9-3.23 *Adjustments*:

1. Verify temporary bracing remains in place during falsework grading.

2. Confirm the presence of the contractors engineer prior to jacking or adjustment activities commence.


viii. Coordinate with the Bridge Construction Engineer to review the constructed falsework per BCM D-2.07, *Field Review of Temporary Structures (Falsework)*.

ix. Obtain the contractor’s certification of the constructed falsework for the project files per the requirements of the *Construction Safety Orders*, Article 1717, *Falsework and Vertical Shoring*.

x. Confirm the Contractor has installed tell-tales for measuring falsework settlements correctly per *Falsework Manual*, Section 9-3.19, *Tell-Tales*.

f. During concrete placement operations on falsework:

i. Monitor, measure, and record falsework settlement; and

1. Confirm the contractor takes corrective actions when excessive settlement occurs in accordance with requirements of the contract documents per *Falsework Manual*, Section 9-4.01, *Inspection During Concrete Placement*.

g. The in-place falsework must be maintained in conformance with the authorized shop drawings including but not limited to the following:

i. Verify falsework elements are in place and functioning as intended.

ii. Verify temporary pedestrian facilities are maintained per BCM 16-2.02, *Temporary Facilities – Temporary Pedestrian Facilities*.

iii. Verify falsework lighting functions as intended per the *Falsework Manual*, Section 9-3.20F, *Lighting at Traffic Openings*. 
h. Document temporary pedestrian facilities comply with Americans with Disabilities Act regulations per BCM 16-2.02, *Temporary Facilities, Temporary Pedestrian Facilities*.

i. Prior to falsework removal operations, discuss with the contractor the sequence for falsework release and falsework removal to verify compliance with the requirements of the contract documents per *Falsework Manual*, Section 9-5, *Removal*.

j. Verify falsework removal, temporary pedestrian facilities removal, and falsework lighting removal are sequenced in accordance with authorized submittals per *Falsework Manual*, Section 9-5, *Removal*.

k. Verify all temporary bracing is placed as falsework elements are removed per the *Falsework Manual*, Section 9-5, *Removal*.

l. Where falsework is removed at traffic openings, prior to resumption of traffic, address the following:
   i. Coordinate traffic control measures with the RE.
   ii. Field measure vertical clearances and notify the RE and Traffic Operations of the actual permanent clearance dimensions per BCM C-4.14, *Notice of Change of Structure Clearance or Permit Rating*.

m. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per *BCM C-4.04, Daily and Weekly Reports*.

6. Following construction:
   a. File all project documentation (materials acceptance documentation, correspondence, daily reports, etc.) in the appropriate category in the project records as specified in the *Construction Manual, 5-102, Organization of Project Documents*.

**Process Outputs**

1. Authorized Falsework shop drawings

2. Temporary Structure Analysis Report when falsework requires an engineer’s stamp. Refer to *Contract Specifications*, Section 48-2.01C(2), *Shop Drawings*

3. Transmittal Letter

4. Welding certification from the contractor
5. Falsework camber strip dimensions
6. Temporary Structure Inspection Report
7. Contractor’s certification of constructed falsework
8. Daily Reports
9. Change in clearance documentation
10. Completed Form CEM-2311, Temporary Pedestrian Access Route Contractor Compliance Report
11. Completed Form CEM-2312, Temporary Pedestrian Access Route Contractor Weekly Report

Attachments

None
Temporary Structures – Falsework – Construction

BCM 48-2.03, *Temporary Structures – Falsework – Construction*, will not be posted.

It has been combined into BCM 48-2, *Temporary Structures – Falsework*. Refer to [BCM 48-2](#).
Temporary Structures – Temporary Supports

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, and installation and removal of temporary supports.

Temporary supports are the supports required during retrofit, reconstruction and removal activities, and include jacking assemblies and accessories.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review Contract Specifications, Section 48-3, Temporary Structures – Temporary Supports, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Contract plans with temporary support details, design loading, and location(s)
2. Contractor’s temporary support submittal
3. Jack Calibration Charts

Procedure

1. All work associated with this process is charged as Project-Direct – Construction.
2. Inspection of field work for this process is:
a. **Continuous** for placement and removal of temporary supports.

b. **Intermittent** for maintenance of in-place temporary supports.

3. Before Construction begins:


   b. When railroad is involved:
      i. Review schedule of work and inform the railroad of the contractor’s proposed schedule.
      ii. Obtain railroad approval prior to authorizing shop drawings.

   c. Discuss the following items with the contractor and Resident Engineer (RE) at preconstruction conference:
      i. Work windows, contingency plan, and traffic control.
      ii. Requirements for the temporary structure engineer who signed the authorized shop drawings to be present during jacking activities and certifying the system prior to loading.
      iii. Contingency plan, and authorization of submittals in accordance with *Contract Specifications, 5-1.23, Control of Work – Submittals*.
      iv. Temporary support erection and removal sequence, and verification that the temporary support erection and removal sequence discussed matches that shown on the authorized shop drawings.
      v. Coordination of temporary supports with temporary pedestrian facility, where applicable.

   d. Review as-built plans and compare to actual field conditions.

   e. Verify all required materials that are on-site are per the authorized shop drawing.

   f. Verify the jack has a current calibration chart.

   g. Verify the contractor performed an initial survey of the structure.

   h. Determine welds that require inspection, including visual inspection in accordance with the *American Welding Society, Structural Welding Code – Steel (AWS D1.1)* or *American Welding Society, Structural Welding Code – Steel Reinforcing Bars (AWS D1.4)* for welding rebar.

4. During Construction:
a. Verify the presence of the contractor’s engineer before jacking activities commence.

b. Verify temporary supports are installed in accordance with the requirements of the contract documents and authorized shop drawings.

c. Verify that the contractor is monitoring and recording the vertical and horizontal displacements of the temporary supports and the existing structure during the jacking operations.

d. Confirm the Temporary Structure Inspection Report addresses all requirements of Contract Specifications, Section 48-1.01C(2), Temporary Structure Inspection Report.

e. Maintenance of in-place temporary supports is required as follows:
   i. Verify temporary support elements are in place and functioning as intended.
   ii. Verify temporary pedestrian facilities are maintained per BCM 16-2.02, Temporary Facilities – Temporary Pedestrian Facilities.

f. Document temporary pedestrian facilities comply with Americans with Disabilities Act regulations per BCM 16-2.02, Temporary Facilities – Temporary Pedestrian Facilities.

g. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

h. Measure and document any change in bridge clearance or weight rating in accordance with BCM C-4.14, Notice of Change in Structure Clearance or Permit Rating.

i. Verify welding and welder certification are in accordance with AWS D1.1 or AWS D1.4 as applicable.

j. Following these procedural steps will mitigate the following risks associated with construction of temporary supports:
   i. Potential for delay in schedule due to review time
   ii. Potential for collapse or failure
   iii. Unplanned movement of structure during operations
   iv. Miscommunication with railroad or other Right of Way entities
   v. Potential for equipment failure
   vi. Extended traffic closure windows

5. After Construction:
a. File all project documentation (correspondence, material acceptance documentation, authorized shop drawings, daily reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized Shop Drawings
2. Temporary Structure Analysis Report when falsework requires an engineer’s stamp. Refer to Contract Specifications, Section 48-3.01C(2), Shop Drawings
3. Transmittal Letter
4. Temporary Structure Inspection Report
5. Daily Reports
6. [Form TR-0019](#), Notice of Change in Clearance or Bridge Weight Rating

**Attachments**

None
Temporary Structures – Temporary Decking

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, and installation and removal of temporary decking, including placement of traffic tapers.

Temporary decking refers to decking materials used to bridge a temporary gap in the bridge deck, such as those that may occur during bridge deck rehabilitation activities.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review Contract Specifications, Section 48-4, Temporary Structures – Temporary Decking, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Contract documents with temporary decking details, design loading, and location(s)
2. Contractor’s temporary decking submittal

Procedure

1. All work associated with this process is charged as Project-Direct – Construction.
2. Inspection of field work for this process is:
a. **Continuous** for installation and removal of temporary decking.

b. **Intermittent** for maintenance of temporary decking.

3. Before Construction begins:

   a. Review the temporary decking submittal for conformance with contract documents and authorize in accordance with **BCM C-4.12, Shop Drawing Review of Temporary Structures and Falsework Manual, Chapter 2, Review of Shop Drawings.** Refer to **Attachment 1, Sample Temporary Decking Plan**, for reference.

   b. Review the concrete mix design and authorize in accordance with **Contract Specifications, Section 5-1.23, Submittals.**

   c. Review the construction sequence and schedule for conformance with the following:
      
      i. Cure time for concrete prior to placing decking
      
      ii. Installation and removal of decking within traffic control windows

   d. Discuss work windows, contingency plan, and transverse taper requirements specified in the **Contract Specifications, Section 7-1.03, Public Convenience,** with the Resident Engineer (RE) and the contractor.

   e. Review as built plans and compare to actual field conditions.

   f. Prior to the start of work, verify all required materials are on-site and are per the authorized shop drawings.

   g. Notify the RE and Traffic Operations in advance of temporary vertical clearance or load restrictions per **BCM C-4.14, Notice of Change of Structure Clearance or Permit Rating.**

4. During Construction:

   a. Verify temporary decking is installed in accordance with the requirements of the contract documents and authorized shop drawings.

   b. Verify the taper requirements for horizontal gaps, vertical differences, and transverse taper locations comply with the requirements of the **Contract Specifications, Section 7-1.03, Public Convenience.**

   c. Verify layouts, anchor locations, and minimum concrete thickness comply with contract documents.

   d. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per **BCM C-4.04, Daily and Weekly Reports.**
e. Measure and document any change in bridge clearance or weight rating in accordance with BCM C-4.14, Notice of Change in Structure Clearance or Permit Rating.

f. Verify structure is returned to original condition by patching holes and grinding surfaces.

5. Following Construction:

a. File all project documentation (correspondence, materials acceptance documentation, daily reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, 5-1.02, Organization of Project Documents.

**Process Outputs**

1. Authorized Temporary Decking Shop Drawings
2. Temporary Structure Analysis Report when falsework requires an engineer’s stamp. Refer to the Contract Specifications, Section 48-2.01C(2), Shop Drawings
3. Transmittal Letter:
4. Concrete Compressive Strength Test Data
5. Daily Reports
6. Form TR-0019, Notice of Change in Clearance or Bridge Weight Rating

**Attachments**

1. Attachment 1, Sample Temporary Deck Plan Sheet
Sample Temporary Decking Plan

Figure 1, Sample Temporary Decking Plan, is an example of a contract plan sheet with details for temporary decking.

Figure 1. Sample Temporary Decking Plan
Temporary Structures – Jacking

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for the review and authorization of submittals, quality assurance, installation and removal of jacking systems, and the procedure for jacking the bridge superstructure.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 48-5, Temporary Structures – Jacking, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Jacking support system submittal
2. Jack Calibration Charts

Procedure

1. All work associated with this process is charged as Project Direct – Construction
2. Inspection of field work for this process is:
   a. Benchmark inspection for maintenance of in-place jacking systems.
   b. Intermittent inspection of jacking system construction, erection, and removal.
   c. Continuous for displacement monitoring and jacking operations.
3. Before construction begins:
a. Review the following:
   i. Contract documents
   ii. Railroad and local Right of Way guidelines and requirements (if applicable)
   iii. The contractors work schedule

b. Review the temporary jacking support system submittal for conformance with contract documents and railroad requirements and authorize in accordance with BCM C-11, Shop Drawing Review of Temporary Structures and Falsework Manual, Chapter 2, Review of Shop Drawings.

c. Verify displacement monitoring system is installed for the structure and jacking support system.

d. Verify baseline data has been collected.

e. Verify that the contractor coordinates work with the railroad or other right-of-way entities when required in contract documents.

f. Verify soil bearing capacity based on soil test results or other geotechnical information.

g. Discuss the redundant system of support for jacking activities with the contractor.

h. Verify that the jack and pressure gauge or load cell have been calibrated by an authorized laboratory within 6 months of use or after each repair:
   i. Check with the METS Representative for the certification of the authorized laboratory.

i. Coordinate traffic control and local agency requirements, including the railroad, with the Resident Engineer and the contractor.

4. During construction:
   a. Verify the contractor's jacking system matches the certified calibration charts.
   b. During installation of temporary jacking supports, confirm the contractor is following the requirements of the authorized temporary jacking support system submittal:
      i. See Attachment 1, Jacking System for Jacking a Bridge Superstructure, for a photo of a jacking system.
   c. Coordinate the final walk-through with the Bridge Construction Engineer prior to jacking.
   d. Verify jacking loads are applied in conformance with the authorized temporary jacking support system submittal and requirements of the contract documents.
e. Verify the contractor performs displacement monitoring activities per authorized temporary jacking support system submittal.

f. Verify the redundant system of support is installed.

g. Ensure that the contractor and operation comply with applicable safety requirements. Refer to the Construction Manual, Section 2-103, Managing Safety Hazards.

h. Document displacement at the minimum intervals specified in the contract documents and verify displacement complies with contract tolerances.

i. Verify monitoring records are available at the job site.

j. Monitor the jacking operation for unplanned events, including unanticipated displacement, equipment failures, cracking, damage, or unanticipated jack loads. If unplanned or unanticipated events occur, take the following steps:
   i. Stop work
   ii. Notify the contractor
   iii. Check all equipment
   iv. Require the contractor’s engineer to submit a proposal for correction
   v. Authorize corrective measures

k. During removal of temporary jacking supports, confirm the contractor is following the requirements of the temporary jacking support system submittal.

l. Verify all attachments to the existing structure are removed and concrete surfaces are repaired.

m. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Following construction:

   a. File all project documentation (correspondence, material acceptance documentation, authorized shop drawings, daily reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

   b. Review and file all displacement monitoring records.

**Process Outputs**

1. Authorized jacking superstructure shop drawings

2. Temporary Structure Analysis Report(s) (as applicable)

3. Transmittal Letter
4. Chronological record of jacking superstructure review
5. Daily reports
6. Signed displacement monitoring records

**Attachments**

*Attachment 1*: *Jacking System for Jacking a Bridge Superstructure*
Jacking System for Jacking a Bridge Superstructure

The photographs below illustrate a jacking system used to jack a bridge superstructure. Various components of the system include jack supports, bracing, jacks, buildup, shims, gauges, etc.

Figure 1. A fairly typical jacking system. Note the restraint of the cap beam to prevent unwanted movement.
Figure 2. A jacking manifold used to split the hydraulic line to individual jacks. Note that each jack has a dedicated control valve and pressure gauge.
Temporary Structures – Jacking
Superstructure – Submittals

BCM 48-5.01C, *Temporary Structures – Jacking Superstructure – Submittals*, has not been posted yet.

Until it is posted, refer to the *Contract Specifications*, Section 48-5.01C, *Temporary Structures – Jacking Superstructure – Submittals*. 
Temporary Structures – Jacking
Superstructure – Quality Assurance

BCM 48-5.01D *Temporary Structures – Jacking Superstructure – Quality Assurance*, has not been posted yet.

Until it is posted, refer to the *Contract Specifications*, Section 48-5.01D, *Temporary Structures – Jacking Superstructure – Quality Assurance*. 
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Piling – General

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Background

This process establishes the Structure Construction (SC) responsibilities and procedures for review and authorization of general piling submittals, quality assurance, materials, and construction that apply to all piling specified in Section 49 of the Contract Specifications.

Pile load tests are specified in the contract documents:

1. When piles are installed in soils with variable geologies or poor-quality soils where there is no other means to determine capacity.
2. To validate design assumptions.
3. To provide sufficient information to modify the design tip elevation when there is a potential for large cost savings.
4. When driven piles are too large (typically larger than 36-inch diameter) to use dynamic monitoring for bearing acceptance criteria.

Dynamic monitoring of driven piling is specified in the contract documents:

1. When the piles to be driven are too large (typically 18-inch to 36-inch diameter) to use the Gates Formula per BCM 49-2, Piling – Driven Piling, for bearing acceptance criteria.
2. When ground conditions are not well known and bearing acceptance criteria needs to be established for the control zone.
3. To monitor driving stresses to prevent pile damage.
Dynamic monitoring may be required with pile load testing to:

1. Calibrate bearing acceptance criteria to the pile load test.
2. Evaluate capacity of static load test anchor piles.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 49-1, Piling – General, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Contract work that requires piling
2. Submittals:
   a. Pile Handling Work Plan
   b. Value Engineering Change Proposal (VECP) for revisions to specified tip elevations shown or installation methods
   c. Test Boring Report and Log of Test Borings, if specified
3. Load Test Piles:
   a. Pile Load Testing specified in the contract documents
   b. Form CEM-3101, Notice of Materials to be Used
   c. Static Pile Load Test Request form
   d. Authorized Pile Installation Plan for load test Cast-In-Drilled-Hole concrete piling per BCM 49-3, Piling - Cast-In-Place Concrete Piling
4. Dynamic Monitoring:
   a. Dynamic Monitoring specified in the contract documents
   b. Pile Driving Analysis Test Request Form
   c. Authorized Driving System Submittal for driven piling to be dynamically monitored per BCM 49-2, Piling – Driven Piling

**Procedure**

1. All work associated with this process is charged as Project Direct – Construction.
2. Inspection for this process is:
   a. Benchmark for:
i. Work associated with authorization of submittals and field release of materials.

ii. Load test and anchor piles construction and pile load testing.

b. **Continuous** for:

   i. Piles driven with dynamic monitoring.

3. Before construction begins:

   a. Perform document review of the following:

      i. Contract documents, Structures RE Pending File, Foundation Report, Authorized Driving System submittal, and authorized Pile Load Testing submittal. Also review Project Information Handout and contract documents for applicable environmental commitments and railroad requirements.

      ii. Project-specific Code of Safe Practices (COSP) and the requirements of Cal/OSHA Title 8, Chapter 4, Subchapter 4, *Construction Safety Orders*, for review of the Pile Handling Work Plan and work involving pile load testing and dynamic monitoring, including but not limited to:

         1. **Article 9**, *Derricks, Cranes, Boom-type Excavators*

         2. **Article 12**, *Pile Driving and Pile Extraction*

         3. **Article 15**, *Cranes and Derricks in Construction*

         4. **Article 24**, *Fall Protection*

      iii. *Foundation Manual, Chapter 8, Static Pile Load Testing and Pile Dynamic Analysis*, for additional information on the reasons for performing pile load testing and dynamic monitoring, and the expected results.

   b. Perform review and authorization of submittals as follows:

      i. Discuss with the Resident Engineer (RE) and the contractor any concerns with existing facilities and agency requirements, such as overhead power lines and underground utilities and the railroad requirements. Call Dig Alert (USA) if applicable.

      ii. For Pile Handling Work Plan:

         1. Discuss the requirements of the Pile Handling Work Plan during the preconstruction conference.

         2. Receive, review, and authorize the Pile Handling Work Plan:

            a. Review public safety requirements.

            b. Review work zone layout for material and equipment conflicts, especially for cranes or other “boomed” equipment.

            c. Review and mitigate any utility conflicts.
3. Notify the contractor in writing of authorization or rejection of the submittal.

iii. For VECP revisions to specified tip elevations or installation methods:

1. Receive, review, and authorize the VECP in accordance with the requirements of the *Construction Manual*, Section 3-405, *Value Engineering*.
   a. Discuss proposed revisions with the BCE, Structure, and Geotechnical Designer.
   b. Get concurrence from the district construction deputy director if the VECP is unacceptable, as per Section 3-405 of the *Construction Manual*.

2. Notify the contractor in writing of authorization or rejection of the submittal.

iv. When test borings are specified in the contract documents:

1. Discuss the following requirements of test borings during the preconstruction conference:
   a. Direct the contractor to submit four (4) copies of the Test Boring Report and the Log of Test Borings to Structure Design (SD) Documents Unit.
   b. If corrections are required, direct the contractor to submit one copy of the corrected test boring report and the log of test borings to SD Documents Unit.

2. Receive notification of the submittal from the contractor.

3. Coordinate the review with the Structure and Geotechnical Designer.

4. Act upon the recommendations of the Structure and Geotechnical Designer.

v. Review and forward to Materials Engineering and Testing Services (METS) Form CEM-3101, *Notice of Materials to be Used*.

c. When Load Test Piles are specified in the contract documents:

i. Verify anchor pile layouts are correctly shown. Discuss any issue with the Geotech Engineer, Bridge Construction Engineer (BCE), and Substructure Engineer.

ii. Notify Foundation Testing and Instrumentation (FTI) Branch of scheduled pile load testing by submitting the *Static Pile Load Test Request Form*.

iii. Discuss requirements for pile load testing with FTI prior to the preconstruction conference.

iv. Discuss requirements for pile load testing with the contractor at the preconstruction conference.
v. Review the contractor’s schedule to verify load test piles are included with sufficient time to perform the test and generate a report.

vi. Discuss logistical requirements for performing the pile load test with FTI and the contractor and issue a change order in accordance with the requirements of the contract specifications.

vii. Assist the contractor and FTI with preparing the load test pile for load testing according to the Foundation Manual, Chapter 8-4, Inspection Requirements During Static Load Testing and Pile Dynamic Analysis:

1. Coordinate installation of pile load test instrumentation package with FTI and the contractor.


ix. Review requirements of AWS D1.1, Structural Welding Code – Steel, for load test piles that are to be incorporated into the permanent work (found in the Engineering Workbench. SC staff must create an account).

d. When Dynamic Monitoring is specified in the contract documents:

i. Confirm with the Geotech Designer the intended control zones for piles to be dynamically monitored.

ii. Notify FTI of scheduled pile dynamic monitoring using the Pile Driving Analysis Test Request Form.

iii. Discuss requirements for pile dynamic monitoring with FTI prior to the preconstruction conference.

iv. Discuss requirements for pile dynamic monitoring with the contractor at the preconstruction conference.

v. Discuss the contractor’s planned production pile driving procedures with FTI to confirm pile installation procedures for production piling match those used during dynamic monitoring.

vi. Review the contractor’s schedule to verify dynamic monitoring is included with a sufficient time window to perform pile dynamic monitoring, generate a report, and generate bearing acceptance criteria.

vii. Discuss logistical requirements for performing dynamic monitoring with the contractor according to the Foundation Manual, Chapter 8-3, Contract Administration of Static Pile Load Testing & Pile Dynamic Analysis.

viii. Assist the contractor and FTI with preparing the pile(s) for dynamic monitoring according to the Foundation Manual, Chapter 8-4, Inspection Requirements During Static Load Testing and Pile Dynamic Analysis.

e. Preparing for construction of production piling:
   i. When difficult pile installation conditions are specified: Discuss expected difficult pile installation conditions with the geotechnical and structural designers.
   
   ii. Discuss expected difficult pile installation conditions in the preconstruction conference (or preconstruction meeting for Cast-In-Place (CIP) concrete piles per BCM 49-3, *Piling – Cast-In-Place Concrete Piling*).

4. During construction:
   a. For Load Test Piles:
      i. Discuss pile driving operation safety at a Tailgate Safety meeting prior to start of field work.
      
      ii. Inspect and verify construction of the load test pile and anchor piling according to *Foundation Manual*, Chapter 8-4, *Inspection Requirements During Static Load Testing and Pile Dynamic Analysis*:
         1. For driven load test and anchor piling, log pile details such as blow count and stroke on Form SC-4805, *Log Pile Sheet*, and provide to FTI.
         2. For CIDH load test and anchor piling, provide authorized pile submittals per BCM 49-3, *Piling - Cast-In-Place Concrete Piling*, to FTI.
         3. Document inspection of construction of the test pile and anchor piling in the daily reports.
      
      iii. Assist FTI with pile load testing according to the *Foundation Manual*, Chapter 8, *Static Pile Load Testing and Pile Dynamic Analysis*.
      
     iv. Suspend any of the contractor’s operations in conflict with the pile load testing work until pile load testing is completed.
   
   b. For Dynamic Monitoring:
      i. Discuss pile driving operation safety at a Tailgate Safety meeting prior to start of field work.
      
      ii. Inspect and verify construction of the pile being dynamically monitored according to the *Foundation Manual*, Chapter 8-4, *Inspection Requirements during Static Load Testing and Pile Dynamic Analysis*:
         1. Assist FTI with pile dynamic monitoring.
         2. Document inspection of construction of the pile being dynamically monitored in the daily reports.
3. Log pile details, blow count and stroke on Form SC-4805, *Log Pile Sheet*, and provide to FTI.

iii. Suspend any of the contractor’s operations in conflict with the pile dynamic monitoring work until dynamic monitoring is completed.

c. For Production Piling:

i. When difficult pile installation conditions are specified:
   1. Inspect pile installation and verify and record encountered difficult conditions.
   2. Contact geotechnical and structural designers when unexpected pile installation conditions are encountered.

5. Following Construction:

a. For Load Test Piles:
   i. Receive the Pile Load Test report from FTI.
   ii. Review the Pile Load Test report and coordinate with the Geotechnical Designer and the Structure Designer to obtain recommendations for raising or lowering the piling specified tip elevations.
   iii. Notify the contractor of final specified tip elevations in writing.
   iv. If necessary, issue a change order to implement revised specified tip elevations.

b. For Dynamic Monitoring:
   i. Receive the Dynamic Monitoring Test report and bearing acceptance criteria from FTI.
   ii. Review the Dynamic Monitoring Test report and coordinate with the Geotechnical and Structural Designers to obtain final specified tip elevations.
   iii. Notify the contractor of final specified tip elevations and bearing acceptance criteria in writing.
   iv. If necessary, issue a change order to implement revised specified tip elevations.

6. Document all inspection construction, and quality assurance activities, pertinent to the BCM, in the Daily Reports per *BCM C-7, Daily and Weekly Reports*.

7. File all materials acceptance documents and Daily Reports in the in the appropriate category in the project records as specified in the *Construction Manual, 5-102, Organization of Project Documents*.
Process Outputs

1. Authorized submittals
2. Completed Static Pile Load Test Request and/or Pile Driving Analysis Test Request Forms
3. Form SC-4805, Log Pile Sheet
4. Daily reports
5. Static Pile Load Test report and/or Dynamic Monitoring Test report
6. Bearing acceptance criteria
7. Change order for revisions to specified tip elevations if required

Attachments

None
Piling – Driven Piling

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Background

This process establishes the Structure Construction (SC) responsibilities and procedures for review and authorization of driven piling submittals, quality assurance, materials, construction, and payment that apply to all driven piling specified in Section 49-2 of the Contract Specifications.

Additional unique requirements for this process are detailed in:

- BCM 11-2, Welding - Quality Control
- BCM 49-1, Piling – General

Prior to reviewing this BCM, it is essential to review Contract Specifications, Section 49-2, Piling – Driven Piling, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. All Driven Piling:
   a. Form CEM-3101, Notice of Materials to be Used
   c. Form SC-4803, Pile Quantity & Driving Record (Driven Piles)
   d. Form SC-4806, Pile Layout Sheet
e. **Form SC-4809**, *Pile Driving (US Customary) Blows Per Foot using Gates Formula (Vertical & Battered)*

f. Pile and Driving Data form submittals for each hammer

g. Authorized Pile Handling Plan submittal

h. Driving System Submittal for each hammer, when specified

i. Printed hammer energy readouts from the contractor, when required

2. **Steel Piling:**
   a. Shop drawings for pile handling devices
   b. Inspection request form
   c. Field welding submittals
   d. Certificates of compliance

3. **Precast Prestressed Concrete Piling:**
   a. Shop drawings (when requested)

**Procedure**

1. All work associated with this process is charged as [Project Direct – Construction](#).

2. Inspection of field work for this process is:
   a. **Benchmark** for:
      i. Inspection of piling delivered to the project.
      ii. Field welding of steel piling.
   b. **Continuous** for:
      i. Inspection of the pile driving operation.
      ii. Determining pile acceptance during pile driving.

3. Before construction begins:
   a. Review the following documents:
      i. Contract documents for noise, vibration, and other environmental requirements.
      ii. Contract documents for difficult pile installation conditions per BCM 49-1, *Piling – General*.
      iii. Structures RE Pending File, Foundation Report, and Project Information Handout for applicable environmental commitments and railroad requirements.
iv. Project-specific Code of Safe Practices and the requirements of Cal/OSHA Title 8, Chapter 4, Subchapter 4, *Construction Safety Orders*, for driven piling construction, including but not limited to:

1. Article 6, *Excavations*
2. Article 9, *Derricks, Cranes, Boom-type Excavators*
3. Article 12, *Pile Driving and Pile Extraction*
4. Article 15, *Cranes and Derricks in Construction*
5. Article 24, *Fall Protection*

b. Coordinate action with the following:

i. Discuss with Resident Engineer (RE) and contractor any existing facilities concerns and agency requirements, such as overhead power lines, underground utilities, environmental and railroad requirements. Verify that the contractor called DigAlert (Underground Service Alert), if applicable.

ii. Contact Foundation Testing and Instrumentation (FTI) to review the pile driving requirements and timeframe for FTI’s involvement for the project.

iii. Discuss guidelines for hard driving, soft driving and redrive with the SC Substructure Engineer and the GS Geoprofessional and how it applies to construction:

   1. Discuss the possibility of installing driven piles using a vibrating hammer, and if so, to what elevation, with the Structural and Geotechnical designers.

   2. Discuss with and concur on the definition of “refusal” and remedial measures with the Geotechnical Designer and FTI. Refer to the *Foundation Manual, Chapter 7, Driven Piles, Section 7-7, Driving Challenges*.

c. Review and authorize each submittal required by Contract Specifications for this process, as follows:

i. Discuss requirements for Pile and Driving Data forms and Driving Systems Submittal (DSS) requirements during the preconstruction meeting per the *Foundation Manual, Chapter 7, Driven Piles, Section 7-5, Nominal Resistance/Bearing Capacity*.

ii. Review and authorize or reject the submitted Pile and Driving Data forms:

   1. Contact FTI for questions regarding information on the *Pile and Driving Data Form(s)*, which is included the *Special Provisions* and completed by the contractor.

   2. Discuss issues preventing authorization of the Pile and Driving Data forms with the contractor.
iii. If a DSS is required, perform an initial review of the submitted DSS for completeness:
   1. Review the DSS with the RE to verify compliance with any additional project requirements and request contingency plan from the contractor as needed.
   2. Request additional information from the contractor if needed until the DSS is complete.
   3. Forward the complete DSS to FTI for review, per the instructions on the FTI website. Authorize or reject the DSS based on FTI recommendation. Refer to the Foundation Manual, Section 7-5, Nominal Resistance/Bearing Capacity, and Appendix K1, Driven Piling Construction Checklist.
   4. Notify the contractor in writing of rejection or authorization of the DSS.

iv. Perform a concurrent review of the authorized Pile Handling Plan submitted per BCM 49-1, Piling – General, and verify compatibility of the Pile Handling Plan, Pile and Driving Data forms, and the DSS.

v. For steel pipe piling:
   1. Verify with the Materials Engineering and Testing Services (METS) Representative that the proposed steel pipe piling fabrication facility is on the Department’s Authorized Facility Audit list.
   2. Review American Welding Society (AWS) D1.1 requirements.
   3. Discuss shop drawing review and authorization, certificates of compliance, steel pipe piling fabrication, welding certifications for Class N steel pipe piling, and field welding requirements with the contractor and METS Representative.

vi. For structural shape steel piling and precast prestressed concrete piling:
   1. Review submittals and notify the contractor in writing of rejection or authorization of the steel piling and/or concrete piling submittals.

d. Review Materials, as follows:
   i. Review and discuss with the METS Representative any materials to be inspected and released via Form CEM 3101, Notice of Materials to be Used, and Form TL-0029, Report of Inspection of Material, and which materials are to be field released via Form SC-4102, Material Inspected and Released on Job. Utilize the forms to justify any materials on hand payments:
      1. Confirm steel that meets the contract requirements is being procured and that METS has been notified.
ii. For field welding of steel piling, verify Welding Quality Control Plan and welder certification requirements have been met per BCM 11-2, Welding – Quality Control.

iii. Perform timely field verification that the materials delivered meet contract requirements and were not damaged in shipping.

iv. Collect orange Inspection Tags and match them with the appropriate Form TL-0029, Report of Inspection of Material.

v. Verify material condition meets the requirements of the contract documents.

e. Prepare for construction of driven piling by performing the following:

i. Coordinate with FTI if dynamic monitoring or pile load tests are required per BCM 49-1, Piling – General.

ii. Prepare Form SC-4803, Pile Quantity and Driving Record (Driven Piles), Form SC-4805, Log Pile Sheet, and Form SC-4806, Pile Layout Sheet, for all locations with driven piling. See Foundation Manual, Chapter 7, Driven Piles, Section 7-6, Preparing to Drive Piles and Appendix K1.

iii. Prepare bearing acceptance criteria:

1. For driven piling to be accepted using the Gates Formula, prepare pile acceptance charts for each authorized hammer using Form SC-4809, Pile Driving (US Customary) Blows Per Foot using Gates Formula, as described in Attachment 2, Driven Piling – Acceptance Criteria, with modifications as required to account for battered piling.

2. For driven piling to be accepted using bearing acceptance criteria determined by dynamic monitoring, verify bearing acceptance criteria has been received from FTI per BCM 49-1, Piling – General.

iv. Review the project specific Code of Safe Practices (COSP) for personal protective equipment requirements and safety hazards associated with the pile driving operation.

v. Review the pile driving equipment and verify it matches the authorized DSS and/or Pile and Driving Data Form per the Foundation Manual, Section 7-6 and Appendix K1.

vi. If the pile driving crane is used for tasks other than pile driving, verify the operator certification meets the requirements of CCR Cal/OSHA CSO §1618.1, Operator Qualification and Certification.

viii. Confirm how the hammer stroke will be measured during driving.
ix. Verify pile lengths for the given location where piles are to be driven. See *Foundation Manual*, Section 7-6, and Appendix K1.
x. Verify the locations of reference staking hubs where piles are to be driven to provide pile cutoff elevations during driving. See *Foundation Manual*, Section 7-6, Table 7-11, and Appendix K1.
xi. Verify pile marking at 1-foot intervals to measure penetration during driving. See *Foundation Manual*, Section 7-6, and Appendix K1.
xii. Check that the contractor’s pile layout meets contract requirements. See *Foundation Manual*, Section 7-6, and Appendix K1.

4. During construction:
a. Inspect piling delivered to the job site, as follows:
   i. Review materials as they are delivered to the job site:

b. Discuss driven piling operations in a Tailgate Safety meeting before field operations begin:
   i. Ensure personal protective equipment, including hearing protection, is available and ready for use.

c. When predrilled holes are required through new embankments, verify the hole is 6-inches greater than the largest pile dimension.

d. Use Form SC-4806, *Pile Layout Sheet*, to verify the pile location at the start of driving.

e. Verify the vertical alignment (plumb or battered) of the pile at the start, and during driving.

f. Monitor and log the blow count, hammer stroke, any predrilling completed, vibratory hammer usage, driving stoppages, cushion changes and pile penetration during driving on Form SC-4803, *Pile Quantity and Driving Record (Driven Piles)* and Form SC-4805, Log Pile Sheet. See *Foundation Manual*, Section 7-6:
g. Monitor at the start and periodically check the noise and vibration due to pile driving to ensure compliance with the requirements of the contract documents.

h. Monitor the hammer performance during driving to verify it is operating as anticipated.

i. For double-acting pile driving hammers or other hammer types where the ram stroke cannot be visually observed:
   i. Receive the printed readout of hammer energy for each pile during driving operations from the contractor.
   ii. Determine pile acceptance using the printed readout hammer energy delivered at the pile specified tip elevation.

j. Verify piles are driven to the correct position and alignment. See *Foundation Manual*, Section 7-7.3.

k. If hard driving is encountered, address the contractor’s request for use of driving aids such as drilling, spudding, jetting, or raising the specified tip elevation. See *Foundation Manual*, Section 7-7, and Appendix K1:
   i. Consult with Geotechnical Services before authorizing the contractor’s requests.
   ii. Consider if the hammer is not operating properly. Consult with FTI.
   iii. After conferring with the Geotechnical Engineer, if deemed appropriate, the contractor may use a predrilled hole no larger than the minimum cross-sectional pile dimension.

l. If soft driving is encountered, implement the use of pile lugs in accordance with *Attachment 1, Driven Piling – Steel H-Pile Lugs*, lower the specified tip elevation, or re-drive the pile. See *Foundation Manual*, Section 7-7, and Appendix K1:
   i. Consult with Geotechnical Services before authorizing contractor requests.

m. Check the reference staking hubs periodically to verify elevation is not changing due to soil heave during pile driving.

n. Confirm field welded splices meet the requirements of the contract documents:
   i. Coordinate inspection of field welded splices with the METS Representative as needed.

o. For rejected piling proposed for use, the contractor must propose a repair plan in writing. Coordinate review of the repair plan with the Structure and Geotechnical Designers.
p. Contact the Structure and Geotechnical Designers for pile design revisions, if needed due to:
   i. Fabrication issues.
   ii. Proposals to raise or lower tip elevation.
   iii. Pile relocation.
   iv. Other unforeseen issues.
q. Use the pile driving acceptance criteria chart for the impact hammer used to drive each pile to determine whether each driven pile can be accepted for bearing.
r. Accept driven piling that is in the correct position and alignment and achieves proper bearing and specified tip. If specified tip elevation is not reached, the Structure Representative determines whether to accept or reject the pile, with concurrence from Geotechnical Services.
s. Keep accurate pile logs and field documentation to ensure:
   i. Good documentation for claim disputes and record audits.
   ii. Sufficient information for progress payments.
t. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Measurement and Payment:
   a. Prior to each progress payment, compare Materials on Hand vs. Furnish Piling requirements per Attachment 3, Driven Piling – Measurement & Payment.
   b. Prior to authorizing payment for Furnish Piling:
      i. Review Attachment 3, Driven Piling – Measurement & Payment.
      ii. Inspect piling delivered to the job site.
      iii. Reject damaged precast concrete piling per Foundation Manual, Section 7-6.2.1, Precast Concrete Piles.
   c. Prior to authorizing payment for Drive Piling:
      i. Review Attachment 3, Driven Piling – Measurement & Payment.
      ii. Verify accurate completion of Form SC-4803, Pile Quantity and Driving Record (Driven Piles), and Form SC-4806, Pile Layout Sheet.
   d. After consulting with the Structural and/or Geotechnical Designer, prepare change order(s) per BCM C-10, Change Orders, for piling driven beyond the specified tip elevation to achieve bearing, if applicable. If bearing is reached
at specified tip, no payment is made for piling driven beyond specified tip elevation.

e. File all payment records in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

6. Following construction:


b. File all project documentation (materials acceptance documentation, correspondence, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Submittals:

a. Authorized Pile and Driving Data forms

b. Authorized Driving System Submittal, if applicable

c. Authorized pile submittals for steel pipe piling, structural shape steel piling, precast prestressed concrete piling, and steel sheet piling

2. Materials:

a. Form TL-0029, Report of Inspection of Material, and matching orange tags

b. Completed Form SC-4101, Materials Release Summary, and Form SC-4102, Material Inspected and Released on Job

3. Construction:

a. Completed pile driving acceptance criteria charts

b. Completed Forms SC-4803, SC-4805, and SC-4806

c. Daily Reports

**Attachments**

- **Attachment 1:** Driven Piling – Steel H-Pile Lugs
- **Attachment 2:** Driven Piling – Acceptance Criteria
- **Attachment 3:** Driven Piling – Measurement & Payment
Pile lugs are welded onto steel H-piles prior to driving. The lug increases the friction resistance of the pile so that the bearing is achieved with a shorter pile. Welding of steel pilings, including attachment of lugs, must conform to Section 11, Welding, of the Contract Specifications. The details for pile lugs are shown in Figure 1, Pile Lug Details.

When recommended by Geotechnical Services, the pile lug detail will be shown on the plans. Review the Special Provisions for measurement and payment. Lugs that are shown on the plans are paid as furnishing piling per the Contract Specifications.

When lugs are not shown on the plans, and when the piles are driving longer than anticipated, immediately contact Geotechnical Services. An alternative to the use of lugs is to let the piles set up and to re-drive (and check bearing) a day or two later.

The contractor may request lugs, or the engineer may order lugs. Savings from reducing the length of the pile must be compared with the cost for furnishing, welding, and performing welding quality control on the lugs. Lugs might not be economical when there is no other welding on the job.

Lugs installed at the direction of the engineer are paid for as change order work.
Driven Piling – Steel H-Pile Lugs

Figure 1. Pile Lug Details

SECTION A-A
PILE LUG

Figure 1. Pile Lug Details
Driven Piling – Acceptance Criteria

To verify that the proposed hammer can develop the required minimum energy as required by the specifications, use the manufacturer’s maximum energy rating and the nominal driving resistance to calculate the maximum acceptable blow count (not exceeding 96 blows per foot which is equivalent to a penetration rate of not less than 1/8 inch per blow). Hammer data is typically submitted by the contractor and can be found at the hammer manufacturer website or by contacting Foundation Testing and Instrumentation.

When calculating the number of blows for the required nominal driving resistance, the hammer energy rating \( (E_r) \) can be calculated by multiplying the hammer ram weight by the observed stroke.

Form SC-4809, *Pile Driving (US Customary) Blows Per Foot using Gates Formula*, is used to calculate number of blows in the last foot \( (N) \) value based on the stroke height \( (H) \) and the hammer energy rating \( (E_r) \).

Appendix E, *Driven Piles*, of the *Foundation Manual* provides example calculations for minimum hammer energy, establishing a blow count chart, battered pile blow count chart, and other examples.

It is important to note that:

- The *Gates Formula* uses nominal values. Nominal resistance and nominal driving resistance of a given pile are shown in the Pile Data Table on the contract plans.

- The nominal driving resistance is always equal to or greater than the nominal resistance. This is because the nominal driving resistance accounts for driving resistance through unsuitable penetrated soil layers (very soft, liquefiable, scourable, etc.) which do not contribute to the design nominal resistance.

- Even under ideal hammer operations, the energy dissipation from impact and losses to the hammer mechanism may greatly reduce the actual energy delivered to the pile during driving. Additional losses may occur due to improper or inadequate hammer use, changing fuel setting, using interchangeable ram, etc. Be aware of reductions in actual hammer energy. Using a false high hammer energy value in the *Gates Formula* will give false high nominal resistance results.
Driven Piling – Measurement & Payment

Driven piling that fails to reach tip elevations shown on the plans but has been determined to be adequate and approved by the designer, is measured along the longest side, from the tip elevation shown on the plans to the plane of cut-off elevation.

Materials on Hand

When the contract special provisions qualify the material for Materials on Hand and it does not meet the requirements for “furnishing”, payment may be made as Materials on Hand at the contractor’s request.

Steel piling and precast concrete piling are typically listed in the contract special provisions as being eligible for payment for Materials on Hand, but not yet incorporated in the work.

Determine eligibility for Materials on Hand payments per the Construction Manual, Section 3-906E, Materials on Hand.

Furnish and Drive Piling Contract Item Payment

When steel or precast concrete piling of proper length are delivered to the job site ready for driving, the Contract Specifications requirement for furnishing have been met and the material should be paid under furnish piling item on the monthly progress pay estimate. Piles stored offsite, or onsite but not ready for driving, are to be considered as Materials on Hand.

For steel pipe piling, full payment on the furnished item will not be made until the piling is on site and all field welds are completed and approved. This work includes welding of splices, and shear rings, when required in the contract documents.

The length of piling that extends beyond the tip elevation shown on the plans, as ordered by the engineer to meet design requirements, will be paid for as Extra Work or change order work.
Piling – Cast-In-Place Concrete Piling

Revision and Approval

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Background

This process establishes the Structure Construction (SC) responsibilities and procedures for review and authorization of cast-in-place concrete piling submittals, quality assurance, materials, construction, and payment that apply to all cast-in-place concrete piling.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review Contract Specifications (CS), Section 49-3, Piling – Cast-In-Place Concrete Piling, that this BCM is based on as identified in the title block above. The information in the CS typically will not be repeated in the text of this BCM.

Process Inputs

1. For all Cast-In-Place (CIP) concrete piling:
   a. Concrete mix design:
      i. Prequalification of concrete
      ii. Mass concrete requirements, if applicable
   b. Form CEM-3101, Notice of Materials to Be Used
   c. Form TL-0029, Report of Inspection of Material
   d. Crane certification
2. For all Cast-In-Drilled-Hole (CIDH) concrete piling and CIDH concrete piling rock sockets:
a. The Contractor arranges CIDH pile preconstruction meeting
b. CIDH Pile forms, as applicable:
   i. Form SC-3801, GGL Inspection Pipe Verification
   ii. Form SC-3802, Drilled Shaft Inspector’s Checklist
   iii. Form SC-3803, Drilled Shaft Excavation Log
   iv. Form SC-3804, Drilled Shaft Excavation Profile
   v. Form SC-3805, Drilled Shaft Bottom Inspection
   vi. Form SC-3806, Slurry Test Record
   vii. Form SC-3807, Inspection Pipe and Rebar Coupler Log
   viii. Form SC-3808, Drilled Shaft Concrete Placement Log
   ix. Form SC-3809, Drilled Shaft Concrete Placement Graph
   x. Form SC-4804, Pile Quantity and Drilling Record (CIDH Piles)
   xi. Form SC-4806, Pile Layout Sheet
c. Drilling equipment operational capacities, if applicable
d. Pile installation plan (PIP)
e. Plastic spacer manufacturer’s data and sample

3. For CIDH concrete piling and CIDH concrete piling rock sockets constructed with inspection pipes:
   a. Authorized concrete test batch for concrete to be placed under slurry
   b. Synthetic slurry manufacturer staff certifications
   c. Pile acceptance test report from Foundation Testing and Instrumentation (FTI)

4. For rejected CIDH concrete piling:
   a. Revised pile installation plan
   b. Coring logs and concrete cores, when required
   c. Pile Design Data Form from FTI
   d. CIDH concrete pile testing report for authorized tests performed by the Contractor on rejected piles
   e. Contractor arranges CIDH Pile Nonstandard Mitigation Meeting, if applicable
   f. Pile mitigation plan, if applicable
   g. Pile mitigation plan review memo, if applicable
   h. Pile mitigation report, if applicable
5. For all cast-in-steel-shell (CISS) concrete piling:
   a. Submittal for cleanout method of open-ended steel shells
   b. Steel shell submittals per BCM 49-2, Piling – Driven Piling

Procedure

1. All work associated with this process is charged as Project Direct – Construction.
2. Inspection of field work for this process is:
   a. Benchmark for:
      i. Review of CIP concrete piling submittals
      ii. Inspection and verification of materials used during construction
      iii. Inspection of pile layout and reference elevations
   b. Intermittent for:
      i. Inspection of pile cage reinforcement
      ii. Water removal
      iii. Inspection pipe installation
      iv. Concrete coring
      v. Temporary casing installation
      vi. Field welding of permanent casing and steel shells
   c. Continuous for:
      i. Installation of steel shells
      ii. Drilling
      iii. Inspection pipe integrity verification
      iv. Cleaning drilled holes
      v. Slurry testing
      vi. Critical Lifts/Work adjacent to traffic
      vii. Placing Concrete
      viii. Pile mitigation work

3. Before construction begins, the Structure Representative (SR) or delegate must:
   a. Perform the following document review and collaboration:
      i. Identify environmental and other physical conditions that affect CIP concrete piling construction during a preconstruction jobsite visit.
ii. Review the contract documents for difficult pile installation conditions per BCM 49-1, Piling – General.

iii. Review the contract documents, Resident Engineer (RE) Pending File, foundation report, and supplemental project information for applicable environmental commitments and railroad requirements.

iv. Review the project-specific Code of Safe Practices and the requirements of Cal/OSHA Title 8, Chapter 4, Subchapter 4, Construction Safety Orders, for CIP concrete piling construction, including but not limited to:
   1. Article 6, Excavations
   2. Article 9, Derricks, Cranes, Boom-type Excavators
   3. Article 12, Pile Driving and Pile Extraction
   4. Article 15, Cranes and Derricks in Construction
   5. Article 24, Fall Protection
   6. Article 37, Confined Spaces in Construction

v. For CIDH concrete piles over 20 feet in depth or 30 inches in diameter where there is potential of human entry, review the requirements of Cal/OSHA Title 8, Chapter 4, Subchapter 17, Mine Safety Orders, and Cal/OSHA Title 8, Chapter 4, Subchapter 20, Tunnel Safety Orders.

vi. Discuss with the RE and the Contractor any existing facilities concerns and agency requirements, such as overhead power lines, underground utilities, railroad requirements, and call Underground Service Alert (USA) if applicable.

vii. Notify the Foundation Testing and Instrumentation Branch (FTI) of the pile driving requirements for permanent casings and steel shells.

b. Perform the following submittal review and authorization:

i. For all CIP concrete piling:
   1. Review submittal requirements and identify when each submittal is needed per the contract documents. For information pertinent to submittal review, refer to the Foundation Manual, Section 6-6, Inspection and Contract Administration; Section 9-8, Inspection and Contract Administration; Section 9-9, Pile Acceptance Testing; Section 9-10, Defective Piles; and Section 9-11, Pile Mitigation and Acceptance.
   2. Discuss submittal concerns with the Bridge Design (BD) Structure Project Engineer, Geotechnical Services GS Geoprophessional, FTI, the SC Substructure Engineer who is also the DES Pile Mitigation Committee Chair, and the Materials Engineering and Testing Services Representative (METS Rep).
3. Verify the concrete mix design, cementitious material content, and aggregate gradation requirements are met in accordance with the requirements of the contract documents. Discuss concrete testing requirements with the Contractor. For additional information, refer to BCM 90-1, Concrete – General.

4. Receive, review, and authorize or reject all required submittals. Notify the Contractor in writing.

5. Track the status of all CIP concrete piling submittals for complete and timely review.

   ii. For Cast-in-Drilled-Hole (CIDH) concrete piling and CIDH concrete piling rock sockets:

   1. Prior to the CIDH pile preconstruction meeting, receive and review the pile installation plan.

   2. Discuss submittal requirements, including complete and timely submittals, during the CIDH pile preconstruction meeting.

   3. Verify cementitious material content, and aggregate gradation requirements are met for the grout mix design or slurry cement backfill mix design for use with permanent steel casings.

   4. Verify drilling equipment operational capacities are included in the pile installation plan when required. Discuss whether the proposed drilling equipment is viable for the ground conditions with the SC Substructure Engineer, FTI, and GS Geoprofessional.

   5. Verify spacers meet the requirements of the contract documents and are field released via Form SC-4102, Material Inspected and Released on Job, and Attachment 6, CIDH Concrete Piling – Materials.

   6. CIDH concrete piling constructed without inspection pipes do not require submittals for slurry test records, inspection pipe and reinforcing cage couplers log, coring logs and concrete cores, testing reports, pile mitigation plans, or mitigation reports.

   7. For CIDH concrete piling and CIDH concrete piling rock sockets constructed with inspection pipes:

      a. Verify appropriate certifications for trained Contractor employees, synthetic slurry, and any proposed additives are authorized for use as shown in the contract documents are submitted per Attachment 6, CIDH Concrete Piling – Materials.

      b. Verify inspection pipes meet the requirements of the contract documents and are field released via Form SC-4102, Material Inspected and Released on Job.
c. Witness the production of the concrete test batch and verify the requirements of the contract documents are met.

8. Following the CIDH pile preconstruction meeting, authorize or reject the pile installation plan. Notify the Contractor in writing. Review and authorize revisions as needed.

iii. For CISS concrete piling:

1. Refer to BCM 49-2, Piling – Driven Piling, for submittal requirements for steel shells.

2. Review and authorize the submittal for cleaning out open ended steel shells.

c. CIDH pile preconstruction meeting:

i. Identify and invite required CIDH pile preconstruction meeting attendees as described in Attachment 1, CIDH Concrete Piling – Preconstruction Meeting Instructions.

ii. Provide the submitted pile installation plan to all required CIDH pile preconstruction meeting attendees.

iii. Prior to the CIDH pile preconstruction meeting:

1. Visit the site of each CIDH concrete pile to evaluate potential conflicts.

2. Discuss concerns with the SC Substructure Engineer, BD Structure Project Engineer, GS Geoprofessional, and FTI. Invite appropriate staff to the CIDH pile preconstruction meeting.

3. Review the standard CIDH pile preconstruction meeting agenda in Attachment 1 with Caltrans attendees and the Contractor. Customize the standard CIDH pile preconstruction meeting agenda as needed with specific discussion topics. Distribute the meeting agenda to all invitees prior to the meeting.

4. Coordinate the date, time, and location of the CIDH pile preconstruction meeting with the Contractor. Verify the Contractor schedules the CIDH pile preconstruction meeting in the time frame specified in the contract documents.

iv. Conduct the CIDH pile preconstruction meeting and take meeting minutes as described in the Foundation Manual, Section 6-6.2, CIDH Pile Preconstruction Meeting, and Attachment 1.

1. Discuss contingency plans for capturing risks and opportunities identified during the CIDH pile preconstruction meeting. Document them in the meeting minutes.

2. Discuss the pile installation plan with attendees and discuss potential issues. Require resubmittal if needed.
v. Following the CIDH pile preconstruction meeting:
   1. Distribute the meeting minutes to all invitees.
   2. File CIDH pile preconstruction meeting minutes and any other
documented information from the meeting in the appropriate category
in the project records as specified in the Construction Manual,
Section 5-102, Organization of Project Documents.

vi. Review and authorize any revisions to the pile installation plan.

d. Materials review:
   i. Review and discuss with the METS Rep any CIP concrete piling materials
to be inspected and released via Form CEM 3101, Notice of Materials to
be Used, and Form TL-0029, Report of Inspection of Material, and which
materials are to be field released via Form SC-4102, Material Inspected
and Released on Job. Utilize the forms to justify any materials on hand
payments.

   ii. Discuss field welding requirements per the contract documents and AWS
D1.1, Structural Welding – Steel, with the Contractor and the METS Rep.
The AWS D1.1, Structural Welding – Steel, can be accessed using the
Engineering Workbench section of the Caltrans Transportation Library,
which requires a one-time registration to access.

   iii. Authorized or reject Field Welding Submittals, Personnel Qualifications
and Certifications if necessary, per the CS, Section 11-2, Welding –
Quality Control, and guidance in BCM 11, Welding.

   iv. Review the Construction Manual, Section 6-107, Materials Acceptance
Sampling and Testing, Table 6-1.17, Materials Acceptance Sampling and
Testing Requirements: Concrete, for CIP concrete piling materials testing
schedules.

e. Preparing for construction:
   i. For all CIP concrete piling:
      1. Review the Log of Test Borings.
      2. Review the location of existing utilities.
      3. Review contract documents for mass concrete requirements, when
applicable.

   ii. For CIDH concrete piling and CIDH concrete piling rock sockets:
      1. Prepare Form SC-4806, Pile Layout Sheet, for each support location
with CIDH concrete piling.
      2. Prepare Form SC-4804, Pile Quantity and Drilling Record (CIDH
Piles), for each support location with CIDH concrete piling.
3. For CIDH concrete piles less than 24 inches in diameter with potential groundwater issues, discuss the potential for increasing the diameter and revising the pile tip elevation with the Contractor. Tip elevation must not be revised for retaining walls and sound walls.

4. Discuss drilling sequence with the Contractor when CIDH concrete piles are in close proximity per the requirements of the contract documents.

5. Discuss with the Contractor the handling and disposal of drill cuttings and groundwater:
   a. Coordinate environmental, water pollution control, and traffic control requirements with the Resident Engineer.
   b. Verify compliance with authorized project Authorized Storm Water Pollution Prevention Plan or Water Pollution Control Program.

6. If proposed for use, verify drilling slurry and any proposed additives are authorized for use as described in the contract documents, and that appropriate certifications for trained Contractor employees are submitted. For additional information refer to Attachment 6, CIDH Concrete Piling – Materials.

7. If used, verify plastic spacers meet the requirements of the contract documents per Attachment 6, CIDH Concrete Piling – Materials.

8. If used, verify permanent steel casings are inspected and released by the METS Rep.
   a. For permanent steel casings, verify welding quality control plan and welder certification requirements have been met per the CS, Section 11-2, Welding – Quality Control, and guidance in BCM 11, Welding.

iii. For CISS concrete piling:

1. As applicable discuss with FTI and the GS Geoprofessional dynamic monitoring, pile load testing, potential damage to permanent steel casings or steel shells, and mitigation methods to repair damage.

2. Discuss with the GS Geoprofessional potential risks with soil plugs and seal course and potential mitigation methods.

4. During construction, the SR or delegate must:
   a. For all CIP concrete piling:
      i. Review materials as they are delivered to the job site.
      1. Collect Form TL-0624, Inspection Release Tag, also known as the orange inspection release tag, and match them to Form TL-0029, Report of Inspection of Material.
2. Collect certificates of compliance for the steel reinforcement.


ii. Discuss CIP concrete piling operations in a tailgate safety meeting before field operations begin:

1. Assure personal protective equipment, including fall protection harness and lanyard, is available and ready for use.

iii. Document and photograph all equipment and tooling on the job site.

iv. Verify crane and operator certifications meet the requirements of Cal/OSHA Title 8, Chapter 4, Subchapter 4, Construction Safety Orders, Article 15, Cranes and Derricks in Construction.

v. Sample and test CIP concrete materials per the requirements of the contract documents, as outlined in the Construction Manual, Section 6-107, Materials Acceptance Sampling and Testing, Table 6-1.17, Materials Acceptance Sampling and Testing Requirements: Concrete.

vi. Complete bid item payment and materials on hand payment for the applicable CIP concrete piling bid items upon successful placement of the pile concrete, including receipt of all required forms from the Contractor.

b. For CIDH concrete piling and CIDH concrete piling rock sockets:

i. Review the authorized pile installation plan.

ii. Review Form SC-3802, Drilled Shaft Inspector’s Checklist, Contractor and Equipment Arrive on Site section. Use this form to verify all applicable items are completed.

iii. Review Outline of Field Construction Practices, Section 4, Cast-In-Place (CIP) Concrete Piling.

iv. Complete Form SC-4804, Pile Quantity and Drilling Record (CIDH Piles), for each support location with CIDH concrete piling.

v. If used, for permanent steel casings, verify welding quality control plan and welder certification requirements have been met per the CS, Section 11-2, Welding – Quality Control, and guidance in BCM 11, Welding.

vi. Inspect drilled holes per the Foundation Manual, Chapter 6, Cast-In-Drilled-Hole Piles, and Chapter 9, Slurry Displacement Piles, and Attachments 1-6.

1. Review Form SC-3802, Drilled Shaft Inspector’s Checklist, Shaft Excavation and Cleaning section. Use this form to verify all applicable items are completed:

a. Assure that suitable tools, such as a mirror or flashlight, are available for inspecting the conditions of the drilled hole.
2. Using Form SC-4806, *Pile Layout Sheet* and the contract documents, verify the Contractor’s pile layout of CIDH concrete piling. Verify the location of the drilled hole is within tolerance specified in the contract documents.

3. Verify concrete will be placed against undisturbed material at the limits of excavation.

4. Verify hole drilling pattern conforms to the requirements of the contract documents.

5. For piles 24 inches in diameter or larger, as each hole is being drilled, complete Form SC-3803, *Drilled Shaft Excavation Log*.

6. Evaluate whether the material excavated from the drilled hole is consistent with the material description in the contract documents:
   a. Document deviations on Form SC-3803 for potential identification of differing site conditions.
   b. Discuss deviations with the GS Geoprofessional and the SC Substructure Engineer to determine whether a differing site condition exists.
   c. If the Contractor submits notification of a differing site condition, follow the procedures in the *Construction Manual*, Section 3-404, *Differing Site Conditions*.

7. Verify plumbness of the drilled hole.

8. If caving holes or groundwater are encountered, verify the Contractor uses methods that conform to the requirements of the contract documents.

9. If drilling slurry is introduced into the drilled hole, verify the Contractor’s use of drilling slurry per the requirements of the contract documents and Attachment 6, *CIDH Concrete Piling – Materials*.
   a. Verify that drilling slurry is tested at specified intervals. Verify the Contractor documents results of slurry testing on Form SC-3806, *Slurry Test Record*:
      i. Assure a slurry test kit is available for sampling and testing the drilling slurry periodically per Attachment 6, *CIDH Concrete Piling – Materials*.
      ii. The Contractor can submit this information on their own form, provided the form contains all information required in the contract documents.
   b. Verify drilling slurry levels in the drilled hole are maintained as required in the contract documents.
10. Verify pile tip elevation.

11. For piles 24 inches in diameter or larger, when the pile tip elevation has been reached, complete Form SC-3804, *Drilled Shaft Excavation Profile*:
   a. If special testing is required in the contract documents for the bottom of the hole, verify FTI performs the testing before the Contractor places the pile reinforcement cage and prior to concrete placement.

12. Verify the bottom of the drilled hole is clean. For piles 24 inches in diameter or larger, complete Form SC-3805, *Drilled Shaft Bottom Inspection*, to document the condition of the bottom of the drilled hole.

13. Verify the Contractor provides worker protection for the area per Cal/OSHA Title 8, Chapter 4, Subchapter 4, *Construction Safety Orders*, Article 24, *Fall Protection*.

vii. If used, inspect use of temporary casing per *Foundation Manual*, Chapter 6, *Cast-In-Drilled-Hole Piles*, and Chapter 9, *Slurry Displacement Piles*, and Attachments 1-6:
   1. Discuss potential issues with the use of temporary casings with the Contractor.
   2. Verify temporary casings are used in accordance with the requirements of the contract documents.
   3. For piles 24 inches in diameter or larger, document any use of temporary casings on Form SC-3804, *Drilled Shaft Excavation Profile*.
   4. During concrete placement, verify the Contractor removes the temporary casing in accordance with the requirements of the contract documents.

   1. When permanent steel casings are required:
      a. Verify the permanent steel casing is installed as specified in the contract documents.
      b. Verify grout placement to seal the permanent steel casing is performed in accordance with the requirements of the contract documents.

1. Review Form SC-3802, *Drilled Shaft Inspector’s Checklist, Reinforcing Cage* section. Use this form to verify all applicable items are completed.

2. For piles 24 inches in diameter or larger, verify the Contractor documents and submits the locations of any bar reinforcement couplers on Form SC-3807, *Inspection Pipe and Rebar Coupler Log*. The Contractor can submit this information on their own form, provided the form contains all information required in the contract documents.

3. For cages 4 feet in diameter or larger, verify sufficient rebar intersection ties are present per the requirements of the contract documents.

4. For drilled holes that have authorized increased diameters or revised tip elevations, verify the requirements of the contract documents are met.

5. If plastic spacers are used, verify the location and spacing of the plastic spacers conforms to manufacturer’s recommendations and the requirements of the contract documents per Attachment 6, *CIDH Concrete Piling – Materials*.

6. Verify the bottom of the drilled hole is clean before placing the pile reinforcement cage.

7. Verify the position of the pile and/or column reinforcement conforms to the tolerance and clearance requirements of the contract documents.

8. For any shaft where the reinforcement cage extends 20 feet or more in height above grade, verify the Contractor installs the temporary support system per BCM 52-1, *Reinforcement – General*.

   x. If used, inspect vertical inspection pipes per *Foundation Manual*, Chapter 9, *Slurry Displacement Piles*, and Attachments 1-6:

   1. Assess the conditions of the drilled hole and verify whether inspection pipes are required.

   2. Verify installation of inspection pipes during fabrication of the pile reinforcement cage is performed in accordance with the requirements of the contract documents.

   3. Verify the Contractor documents the locations of inspection pipe couplers on Form SC-3807, *Inspection Pipe and Rebar Coupler Log*.

   4. Following placement of pile concrete:

      a. Verify inspection pipes are clear for acceptance testing as specified in the contract documents. Document the results on Form SC-3801, *GGL Inspection Pipe Verification*. 
b. For any blocked inspection pipes:
   i. Discuss the nature of the blocked inspection pipes with the DES Pile Mitigation Committee, starting with the SC Substructure Engineer.
   ii. Unless the DES Pile Mitigation Committee recommends otherwise, verify the Contractor performs coring to replace the blocked inspection pipe as specified in the contract documents.

xii. Inspect construction joints per Foundation Manual, Chapter 9, Slurry Displacement Piles, and Attachments 1-6:
   1. Verify the Contractor installs a permanent steel casing for worker protection at the location of the construction joint in accordance with the requirements of the contract documents.
   2. Following concrete placement, verify that excess concrete is removed to the elevation of the construction joint. Verify the Contractor’s safety procedures are in accordance with the requirements of Cal/OSHA Title 8, Chapter 4, Subchapter 4, Construction Safety Orders, Article 6, Excavations, and Article 37, Confined Spaces in Construction.

xiii. Inspect CIDH concrete piling concrete placement under drilling slurry per Foundation Manual, Chapter 9, Slurry Displacement Piles, and Attachments 1-6.
   1. Prior to concrete placement:
a. Review Form SC-3802, *Drilled Shaft Inspector’s Checklist, Concrete Placement* section. Use this form to verify all applicable items are completed.

b. Verify the drilling slurry meets the specified material requirements per Attachment 6, *CIDH Concrete Piling – Materials*. Verify the Contractor documents results of slurry testing on Form SC-3806, *Slurry Test Record*.

c. Verify the Contractor performs a final cleaning of the bottom of the drilled hole.

d. Verify the Contractor has Form SC-3808, *Drilled Shaft Concrete Placement Log*, and Form SC-3809, *Drilled Shaft Concrete Placement Graph*, and is ready to fill them out during concrete placement.

e. Verify the Contractor has all necessary equipment and contingency equipment specified in the contract documents.

2. During concrete placement:

a. Verify the concrete mix delivered is the authorized concrete mix design.

b. Verify the Contractor caps or plugs the concrete delivery tube prior to first discharge or concrete into the pile:
   
i. Verify the Contractor recovers the cap or plug after concrete placement begins.

c. Verify the Contractor maintains concrete delivery tube embedment and drilling slurry elevations as specified in the contract documents.

d. When temporary casing is used, verify the Contractor is continuously monitoring the elevation at the bottom of temporary casing as it is removed.

e. If the Contractor loses the seal on the concrete delivery tube, verify the Contractor reinserts the concrete delivery tube per the requirements of the contract documents.

f. Verify the Contractor “wastes” any slurry-contaminated concrete from the top of the pile.

g. After concrete placement is completed:
   
i. Verify the Contractor fills the inspection pipes with water.

   ii. If visible, observe the top pile concrete for signs of excessive bleed water or subsidence.
h. Verify the Contractor completes Form SC-3808, *Drilled Shaft Concrete Placement Log*, and Form SC-3809, *Drilled Shaft Concrete Placement Graph*, during concrete placement and submits these forms following concrete placement. The Contractor can submit information on the Contractor’s forms, provided the Contractor’s forms contain all information required in the contract documents.

xiv. Document all inspection, construction, and quality assurance activities in the daily reports per BCM C-7, *Daily and Weekly Reports*.

xv. Complete Form SC-4804, *Pile Quantity and Drilling Record (CIDH Piles)*, for each pile placed.

c. For CISS concrete piling:
   ii. Review materials as they are delivered to the job site.
      2. Collect certificate of compliance for the steel reinforcement.
   iii. Inspect steel shells as they are driven for compliance with the requirements of the contract documents.
   iv. Inspect steel shells after they are driven for damage or reduced diameter.
      1. If the steel shells are damaged, reject the steel shell.
      2. Resolve rejected steel shells in coordination with the Contractor, the BD Structure Project Engineer and the GS Geoprofessional.
   v. For open-ended steel shells:
      1. If ground water is present in the steel shell, determine whether:
         a. To allow the Contractor to dewater the steel shell, or
         b. To require the Contractor to seal the bottom of the steel shell with a seal course.
         c. To use of the slurry displacement method if appropriate.
      2. Verify the Contractor does not damage or disturb the soil plug at the bottom of the steel shell.
3. Verify the Contractor cleans out the inside of the steel shell in accordance with the requirements of the contract documents.

4. Verify steel shells are clean and free of debris before placing bar reinforcement and concrete.

vi. Verify placement of reinforced concrete in the steel shell is in accordance with the requirements of the contract documents.

vii. Document all inspection, construction, and quality assurance activities in the daily reports per BCM C-7, Daily and Weekly Reports.

d. Complete the following forms for each CIP concrete pile as applicable:

i. Form SC-4804, Pile Quantity and Drilling Record (CIDH Piles)

ii. Form SC-4806, Pile Layout Sheet

iii. Form SC-3801, GGL Inspection Pipe Verification

iv. Form SC-3802, Drilled Shaft Inspector’s Checklist

v. Form SC-3803, Drilled Shaft Excavation Log

vi. Form SC-3804, Drilled Shaft Excavation Profile

vii. Form SC-3805, Drilled Shaft Bottom Inspection

e. Verify receipt of the following forms from the Contractor for each CIP concrete pile as applicable. The Contractor can submit information on the Contractor’s forms, provided the Contractor’s forms contain all information required in the contract documents:

i. Form SC-3806, Slurry Test Record.

ii. Form SC-3807, Inspection Pipe and Rebar Coupler Log

iii. Form SC-3808, Drilled Shaft Concrete Placement Log

iv. Form SC-3809, Drilled Shaft Concrete Placement Graph

f. For Department Acceptance of CIDH concrete piling and CIDH concrete piling rock sockets (applies to CIDH concrete piling with inspection pipes):

i. Notify FTI of pile acceptance testing within 15 days of anticipated need. Submit the CIDH Pile Acceptance Test Request Form per Attachment 2, CIDH Concrete Piling – Contract Administration and Department Acceptance.

ii. Verify the Contractor prepares for pile acceptance testing per California Test 233, Method of Ascertaining the Homogeneity of Concrete in Cast-In-Drilled-Hole (CIDH) Piles Using the Gamma-Gamma Test Method.

1. Verify that inspection pipes are clear for pile acceptance testing equipment per Attachment 2:
a. Complete Form SC-3801, *GGL Inspection Pipe Verification*, and request pile acceptance testing from FTI per Attachment 2.

b. If the inspection pipes are not clear for pile acceptance testing, discuss next steps with the DES Pile Mitigation Committee per Attachment 2, Section titled *Piles with Blocked Inspection Pipes*. See Attachment 3, *CIDH Pile Mitigation Committee*, for other services and roles of the DES Pile Mitigation Committee.

c. If the Contractor cores the CIDH concrete pile to replace blocked inspection pipes:
   i. Verify that the coring and logging operation comply with the contract requirements.
   ii. Confirm receipt of the coring logs and concrete cores.
   iii. Forward coring logs to FTI for coordinated review and recommendations per the contract documents, and the *Foundation Manual, Section 9-9, Pile Acceptance Testing*. Retain the concrete cores on site for further evaluation if needed.

2. Verify safe access for FTI staff around all installed CIDH concrete piling.

3. Verify the Contractor provides a 25’ radius clear zone around the CIDH concrete pile in preparation for acceptance testing in accordance with the requirements of the contract documents.

4. Document all inspection, construction, and quality assurance activities associated with inspection pipe clearance in the daily reports per *BCM C-7, Daily and Weekly Reports*.

iii. Prior to acceptance testing of constructed CIDH concrete piling:
   1. Forward the following completed forms for each CIDH concrete pile to FTI:
      a. Form SC-3801, *GGL Inspection Pipe Verification*
      b. Form SC-3807, *Inspection Pipe and Rebar Coupler Log*
      c. Form SC-3808, *Drilled Shaft Concrete Placement Log*
   iv. Track and maintain accurate timeline of all testing and mitigation activities below.
   v. FTI performs acceptance testing using California Test 233, *Method of Ascertaining the Homogeneity of Concrete in Cast-In-Drilled-Hole (CIDH) Piles Using the Gamma-Gamma Test Method*.
      1. Verify inspection pipe tops are cut off level and to the elevation confirmed with FTI.
2. Verify the Contractor secures the site from unauthorized entry.

3. Verify all construction staff follow radiation safety protocols.

vi. Review the pile acceptance test report upon receipt from FTI per Attachment 2.

vii. If the pile acceptance test report recommends pile acceptance, accept the pile. Notify the Contractor in writing per Attachment 2.

viii. If the pile acceptance test report recommends rejecting the pile, reject the pile. Notify the Contractor in writing per Attachment 2.

ix. For rejected piles:

1. Suspend concrete placement in the remaining piles.

2. Suspend subsequent reinforcing and concrete work on footings and abutments supported by the rejected pile(s).

3. Request a revised pile installation plan from the Contractor.
   a. Authorize the revised pile installation plan if it addresses the reasons for pile rejection. Notify the Contractor in writing and allow concrete placement to resume in the remaining piles.

4. If the Contractor chooses to perform CIDH concrete pile testing on a rejected pile:
   a. Confirm receipt of the testing report.
   b. Forward the testing report to FTI for coordinated review and recommendations per the Foundation Manual, Section 9-11, Pile Mitigation and Acceptance.
   c. Authorize or reject the acceptance testing report. Notify the Contractor in writing.

5. The pile acceptance test report will specify if FTI is planning to perform cross-hole sonic logging (CSL) testing. Contact FTI to confirm timely testing schedule to minimize debonding of PVC inspection pipes from the concrete pile, which can occur within 7-10 days.

6. Determine whether the rejected pile requires mitigation per Attachment 2:
   a. For rejected piles, the pile acceptance test report includes a Pile Design Data Form (PDDF). Send the PDDF to the BD Structure Project Engineer, GS Geoprofessional, and the METS Rep for Corrosion for completion and return in the time frame specified in the contract documents.
   b. If the pile acceptance test report requires additional pile testing, discuss and schedule additional pile testing with FTI:
i. Upon completion of additional pile testing, send the revised PDDF to the BD Structure Project Engineer, GS Geoprofessional, and the METS Rep for corrosion.

c. Upon receipt of the completed PDDF from the BD Structure Project Engineer, GS Geoprofessional, and the METS Rep corrosion:

i. Send the completed PDDF to the SC Substructure Engineer (DES Mitigation Committee Chair) per BCM C-6, Required Documents to be Submitted During Construction.

ii. Discuss whether mitigation is required with the DES Pile Mitigation Committee.

iii. If the rejected pile requires mitigation, discuss whether the pile can be repaired using the Caltrans Authorized – ADSC Standard Mitigation Plan with the DES Pile Mitigation Committee.

7. If the rejected pile does not require mitigation:

a. Notify the Contractor in writing per Attachment 2.

b. Calculate the administrative deduction and withhold the deduction from the next monthly progress payment.

c. Accept the pile.

d. If the Contractor elects to mitigate the pile in lieu of the administrative deduction, proceed to the next step.

8. If the rejected pile requires mitigation:

a. Require the Contractor to submit a pile mitigation plan.

b. Withhold 30% of the bid item price of the rejected pile in accordance with BCM C-9, Preparation of Progress Payment Documents, from the next progress pay estimate.

c. If the rejected pile requires mitigation and the pile cannot be repaired using the ADSC Standard Mitigation Plan:

i. Remind the Contractor to schedule a CIDH Pile Nonstandard Mitigation Meeting, per the requirements of the contract documents.

ii. Notify the DES Pile Mitigation Committee of the scheduled meeting.

iii. Conduct the meeting per Attachment 4, CIDH Pile Nonstandard Mitigation Meeting, and come to consensus with the Contractor regarding whether the rejected pile will be repaired using a nonstandard mitigation plan, supplemental piling, or replacement piling.
iv. Require the Contractor to submit a pile mitigation plan for non-standard repair, supplemental piling, or replacement piling.

d. Perform an initial review of the pile mitigation plan for completeness.

e. Send the reviewed pile mitigation plan to the DES Pile Mitigation Committee for technical review per the Foundation Manual, Section 9-11.6, Pile Mitigation Plan Development and Authorization Procedures.

f. FTI reviews the pile mitigation plan and issues a pile mitigation plan review memo to the DES Pile Mitigation Committee Chair.

g. Upon receipt of the pile mitigation plan review memo and review comments from the METS Rep for corrosion, BD Structure Project Engineer, GS Geoprofessional, and the DES Pile Mitigation Committee Chair issues the DES Pile Mitigation Committee Memo recommending authorization or rejection of the proposed pile mitigation plan.

9. Authorize or reject the pile mitigation plan per the recommendations of the DES Pile Mitigation Committee Memo.

10. Send the authorized pile mitigation plan to the SC Substructure Engineer (Mitigation Committee Chair) per BCM C-6, Required Documents to be Submitted During Construction.

11. Inspect the pile mitigation work performed in the field per Attachment 2 and the Foundation Manual, Section 9-11.10, What to Expect in the Field During Pile Mitigation:

   a. Verify the Contractor follows the requirements of the authorized pile mitigation plan.

   b. Accept or reject the mitigation work based on field conditions encountered during the mitigation work.

   c. Document all inspection, construction, and quality assurance activities associated with pile mitigation activities in the daily reports per BCM C-7, Daily and Weekly Reports.

12. Request the Contractor to submit a mitigation report:

   a. Perform an initial review of the mitigation report and send the reviewed mitigation report to the SC Substructure Engineer (DES Pile Mitigation Committee Chair) per BCM C-6, Required Documents to be Submitted During Construction:

      i. If the report does not match mitigation work performed, reject the mitigation report and request resubmittal. Review the mitigation report along with the daily reports.
b. Discuss the mitigation report with the DES Pile Mitigation Committee:
   i. If the mitigation report is in accordance with the authorized pile mitigation plan and reflects the mitigation work performed per the Foundation Manual, Section 9-11.11, Procedures for Authorizing the Pile Mitigation Work Performed in the Field and Pile Acceptance, accept the pile. Notify the Contractor in writing.

c. Release any payment withholds taken upon pile acceptance.

d. Inspection pipes can be grouted and sealed per the contract documents.

13. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the daily reports per BCM C-7, Daily and Weekly Reports.

14. File all test results and daily reports in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

5. Following construction, the SR or delegate must:
   a. File authorized submittals in the appropriate category of the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.
   b. Review the contract requirements for CISS concrete piling furnish and drive contract items and make monthly progress payments in accordance with:
      i. Attachment 7, Cast-In-Steel Shell Concrete Piling – Measurement and Payment
      ii. BCM 49-2, Piling – Driven Piling.
   c. When all CIDH concrete piles for the project have been accepted, fill out and submit the Form SC-3812, CIDH Pile Information for Piles Tested by the Foundation Testing Branch (FTB) Memo, to the SC Substructure Engineer (DES Pile Mitigation Committee Chair) per BCM C-6, Required Documents to be Submitted During Construction.
   d. Submit completed applicable final pile records to SC HQ per BCM C-6, Required Documents to be Submitted During Construction.
   e. Complete a Pile Construction Report (PCR) for each applicable CIDH concrete pile per Attachment 5, Pile Construction Report.

6. File all project documentation (correspondence, materials acceptance documentation, test results, completed forms, PCRs, daily reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-1.02, Organization of Project Documents.
**Process Outputs**

1. Authorized CIP concrete piling submittals
2. CIDH pile preconstruction meeting minutes
3. CIDH pile preconstruction meeting list of contacts and a communications protocol
4. CIDH pile preconstruction meeting documented risks and opportunities identified during the meeting that may need to be communicated to the Caltrans Project Manager and other interested parties
5. CIDH pile preconstruction meeting action items
6. Authorized revisions to the pile installation plan (if applicable)
9. Completed CIP concrete pile construction forms and Pile Construction Reports
10. *Pile Acceptance Test Report* (and completed PDDF when required), if applicable
11. Pile Acceptance or Rejection letter, if applicable
12. Pile mitigation plan authorization or rejection letter, if applicable
13. Authorized pile mitigation plan, if applicable
14. Pile Mitigation Report, if applicable
15. Daily reports

**Attachments**

- **Attachment 1**, *CIDH Concrete Piling – Preconstruction Meeting Instructions*
- **Attachment 2**, *CIDH Concrete Piling – Contract Administration and Department Acceptance*
- **Attachment 3**, *CIDH Pile Mitigation Committee*
- **Attachment 4**, *CIDH Pile Nonstandard Mitigation Meeting*
- **Attachment 5**, *CIDH Concrete Pile Construction Report (PCR)*
- **Attachment 6**, *CIDH Concrete Piling – Materials*
- **Attachment 7**, *Cast-In-Steel-Shell Concrete Piling – Measurement and Payment*
CIDH Concrete Piling – Preconstruction Meeting Instructions

Before drilling begins, the Contract Specifications (CS) require the Contractor to schedule, and the Engineer to conduct, a Cast-in-Drilled-Hole (CIDH) preconstruction meeting. The purpose of the preconstruction meeting is to establish contacts and communication protocol for the Contractor, the Engineer and their representatives involved in CIDH concrete pile design and construction, and to afford all parties a common understanding of the construction process, acceptance testing, and mitigation of CIDH concrete piles.

Attendance for the preconstruction meeting is dependent on the size and complexity of the project. In general, for CIDH concrete piles that will be constructed without inspection pipes (the dry construction method), required attendees for the preconstruction meeting include the:

1. Resident Engineer
2. Structure Representative and Assistant Structure Representatives
3. Bridge Design (BD) Structure Project Engineer and Geotechnical Services (GS) Geoprofessional, who will provide construction support for the project
4. Contractor’s Project Manager and Project Superintendent
5. Drilling Subcontractor’s Project Manager and Superintendent/Foreman
6. Reinforcing Steel Subcontractor’s Foreman/Superintendent

For CIDH concrete piles that will be constructed with inspection pipes (the wet construction method), required attendees for the preconstruction meeting also include:

1. Foundation Testing and Instrumentation Branch Representative
2. DES Pile Mitigation Committee Chair (SC Substructure Engineer)

For most projects, invitees located far from the preconstruction meeting location can call in to limit travel cost. For complex projects, a face-to-face preconstruction meeting for all involved parties will be required.

Coordinate with Caltrans attendees prior to the preconstruction meeting to identify concerns to present a united front with the Contractor. Discuss with the BD Structure Project Engineer: pile design details, spacing, bundling and splicing of bar reinforcement, inspection pipe clearance to adjacent bar reinforcement, concrete cover, welding issues, and applicability of Cal/OSHA mining and tunneling requirements (see links in Sample Agenda Topic 5.b.). Discuss with the GS Geoprofessional: possible
construction methods and tooling, design requirements (end bearing versus skin friction), corrosion, ground water, drilling slurry, and all applicable construction considerations. Discuss in detail any potential problem areas and associated risks.

General topics to be discussed in the preconstruction meeting should include:

1. Review of the Contractor’s pile installation plan.
2. Any recently revised section of the CS.
3. Environmental commitments.
5. The Contractor’s planned method of operation and schedule.
6. The equipment to be used.
7. The plan for avoiding existing utilities (if any).
8. Safety precautions to be taken during the work.

A general preconstruction meeting agenda to assist you with understanding the steps involved in conducting the preconstruction meeting is attached below. However, bear in mind that these are reminders only. Review the general preconstruction meeting agenda regarding your specific project and modify the agenda as necessary. Certain topics may or may not be included depending upon their applicability to a specific project.
CIDH Preconstruction Meeting
Agenda / Minutes

Date: 
Time: 
Location: 

Facilitator: Structure Representative:

Invitees: Resident Engineer: 
Assistant Structure Representative:
BD Structure Project Engineer:
GS Geoprofessional:
Contractor’s Project Manager:
Project Superintendent:
Drilling Subcontractor’s Project Manager:
Drilling Subcontractor’s Superintendent/Foreman:
Reinforcing Steel Subcontractor’s Superintendent/Foreman:
Foundation Testing and Instrumentation Branch Representative:
DES Pile Mitigation Committee Chair:
Concrete Supplier: 

Purpose: Establish contacts and communication protocol for the Contractor, the Engineer, and their representatives involved in CIDH concrete pile design and construction, and to afford all parties a common understanding of the construction process, acceptance testing, and mitigation process of CIDH concrete piles.

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<tr>
<th>Time</th>
<th>Topic*</th>
<th>Who</th>
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<tbody>
<tr>
<td></td>
<td>1. Welcome and Self Introductions</td>
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<td>2. Project Background</td>
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<td>3. Structural, Geotechnical, and Corrosion Design Requirements</td>
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<td>4. Submittals</td>
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<td>5. Safety</td>
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<td>6. Inspection Pipes</td>
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<td>Time</td>
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<td>7.</td>
<td>Emergency Plan</td>
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<td>8.</td>
<td>Acceptance Testing</td>
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<td>9.</td>
<td>Rejected Piles</td>
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<td>10.</td>
<td>Pile Mitigation Process</td>
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<td>11.</td>
<td>Timelines and Critical Path Activities</td>
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<td>12.</td>
<td>Future Meetings</td>
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<td>13.</td>
<td>Action Items/Adjourn Meeting</td>
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* These topics are reminders only. Items will or will not be included depending upon their applicability to a specific project.

**Topic 1. Welcome and Self Introductions**
- a. Pass out attendance sheet
- b. State purpose of this meeting
- c. Self-Introductions: state each person’s responsibilities for construction of CIDH concrete piles

**Topic 2. Project Background**
- a. Discuss project-specific details
- b. Discuss environmental commitments

**Topic 3. Structural, Geotechnical, and Corrosion Design Requirements**
- a. Discuss design performance requirements
- b. Verify construction methods do not impact performance requirements
- c. Discuss structural considerations:
  - i. Location of construction joint
  - ii. Allowable rebar splice zones
  - iii. Isolation casing
  - iv. Column to shaft connection detail for Type II shaft
  - v. Location of inspection pipes
  - vi. Bundling of longitudinal rebar
  - vii. Concrete cover
d. Discuss geotechnical considerations:
   i. End bearing
   ii. Skin friction
   iii. Permanent casing
   iv. Rock socket

e. Discuss corrosion considerations:
   i. Corrosive soil
   ii. Lowest ground water elevation

Topic 4. Submittals

a. Review the following regarding definitions for dry hole and dewatered hole, and inspection pipe requirements:
   i. CS, Section 49-1.01B, *Department Acceptance – Piling – General – Definitions*, and
   ii. CS, Section 49-3.02A(4)(d)(i), *Department Acceptance – General*

   iii. Inspection pipe requirements are summarized in the Table 1.

   Table 1. Inspection pipe requirements.

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<thead>
<tr>
<th></th>
<th>Dry Hole</th>
<th>Dewatered Hole</th>
<th>Slurry</th>
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<tbody>
<tr>
<td>No temporary</td>
<td>No Inspection</td>
<td>No Inspection</td>
<td>Inspection Pipes required</td>
</tr>
<tr>
<td>casing used</td>
<td>Pipes</td>
<td>Pipes</td>
<td></td>
</tr>
<tr>
<td>Temporary</td>
<td>No Inspection</td>
<td>Not Applicable</td>
<td>Inspection Pipes required</td>
</tr>
<tr>
<td>casing used</td>
<td>Pipes</td>
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</table>


c. Review the following forms completed during construction by the Engineer:
   i. Form SC-3802, *Drilled Shaft Inspector’s Checklist*
   ii. Form SC-3803, *Drilled Shaft Excavation Log*
   iii. Form SC-3804, *Drilled Shaft Excavation Profile*
   iv. Form SC-3805, *Drilled Shaft Bottom Inspection*
   v. Form SC-3806, *Slurry Test Record*
d. Review the following forms completed during construction by the Contractor:

i. Review CS, Section 49-3.02A(3)(c), Inspection Pipe and Reinforcing Cage Coupler Log:
   1. Form SC-3807, Inspection Pipe and Rebar Coupler Log

ii. Review CS, Section 49-3.02A(3)(d), Concrete Placement Log:
   1. Form SC-3808, Drilled Shaft Concrete Placement Log
   2. Form SC-3809, Drilled Shaft Concrete Placement Graph

**Topic 5. Safety**

a. Discuss applicable requirements of Cal/OSHA Title 8, Chapter 4, Subchapter 4, Construction Safety Orders.

b. Discuss requirements of Cal/OSHA Title 8, Chapter 4, Subchapter 17, Mine Safety Orders, and Cal/OSHA Title 8, Chapter 4, Subchapter 20, Tunnel Safety Orders (CIDH concrete piles greater than 30" diameter and deeper than 20').

c. Discuss safety data sheets (SDS) for all drilling slurries and chemical additives.

d. Discuss day work vs. night work concerns.

e. Discuss other project safety concerns as applicable.

**Topic 6. Inspection Pipes**

a. Review CS, Section 49-3.02C(5), Vertical Inspection Pipes:

   i. Run dummy probe through all inspection pipes prior to requesting acceptance testing.

   ii. Complete Form SC-3801, GGL Inspection Pipe Verification.

   iii. Blocked inspection pipes and coring:

      1. Review CS, Section 49-3.02A(3)(e), Coring Logs and Concrete Cores.

**Topic 7. Emergency Plan**

a. Discuss handling of the following situations:

   i. Sidewall sloughing or water inflow during concrete placement.

   ii. Broken tremie pipe, breach of tremie pipe seal, tremie pipe blockage, tremie removal and reinsertion.

   iii. Temporary casing removal, breach of casing seal.

---

1 The Contractor can use their own forms provided all information contained on the Department’s forms is addressed.

v. Rebar cage movement.

vi. Who is authorized to make the decision to abandon concrete placement and remove the rebar cage?

**Topic 8. Acceptance Testing**

a. Caltrans performs acceptance testing using Gamma-Gamma Logging (GGL) to test the concrete density of the pile for homogeneity.

b. *CIDH Pile Acceptance Test Request Form*: Discuss time requirements for submission of this form.

c. Review CS, Section 49-3.02A(4)(d)(ii), *Gamma-Gamma Logging*:
   
i. Acceptance test report from Foundation Testing and Instrumentation Branch (FTI) (distribution list – emails).
   
ii. Discuss time allowance for *California Test 233, Method of Ascertaining the Homogeneity of Concrete in Cast-in-Drilled-Hole (CIDH) Piles Using the Gamma-Gamma Test Method*.
   
iii. Discuss exclusion zone around pile during testing operations.

**Topic 9. Rejected Piles**

a. Review CS, Section 49-3.02A(4)(d)(iii), *Rejected piles*:
   
i. If pile is rejected, suspend concrete placement until revised pile installation plan is authorized.
   
ii. Discuss time allowance for additional testing:
      
1. Acceptance test report will address any additional testing, such as Cross-Hole Sonic Logging (CSL), to be performed by FTI.
      
2. Contractor may also do their own testing when FTI elects not to do so.


c. Review CS, Section 49-3.02A(4)(d)(iii), *Rejected Piles*. Determine whether pile mitigation is required:
   
i. Discuss time allowance for determining whether rejected piles require mitigation.

   d. Review CS, Section 49-3.02A(4)(d)(iii), *Rejected Piles*. If mitigation of a rejected pile is required, to what extent?
   
   i. Use of the *Pile Design Data Form* (PDDF)
      
1. The PDDF is part of the acceptance test report
2. The PDDF is used:
   a. To collect information from the CIDH concrete pile designers to determine if the anomaly requires mitigation.
   b. To determine the type of mitigation that can be performed.
   c. For the development and evaluation of a pile mitigation plan.

3. Required sections of the PDDF and distribution:
   a. Section 1 of the PDDF is completed by FTI and provided in the acceptance test report.
   b. The Structure Representative distributes the PDDF and receives the completed PDDF from the following parties:
      i. Section 2 of the PDDF is completed by the GS Geoprofessional.
      ii. Section 3 of the PDDF is completed by the BD Structure Project Engineer.
      iii. Section 4 of the PDDF is completed by the Materials Engineering and Testing Services (METS) Corrosion Engineer.
   c. Upon return of the PDDF with Sections 2-4 completed, Section 5 of the PDDF is completed by the Structure Representative.
   ii. For piles that require mitigation that can be repaired using the Caltrans Authorized - ADSC Standard Mitigation Plans:
      1. Engineer determines rejected pile can be repaired using basic or grouting repair method.
   iii. For piles that require mitigation that cannot be repaired using the Caltrans Authorized – ADSC Standard Mitigation Plans:
      1. Engineer determines rejected pile cannot be repaired using basic or grouting repair method.
      2. Engineer determines rejected pile requires structural bridging, replacement, or supplementation.
      3. Discuss CIDH Pile Nonstandard Mitigation Meeting.
      4. Discuss CIDH Pile Mitigation Plan Review Meeting.
   e. Review CS, Section 49-3.02A(4)(d)(iii), Rejected Piles. If mitigation of a rejected pile is not required, what then?
      i. Discuss use of administrative deduction.
Topic 10. Pile Mitigation Process

a. Review Form SC-3810, *Pile Mitigation Flowchart*

b. Review CS, Section 49-3.02A(3)(g), *Mitigation Plans*:
   i. Basic repair within the upper five feet of the CIDH concrete pile – repair requirements.
   ii. Basic repair below the upper five feet of the CIDH concrete pile – repair requirements.
   iii. *Caltrans Authorized - ADSC Standard Mitigation Plan*:
       1. Basic repair requirements
       2. Grouting repair requirements
   iv. Nonstandard mitigation plan:
       1. Structural bridging requirements
       2. Supplement/replacement requirements

c. Review CS, Section 49-3.02A(3)(h), *Mitigation Report*:
   i. Mitigation report submitted after completion of repair work.

Topic 11. Timelines – Critical Path Activities


Topic 12. Future Meetings

a. Discuss requirements of CS, Section 49-3.02A(4)(d)(iii), *Rejected Piles*:
   i. CIDH Pile Nonstandard Mitigation Meeting per Attachment 4, *CIDH Pile Nonstandard Mitigation Meeting*.
   ii. CIDH Pile Mitigation Plan Review Meeting.

Topic 13. Action Items / Adjourn

a. List action items, responsible parties, and due dates.

b. Adjourn meeting.
CIDH Concrete Piling – Contract Administration and Department Acceptance

The following provides information and instructions regarding how to administer construction of and accept Cast-in-Drilled-Hole (CIDH) concrete piling on behalf of the Department including a chronological outline of the contract administration process.

1 - CIDH Piling Contract Administration Chronological Outline

A chronological outline for contract administration of Cast-in-Drilled-Hole (CIDH) piling without inspection pipes is shown below (dry method):

1. Pile installation plan submittal:
   1.1. Review the plan.
   1.2. Respond to the Contractor.

2. CIDH pile preconstruction meeting:
   2.1. Conduct meeting per Attachment 1, CIDH Concrete Piling – Preconstruction Meeting Instructions.

3. Pile construction

4. Payment

A chronological outline for contract administration of CIDH piling with inspection pipes is shown below (wet method):

1. Pile installation plan submittal:
   1.1. Review the plan.
   1.2. Respond to the Contractor.

2. CIDH pile preconstruction meeting:
   2.1. Conduct meeting per Attachment 1, CIDH Concrete Piling – Preconstruction Meeting Instructions.
   2.2. Following the preconstruction meeting, authorize or reject the pile installation plan.

3. Concrete test batch:
   3.1. Witness the test batch.
   3.2. Review the results.
   3.3. Respond to the Contractor.
4. Pile construction:
   4.1. Complete required forms for each pile.
   4.2. The Contractor completes and submits forms for concrete placement, bar reinforcement coupler locations, and inspection pipe coupler locations.
   4.3. The Contractor makes safe access for testing in accordance with the contract documents.
   4.4. Witness the Contractor's probe of inspection pipes.
   4.5. Notify the Division of Engineering Services (DES) Pile Mitigation Committee of blocked inspection pipes and request guidance.

5. Track and maintain accurate timeline of all the following testing and mitigation activities.

6. Testing:
   6.1. Use the CIDH Pile Acceptance Test Request Form to schedule testing with Foundation Testing and Instrumentation (FTI) so that testing can be completed as soon as possible.
   FTI performs tests and sends a pile acceptance test report for each pile tested.

7. Pile acceptance or rejection:
   7.1. Send a letter to the Contractor either accepting or rejecting a pile based on the pile acceptance test report recommendations. For an example see Sample Letter 1.

8. Rejected piles – suspend future pile concrete placement:
   8.1. The Contractor submits a revised pile installation plan to correct methods that resulted in anomalies.
   8.2. Review revised pile installation plan.
   8.3. Notify the Contractor when the plan is authorized, and pile construction work can resume. For an example see Sample Letter 4.

9. Rejected piles – Pile Design Data Form (PDDF):
   9.1. Immediately contact the Bridge Design (BD) Structure Project Engineer, the Geotechnical Services (GS) Geoprofessional, and the Materials Engineering and Testing Services (METS) Corrosion Specialist (Corrosion Technology Branch) to ensure that they complete the PDDF included in the pile acceptance test report. For a sample PDDF see Figure 1.
9.2. Based on the completed PDDF (Sections 1 through 5), determine whether the rejected pile requires repair and if so, the feasibility of repairing the rejected pile. Consult with the DES Pile Mitigation Committee.

9.3. Send a copy of the completed PDDF to the members in the DES Pile Mitigation Committee and allow two working days for a cursory check.

9.4. Send appropriate letter and information to the Contractor. For an example see Sample Letters 2 and 3.

10. Rejected Piles – CIDH Pile Nonstandard Mitigation Meeting:

10.1. This meeting is necessary only when a nonstandard mitigation method is required.

10.2. Conduct the meeting per Attachment 4, CIDH Pile Nonstandard Mitigation Meeting.

11. Rejected piles – pile mitigation plan:


11.2. Directly review if it is for Basic Repair.

11.3. Coordinate review with the DES Pile Mitigation Committee for non-basic mitigation by sending a copy of the proposed pile mitigation plan to the DES Pile Mitigation Committee.

11.4. DES Pile Mitigation Committee must provide a consensus of the recommendations to the SR.

11.5. Respond to the Contractor authorizing or rejecting the pile mitigation plan.

11.6. If rejected, schedule Pile Mitigation Review Meeting to resolve comments.

12. Rejected piles – pile mitigation:

12.1. The Contractor performs pile mitigation in accordance with the authorized pile mitigation plan.

12.2. The Contractor submits the mitigation report. Send a copy of this report to the members of the DES Pile Mitigation Committee.

12.3. Determine whether rejected pile can now be accepted.

13. CIDH pile information:

13.1. Verify that all final data has been submitted on the CIDH pile-information memo per BCM C-6, Required Documents to be Submitted During Construction, to the DES Pile Mitigation Committee Chair.
The following contains information, instructions, and a narrative description of CIDH concrete pile acceptance testing, evaluation of rejected piles, and pile mitigation.

2 - Acceptance Testing

Concrete that is placed under slurry or placed using temporary casing to control groundwater must be tested for quality. If there is soil contamination, slurry mixed with concrete, or zones of low-density concrete, repairs might be required. Concrete placed in dry conditions is assumed to be structurally sound because it can be visually inspected during placement.

The Contract Specifications (CS) requires Gamma-Gamma Logging (GGL) under California Test (CT) 233, Method of Ascertaining the Homogeneity of Concrete in Cast-In-Drilled-Hole (CIDH) Piles Using the Gamma-Gamma Test Method, for CIDH piles 24 inches in diameter or larger and placed under slurry or when a temporary casing is used to control groundwater. Piles less than 24 inches in diameter are designed assuming that the concrete will be placed in a dry or a dewatered hole. For these small diameter CIDH piles, if water is encountered and dewatering does not work, immediately contact the BD Structure Project Engineer, GS Geoprofessional, and DES Pile Mitigation Committee Chair. The pile type or size may be inappropriate for the site conditions.

The DES Pile Mitigation Committee provides technical support for CIDH pile acceptance activities. Committee membership and responsibilities are included in BCM 49-3, Piling – Cast-in-Place Concrete Piling, Attachment 3, DES Pile Mitigation Committee.

Foundation Testing and Instrumentation (FTI) provides statewide foundation testing services. FTI's workload fluctuates widely throughout the year; therefore, to provide timely services, advance notice will be required for scheduling GGL, especially at the beginning of a new contract. Notify FTI fifteen (15) days before testing is needed, or as early as possible. Obtain the current version of the CIDH Pile Acceptance Test Request form from FTI's website.

Complete the form, providing an estimated date for testing, and email the form to FTI using the email address provided on the form. FTI will assign an engineer who will contact you for further scheduling and foundation testing on your project.

Coordinate the Contractor's pile construction operations with FTI. Notify FTI so piling can be tested as soon as possible. Remember, GGL can be performed even before the concrete is cured. It is important to inform FTI as soon as possible so the Contractor does not construct numerous CIDH piles before FTI can perform testing. The goal is to avoid having to reject several piles with the same problem.

For FTI to perform GGL, inspection pipes must be completely accessible for the Gamma-Gamma probe and either completely filled with water or completely dry. Contractors will typically fill the inspection pipes with water during construction. If the
Contractor elects testing in dry inspection pipes, the inspection pipes must be completely purged of water prior to testing. However, testing can be performed in inspection pipes completely filled with water. The Contractor checks the inspection pipes for accessibility by passing a probe (a 1 1/4-inch diameter by 4-1/2 feet long rigid cylinder) through the length of the pipe. The Engineer must witness the entire probe check of the inspection pipes and complete Form SC-3801, GGL Inspection Pipe Verification. When the inspection pipes are confirmed to be clear, immediately notify FTI using the CIDH Pile Acceptance Test Request Form so that testing can be performed. Verify that the Contractor has provided access to the pile for the FTI Engineer.

FTI will perform testing and submit a pile acceptance test report. FTI will transmit the report to the Structure Representative (SR), Structure Construction Headquarters (SC HQ), Structure Design, Geotechnical Services, and the Corrosion Engineer.

If the pile is free of anomalies, FTI will recommend pile acceptance. If the pile has an anomaly, the location and details will be provided, and FTI will recommend rejection. Follow the recommendation in the pile acceptance test report and immediately notify the Contractor of either pile acceptance or rejection. Refer to Sample Letter 1. for a sample rejection letter.

3 - Piles with Blocked Inspection Pipes

If an inspection pipe is blocked, and the Contractor was not able to clear the blockage, the CS require the Contractor to core through the entire length of the pile for each blocked inspection pipe. The Contractor logs the coring operation and provides the cored materials to the Engineer per the requirements of the contract documents. Send a copy of the coring report to FTI for review and evaluation of the portion of the pile represented by coring. No GGL is performed in the cored holes.

Although the CS require coring to mitigate a blocked pipe, there are cases where coring may not be necessary. For example, if the blockage is within one pile diameter of the pile tip, the pile does not require end bearing, and corrosion is not an issue, then it is likely that the pile is adequate from a structural, geotechnical, and corrosion standpoint without verification of the concrete condition below the blocked zone. In this case the concrete, represented by the blocked pipe, from the top of the blockage to the tip of the pile, can be considered an anomaly that does not require mitigation and treated as such. Therefore, it is recommended to contact FTI and the DES Pile Mitigation Committee Chair for guidance prior to coring for blocked pipes.

4 - Evaluation of Rejected Piles

If an anomaly is found, the pile is rejected. An anomaly may be due to soil contamination, a zone of low-density concrete, or slurry mixed with concrete. An
anomaly may or may not represent a defect in the CIDH pile. Therefore, each anomaly must be investigated separately.

When a pile is rejected, suspend all depositing of concrete for CIDH piles that require GGL testing until the Contractor submits a revised pile mitigation plan. The revised plan must explain how the anomaly occurred and what changes are made to avoid the same problem. Immediately notify the Contractor when a revised pile mitigation plan has been reviewed, the new plan is acceptable, and the work may resume.

In some cases, FTI will release a pile acceptance test report and then might choose to do additional testing (such as cross-hole sonic logging) to better define the type and limits of an anomaly. When FTI plans to do additional testing, do not wait on these results; send the rejection letter. The FTI decision whether to perform additional tests will be evaluated and presented in the pile acceptance test report.

In the pile acceptance test report, FTI will include the Pile Design Data Form (PDDF). Refer to Figure 1 for a sample PDDF. Completion of this form requires input from the BD Structure Project Engineer, GS Geoprofessional, and METS Corrosion Specialist. Do not allow excessive delays to occur in completing this form. If one or more of the responsible persons are unable or unwilling to provide the data needed to complete this form in a timely manner, immediately elevate this to the DES Pile Mitigation Committee Chair. After completing this form, submit it to the DES Pile Mitigation Committee and allow at least two working days for review. Discuss the pile design requirements with the DES Pile Mitigation Committee to determine whether the rejected pile requires mitigation, and if so, to determine viable mitigation methods.

Based on the completed PDDF information and the discussion with the DES Pile Mitigation Committee of whether the rejected pile requires mitigation, proceed with one of the following actions:

1. Determine that the anomaly does not affect the necessary design performance and that the anomaly does not affect the necessary corrosion resistance, so mitigation is not required (consensus with the DES Pile Mitigation Committee is required). The Contractor can forego mitigation that is not required and accept an administrative deduction or mitigate the pile for full payment. Notify the Contractor in writing. For an example see Sample Letter 2.

2. Determine that the anomaly must be mitigated and evaluate viable mitigation methods (see Section 5, Mitigation, below). Notify the Contractor in writing. For an example see Sample Letter 3.

3. Determine that a Basic Repair can be used. Notify the Contractor in writing. For an example see Sample Letter 4.
4. For anomalies that require a nonstandard mitigation plan, as defined in Section 5, Mitigation, below, the Contractor is required to hold a CIDH Pile Nonstandard Mitigation Meeting per Attachment 4, and the requirements of the contract documents. Notify the Contractor in writing. For an example see Sample Letter 4.

5 - Mitigation

A rejected pile is only required to be mitigated to the extent needed for the pile to perform as intended by the design requirements. The DES Pile Mitigation Committee will provide technical support to the Structure Representative and assist in the review of submittals for repair so that mitigation work is appropriate for the design and administered consistently statewide. Common anomalies and mitigation measures are included in the Foundation Manual, Chapter 9, Slurry Displacement Piles. If the Contractor proposes to do the anomaly investigation, immediately consult with the DES Pile Mitigation Committee.

As indicated above, the PDDF will indicate whether the rejected pile requires mitigation and facilitates determining the appropriate mitigation method.

6 - Basic Repair of CIDH Piling

Basic Repair is allowed for piling under the following conditions:

- There are no other repairs in the same pile
- The repair area can be made completely visible

Prior to starting Basic Repairs, the Contractor is required to submit the pile mitigation plan.

Basic Repairs consist of excavation of soils and then removal and replacement of defective concrete. Excavation of soils below five feet will reduce the geotechnical capacity of the pile and is generally not allowed. If the Contractor wants to excavate more than five feet from the top of the pile, then the mitigation plan must be reviewed by the DES Pile Mitigation Committee.

If permanent casing is within five feet of the top of the pile, it might not be feasible to make the defective concrete completely visible, and this is not a Basic Repair. The DES Pile Mitigation Committee must be consulted when an anomaly is inside the permanent casing.

7 - Basic Repair of CIDH Piling for Defects Within 5 Feet of Pile Cutoff
The Contractor is required to submit the pile mitigation plan. Although the DES Pile Mitigation Committee is available for consultation on Basic Repairs within 5 feet of pile cutoff, it is not required to send the pile mitigation plan to the DES Pile Mitigation Committee for review and consensus.

8 - Standard and Nonstandard Repair of CIDH Piling:

Mitigation of a defective CIDH pile can be grouped into four methodologies:

1. **Standard Repair Methodology:**
   a. Unearth and Recast (Basic Repair)
   b. Pressure Grout (Grouting Repair)

2. **Nonstandard Repair Methodology:**
   a. Structural Bridging
   b. Replacement/Supplement

The first two methods are considered standard repair methods and are covered by the Association of Drilled Shaft Contractors – International Association of Foundation Drilling (ADSC) Standard Mitigation Plan. The Standard Mitigation Plan is a set of established procedures used to perform standard repairs; it does not endorse any method to address a particular anomaly repair.

If it is feasible, as determined by the DES Pile Mitigation Committee, an anomaly can be mitigated with standard repairs. If it is not feasible to repair the anomaly, then the pile must be replaced or supplemented with additional piling. The repair strategy is at the option of the Contractor, and subject to the DES Pile Mitigation Committee approval. No additional payment is made for any type of mitigation of rejected piling.

For anomalies that require a nonstandard mitigation plan (i.e. Basic Repair or Grouting Repair are not feasible/acceptable), the Contractor is required to schedule a CIDH Pile Nonstandard Mitigation Meeting per Attachment 4, CIDH Pile Nonstandard Mitigation Meeting, to address a viable nonstandard mitigation plan (structural bridging and replacement/supplement) in a timely manner. A general CIDH Pile Nonstandard Mitigation Meeting agenda to assist with understanding the steps involved is included in Attachment 4.

The Contractor must have a pile mitigation plan submitted to the Structure Representative, and the Structure Representative must authorize it before the mitigation work begins. When a Contractor selects the ADSC Standard Mitigation Plan, all
applicable contractual elements of the pile mitigation plan, as presented in the CS, need to accompany the ADSC Standard Mitigation Plan.

Review the pile mitigation plan to verify it is complete. Call the DES Pile Mitigation Committee Chair if there are questions. Send copies of the plan to the DES Pile Mitigation Committee for technical review. Concurrently, FTI performs a technical review of the pile mitigation plan and issues a review memo to the chair person. Upon receipt of FTI’s review memo, the DES Pile Mitigation Committee reviews and issues recommendations to authorize or reject the pile mitigation plan to the Structure Representative.

Notify the Contractor of authorization or rejection as soon as you receive the DES Pile Mitigation Committee memo. For an example to inform the Contractor that the pile mitigation plan is authorized, see Sample Letter 4.

Generally, the pile can be accepted if the mitigation work is performed in accordance with the provisions of the authorized pile mitigation plan. However, there are circumstances when the pile must be retested. Acceptance criteria of a mitigated pile (i.e., retesting, coring) will be provided in the DES Pile Mitigation Committee memo. The acceptance criteria must be included in the letter authorizing the pile mitigation plan.

After the repair, supplemental, or replacement work is complete, the Contractor submits a pile mitigation report. Send a copy of the mitigation report to the DES Pile Mitigation Committee.
Sample Letter 1: Letter to the Contractor Rejecting a Pile

STATE OF CALIFORNIA—CALIFORNIA STATE TRANSPORTATION AGENCY
DEPARTMENT OF TRANSPORTATION
<Your Office Address>
<Your Office Phone>

Making Conservation a California Way of Life.

<Month Date, Year>

File: <Project Name>
<CO/Rte/PM>
<Project EA>

<Contractor Name>
<Contractor Address>

Dear <Responsible Person>,

The attached CIDH pile acceptance test report for piles, <pile numbers>, dated <report date>, has indicated the presence of anomalies in pile <pile number>, located at Bridge No. xx-xxxx, <Bridge Name>, Pile <rejected pile number> is hereby rejected in accordance with Section 5-1.30, Control of Work – Noncompliant and Unauthorized Work, of the Contract Specifications.

You are reminded of your responsibilities specified in Section 49-3.02A(4)(d)(iii), which states:

If a pile is rejected:
1. Suspend concrete placement in the remaining piles
2. Submit a revised pile installation plan
3. Do not resume concrete placement until the revised pile installation plan is authorized

An investigation is being performed to determine whether mitigation of pile <pile number> is required, and if so, whether pile <pile number> can be repaired or must be supplemented or replaced. You will be notified of the results of this investigation as soon as it has been completed.

Edit as Appropriate

As indicated in the Gamma-Gamma Logging Acceptance Test Report, the Foundation Testing Branch will (will not) perform additional testing to further evaluate the rejected pile. You may perform your own testing on the rejected pile.

Sincerely,

Resident Engineer

Attachments <Pile Acceptance Test Report>
Figure 1. Sample Pile Design Data Form
Sample Letter 2: Letter Informing the Contractor the Mitigation for the Pile is not Required.

STATE OF CALIFORNIA—CALIFORNIA STATE TRANSPORTATION AGENCY  
GAVIN NEWSOM, Governor  
DEPARTMENT OF TRANSPORTATION  
<Your Office Address>  
<Your Office Phone>  

<Month Date, Year>  

File: <Project Name>  
<CO/Rte/PM>  
<Project EA>  

<Contractor Name>  
<Contractor Address>  

Dear <Responsible Person>,  

Please refer to my letter dated <letter date> regarding the rejection of pile <pile number>, located at Bridge No. xx-xxxx,  

An investigation of anomaly(ies) was performed by the Engineer and it was determined that mitigation work is not required. If you elect not to mitigate the anomaly(ies), payment will be reduced for the anomaly(ies) in conformance with Section 49-3.02A(4)(d)(iii), Piling – Cast-In-Drilled-Hole Concrete Piling – Department Acceptance – Rejected Piles, of the Contract Specifications. Full payment will be made if mitigation is completed and accepted.  

Please inform me of your decision to either mitigate or take a reduction in payment.  

Sincerely,  

Resident Engineer
Sample Letter 3: Letter Informing the Contractor that Mitigation for the Pile is Required.

STATE OF CALIFORNIA—CALIFORNIA STATE TRANSPORTATION AGENCY

DEPARTMENT OF TRANSPORTATION

<Your Office Address>
<Your Office Phone>

File: <Project Name>
<CO/Rte/PM>
<Project EA>

<Month Date, Year>  

<Contractor Name >  
<Contractor Address>

Dear <Responsible Person>,

Please refer to my letter dated <letter date> regarding the rejection of pile <pile number>, located at Bridge No. xx-xxxx.

An investigation of the rejected pile performed by the Engineer has determined that mitigation work is required.

Action 3:  
You are reminded of your responsibilities in Section 49-3.02A(4)(d)(iii), Piling – Cast-in-Drilled-Hole Concrete Piling – Department Acceptance - Rejected Piles, of the Contract Specifications, which require “…a plan for repair, removal, or replacement of the rejected piling” before the rejected pile can be accepted.

Action 4:  
You are reminded of our responsibilities in Section 49-3.02A(4)(d)(iii), Piling – Cast-in-Drilled-Hole Concrete Piling – Department Acceptance - Rejected Piles, of the Contract Specifications, which require “…schedule and hold a CIDH Pile Nonstandard Mitigation Meeting within five business days after the Engineer’s determination whether the rejected pile requires mitigation.”

Attached is a copy of the original pile acceptance test report, <the cross-hole sonic pile test report if available>, and the pile design requirements to aid you in the preparation of the mitigation plan.

Please submit a pile mitigation plan to this office for review and approval as soon as possible.

Sincerely,

Resident Engineer

Attachments <Pile Acceptance Test Report, Pile Design Data form>
Sample Letter 4: Letter Informing the Contractor that the Mitigation Plan is Satisfactory.

STATE OF CALIFORNIA—CALIFORNIA STATE TRANSPORTATION AGENCY
DEPARTMENT OF TRANSPORTATION
<Your Office Address>
<Your Office Phone>

<Month Date, Year>

File: <Project Name>
<CO/Rte/PM>
<Project EA>

<Contractor Name>
<Contractor Address>

Dear <Responsible Person>,

The CIDH pile mitigation plan, dated <date>, submitted for pile <abutment/bent number, pile number> at the <bridge name, bridge number> has been reviewed and is satisfactory.

<CONTINGENCIES PARAGRAPH-If the mitigation plan is authorized contingent upon anything, list it here.>

<CRITERIA FOR PILE ACCEPTANCE PARAGRAPH- Certain criteria might be required after the mitigation work is completed to show the mitigation was successful (i.e., additional Gamma-Gamma testing. Cross-hole Sonic Logging or coring). List it here.>

You are reminded of your responsibilities under Section 49-3.02A(3)(g), Piling – Cast-in-Drilled-Hole Concrete Piling – Submittals - Mitigation Plans, of the Contract Specifications, which require: For each rejected pile, submit a mitigation plan for repair, supplementation, or replacement. The mitigation plan must…

Sincerely,

Resident Engineer
DES Pile Mitigation Committee

The Division of Engineering Services (DES) Pile Mitigation Committee does the following:

- Provides technical support to Structure Representatives.
- Reviews the Pile Design Data Form.
- Reviews CIDH pile mitigation plans to ensure statewide consistency for construction means and construction administration.
- Ensures final acceptance of pile after repair mitigation work is completed.
- Liaisons with industry.
- Serves on the DES Substructure Technical Committee.
- Coordinates with METS Corrosion Branch.

Members of the DES Pile Mitigation Committee consist of the SC Substructure Engineer (Chair), the Foundation Testing and Instrumentation (FTI) office chief, the Bridge Design (BD) Structure Project Engineer, the Geotechnical Services (GS) Geoprofessional, and METS Corrosion Engineer.

Current contact information for the DES Pile Mitigation Committee Chair is identified on the Structure Construction website at:


Mail: Caltrans
Division of Engineering Services, SC
1801 30th Street, Mail Station 9-2/11H
Sacramento, CA 95816-8041

Current contact information for the FTI office chief is identified on the Geotechnical Support link at:


Mail: Caltrans
Transportation Laboratory, Geotechnical Services
5900 Folsom Blvd, Mail Station 5
Sacramento, CA 95819-4612
The purpose of the Cast-In-Drilled Hole (CIDH) Pile Nonstandard Mitigation Meeting is to bring together the Contractor, the Engineer, and their representatives involved in CIDH pile mitigation to address a nonstandard mitigation plan for the CIDH pile in a timely manner. It is intended to quickly eliminate any nonviable mitigation methodology and focus all efforts on finding optimal alternatives to mitigate the pile repair. The meeting will provide a forum for free exchange of information so that one or more viable repair solutions can be identified. Identifying these usable repair strategies should not be viewed as directing a Contractor’s work or plan. Ultimately, it is the Contractor’s responsibility to select, develop, and submit the pile mitigation plan. In many cases, the completion of the CIDH concrete pile is a critical path item affecting the schedule. In these circumstances it is imperative that the project team communicates effectively so that a satisfactory mitigation plan can be developed and executed with minimal impact on the schedule and delivery of the project. Attendance of this meeting is mandatory for the following:

- Resident Engineer
- Structure Representative
- Assistant Structure Representatives
- Foundation Testing and Instrumentation Branch (FTI) representative
- Division of Engineering Services (DES) Pile Mitigation Committee representatives
- Bridge Design (BD) Project Engineer and Geotechnical Services (GS) Geoprofessional who are providing construction support for the project
- Contractor’s Project Manager
- Project Superintendent
- Drilling Subcontractor’s Project Manager
- Drilling Subcontractor’s Superintendent/Foreman
- Mitigation Plan Designer

The following general meeting agenda provides guidance for understanding the key topics that need to be addressed during this meeting for timely development of a nonstandard mitigation plan. However, these are reminders only. Review the general meeting agenda regarding your specific project and modify the meeting agenda as necessary. Certain topics may or may not be included, depending upon their applicability to a specific project.
CIDH Pile Nonstandard Mitigation Meeting Agenda/Minutes

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<td>1.</td>
<td>Welcome and Self Introductions</td>
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<td>2.</td>
<td>Anomaly Description Based on GGL, CSL and/or Coring</td>
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<td>3.</td>
<td>PDDF Review (Structural, Geotechnical, and Corrosion Design Requirements)</td>
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<td>4.</td>
<td>Limitation of Standard Mitigation Plan 'B' (Grouting Repair)</td>
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<td>5.</td>
<td>Alternative Repair Methods (i.e. Structural Bridging)</td>
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<td>6.</td>
<td>Discuss Mitigation by Supplementation or Replacement</td>
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<td>7.</td>
<td>Discuss Successful Solutions Used in Past Pile Mitigation</td>
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Facilitator: Structure Representative:

Invitees: Resident Engineer: By phone:
Assistant Structure Representative:
Bridge Design Structure Engineer:
Geotechnical Services Geoprofessional:
Contractor’s Project Manager:
Drilling Subcontractor’s Project Manager:
Project Superintendent:
Drilling Subcontractor’s Superintendent/Foreman:
Foundation Testing and Instrumentation Branch Representative:
DES Pile Mitigation Committee Chair:
Mitigation Plan Designer:

Purpose: Bring together the Contractor, the Engineer, and their representatives involved in CIDH pile mitigation to address a nonstandard mitigation plan (replacement, supplementation, or non-standard pile repair) in a timely manner.

Date: Time: Location: Project Stamp:
<table>
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<th>Time</th>
<th>Topic*</th>
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<td>8. Mitigation Plan Design Requirements</td>
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<td>13. Action Items / Adjourn Meeting</td>
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* These topics are reminders only. Items will or will not be included depending upon their applicability to a specific project.

**Topic 1. Welcome and Self Introductions**

a. Pass out attendance sheet.

b. State purpose of this meeting.

c. Self-Introductions: state responsibilities for construction of CIDH concrete piles.

**Topic 2. Anomaly Description based on GGL, CSL, and/or Coring**

a. Describe the testing performed for acceptance testing and for further evaluation of the anomaly.

b. Characterize the defect. Define nature, location and extent.

**Topic 3. PDDF Review (Structural, Geotechnical, and Corrosion Design Requirements)**

a. Discuss the effect on structural resistance and serviceability.

b. Discuss the effect on geotechnical resistance and serviceability.

c. Discuss the effect on corrosion design and serviceability.

**Topic 4. Limitation of Standard Mitigation Plan ‘B’ (Grouting repair)**

a. High pressure water jets are capable of nozzle pressures up to 20,000 psi and can cut limited quantities of concrete at close range if the jet can be directed and is not shadowed by reinforcing steel. It is not normally feasible to remove large quantities of concrete or other semi-structural material in this manner.

b. This technique can be used to remediate and improve concrete which has inclusions of soil or low strength concrete. Grouting cannot be expected to restore cross sections in zones of high moment demand. Post-treatment cores or cross-hole sonic logs should show improvement but will not be free of anomalies.
c. Grouting within the shaft may not be effective if the defects to be treated include zones on the outside of the reinforcing cage in granular soils below groundwater. In such a case, attempts to hydro-blast outside the shaft would erode unstable soils which might be expected to cave. Jet grouting around the perimeter of the shaft is a technique which might be considered.

d. If the shaft is structurally sufficient except for concerns regarding the concrete cover on the reinforcement, or if a void exists between the outside of the shaft and the soil, then grouting around the perimeter may be considered.

**Topic 5. Alternative Repair Methods (i.e., Structural Bridging)**

a. Increase the structural strength of a defective pile without complete removal of the defect.

b. Install structural steel or pipe section cast into the central portion of the pile with regular or high strength concrete.

c. This additional member is designed to restore structural strength to meet structural design reequipments.

d. It may be possible to extend a central drilled section into formation below tip to increase geotechnical capacity of the CIDH concrete pile.

e. Structural enhancement can also be accomplished by drilling holes in the shaft and grouting in additional rebars or high strength bars.

f. Micropiles can be installed by drilling through the pile to anchor the pile into underlying formation. It may be possible to install these by drilling through existing inspection pipes.

**Topic 6. Discuss Mitigation by Supplementation or Replacement**

a. In some cases where the strength or stiffness of a drilled shaft is less than required, the most effective remediation strategy might be to add additional deep foundation elements (CIDH, driven, micropile). These might be designed to supplement or even completely replace the defective CIDH concrete pile.

b. Incorporating additional deep foundation elements into a common cap with the existing CIDH concrete pile must address the issue of strain compatibility.

**Topic 7. Discuss Successful Solutions Used in Past Pile Mitigation**

a. Discuss lessons learned from previously utilized nonstandard mitigation methods and applicability to this mitigation.
Topic 8. Mitigation Plan Design Requirements
   a. Provide the Contractor’s mitigation plan designer with design information (i.e.,
      moment and shear diagrams) necessary for completion of mitigation plan.

Topic 9. Additional Testing Requirements
   a. Discuss the need for any additional testing/coring prior to mitigation for further
      evaluation of the defect, or after the mitigation for conformance testing.

Topic 10. Timelines and Critical Path Activities

Topic 11. Safety
   a. Discuss applicable Construction Safety Orders.
   b. Discuss Mining and Tunneling Safety Orders (CIDH piles greater than 30"
      diameter and deeper than 20').
   c. Discuss day work vs. night work concerns.
   d. Discuss other project safety concerns as applicable.

Topic 12. Future Meetings
   a. Discuss the need for CIDH Pile Mitigation Plan Review Meeting.

Topic 13. Action Items / Adjourn
   a. List Action Items, responsible parties, and due dates.
   b. Adjourn meeting.
CIDH Concrete Pile Construction Report (PCR)

All Cast-In-Drilled Hole (CIDH) concrete pile construction activities are recorded by the Engineer and the Contractor under the requirements of a CIDH concrete pile quality management program. The quality management program defines quality control measures and documentation responsibilities of the Contractor and quality assurance measures and documentation responsibilities of the Engineer. The resulting documentation is assembled into a Pile Construction Report (PCR) for each CIDH concrete pile constructed.

PCRs are required for the following conditions:

1. For one CIDH concrete pile at each foundation support location where CIDH concrete piles between 24 inches and 60 inches in diameter are constructed.
2. For all CIDH concrete piles 60 inches in diameter or larger.

Two versions of the PCR are available:

1. Construction of CIDH concrete piles in “dry” conditions (without inspection pipes).
2. Construction of CIDH concrete piles in “wet” conditions (with inspection pipes).

The PCR for CIDH concrete piles constructed in “dry” conditions consists of the following documents that are completed by the Engineer:

1. Form SC-3802, Drilled Shaft Inspector’s Checklist
2. Form SC-3803, Drilled Shaft Excavation Log
3. Form SC-3804, Drilled Shaft Excavation Profile
4. Form SC-3805, Drilled Shaft Bottom Inspection
5. Copies of daily reports documenting construction of the CIDH concrete pile.

The PCR for CIDH concrete piles constructed in “wet” conditions consists of the following documents:

Completed by the Contractor:

1. Form SC-3807, Inspection Pipe and Rebar Coupler Log
2. Form SC-3808, Drilled Shaft Concrete Placement Log
3. Form SC-3809, Drilled Shaft Concrete Placement Graph
Completed by the Engineer:

4. Form SC-3801, GGL Inspection Pipe Verification Form
5. Form SC-3802, Drilled Shaft Inspector’s Checklist
6. Form SC-3803, Drilled Shaft Excavation Log
7. Form SC-3804, Drilled Shaft Excavation Profile
8. Form SC-3805, Drilled Shaft Bottom Inspection
9. Form SC-3806, Slurry Test Record
10. Copies of daily reports documenting construction of the CIDH concrete pile.

When completing these forms or reviewing forms completed by the Contractor, keep in mind these are quality assurance documents. Each form should have enough information that the pile construction process can be reconstructed virtually at a later date. Use Form SC-3802, Drilled Shaft Inspector’s Checklist, and the daily reports as quality assurance documents to verify the information submitted by the Contractor.
The following provides information and instructions for review and authorization of materials used to construct Cast-In-Drilled Hole (CIDH) concrete piling.

1 - Slurry Testing for CIDH Piling

Testing requirements for each of the authorized drilling slurries are listed in the contract documents. If the Contractor proposes to use slurry admixtures, discuss the type, concentration and mixing with the Structure Construction (SC) Substructure Engineer. All questions regarding the use of slurries can be directed to the SC Substructure Engineer.

SC has slurry test kits for use in the field. Witness the Contractor’s quality control testing of slurry and then randomly perform quality assurance testing using the kit. If your field office does not have a kit, contact your Bridge Construction Engineer.

The slurry test kits include equipment for testing density, sand content, marsh funnel viscosity, and pH. The test procedures for density, marsh funnel viscosity, and sand content can be found in the Recommended Practice for Field Testing Water-based Drilling Slurry by the American Petroleum Institute, accessed through the Caltrans account on the IHS Markit website, which requires the user to create a user account, then search for (API RP 13B-1).

Extensive background and commentary on slurry (including the reasons for testing slurry) are in the Foundation Manual, Chapter 9, Slurry Displacement Piles.

Key inspection considerations are summarized as follows:

- Before the slurry operation starts, verify that the Contractor’s sampling and testing equipment is adequate.
- Verify the Contractor is proportioning, mixing, agitating (or circulating) per the Contract Specifications. Sand can quickly settle out, especially with synthetic slurries. Mixing or agitating ensures accurate test results.
- Verify the Contractor takes slurry samples at the correct elevations.
- Slurry test results from the same hole (but different elevations) may vary, but each test result must conform to the requirements of the contract documents.

For synthetic slurry (not mineral slurries), occasionally take a sample and send it in to Materials Engineering and Testing Services (METS) to verify that the chemistry still matches the pre-approved product chemistry. On the sample testing ticket request that a copy of the results be sent to the Division of Engineering Services (DES) Pile Mitigation Committee Chair. Send about 8 ounces (200 ml) of the mixed slurry to:
2 - Use of Plastic Spacers in CIP Concrete Piles

Plastic spacers are used to ensure concentric spacing for the entire reinforcing steel cage in Cast-In-Place (CIP) concrete piles. It allows travel of the cage along the wall of the drilled shaft excavation minimizing dislodging soils and accumulation of loose material in the bottom of the excavation. It provides for adequate clearance for fresh concrete to flow up the annular space between the cage and the side of the excavation as well as to maintain a minimum concrete cover. The main concern for usage of plastic spacers for CIP concrete piles is the difference in the coefficient of thermal expansion between the plastic and concrete.

To address this concern, the industry standards and the Concrete Reinforcing Steel Institute (CRSI) recommend that all plastic-side-form spacers should have at least 25% of their gross plane area perforated to compensate for the difference in the coefficient of thermal expansion between the plastic and concrete.

Plastic spacers used in CIP concrete piles between the outside of the pile bar reinforcing cage and the side of the drilled hole must meet the following criteria:

- Spacers must be used near the bottom, the top, and at intervals not exceeding 10 feet vertically or per manufacturer’s recommendation, whichever is less.
- The spacers must be of sufficient size, composition, and durability to support the lateral loads placed by the reinforcing cage upon the sidewall of the shaft. The spacers must also be capable of withstanding impacts during the construction process.
- A minimum of 3 spacers are required at each level or per manufacturer’s recommendation, whichever is greater.
- The spacers must be of adequate dimension to ensure an annular space of not less than 3 inches between the outside of the pile bar reinforcing cage and the side of the excavation along the entire length of the CIP concrete pile.
- Plastic spacers must conform to the provisions in Section 3.4, All-Plastic Bar Supports, and Section 3.5, Side-Form Spacers, of the Concrete Reinforcing Steel Institute Manual of Standard Practice, attached below.
- Plastic spacers must be commercially manufactured. Examples of commercially manufactured plastic spacers are shown below.
3 - Sections 3.4. and 3.5. of the CRSI, *Manual of Standard Practice, 28th Edition*

3.4. All-Plastic Bar Supports

The industry practices presented in this section are intended to serve as a guide for the selection and utilization of all-plastic bar supports used to position reinforcing bars in reinforced concrete.

All-plastic bar supports may have a snap-on action or other method of attachment. All-plastic supports are lightweight, non-porous and chemically inert in concrete. Properly designed, all-plastic bar supports should have rounded seating to avoid punching holes in the formwork and should not deform under load when subjected to normal temperatures encountered in use nor should they shatter or severely crack under impact loading when used in cold weather.

All-plastic bar supports will not rust, therefore eliminating blemishes on the surface of the concrete. These supports are particularly suitable in situations of moderate to severe exposure or when grinding of the concrete is necessary. All plastic bar supports may be used to support epoxy-coated reinforcing bars (see Section 3.6). These bar supports provide maximum rust protection, i.e., Class 1.

3.5. Side-Form Spacers

A side-form spacer is a type of bar support which is used to maintain side concrete cover on the reinforcing bars against a vertical form, such as for walls and columns. Spacers can also be used to align a reinforcing bar cage in a drilled shaft. Spacers can be made of steel wire, precast concrete, or plastic. Examples of side-form spacers are SBC wire bar supports, DSSS and DSWS precast concrete bar supports, and WS, DSWS and VLWS all-plastic bar supports.

Typically, these supports are not shown on the design or contract drawings. There are numerous variations in the placer’s requirements making it difficult for the supplier to estimate. Estimating, detailing or furnishing these materials is not a normal industry practice unless by special arrangement with the General Contractor or placer. Unless agreed to between the buyer and the seller, these materials will not normally be included in the supplier’s bid.

* Published with permission of the Concrete Reinforcing Steel Institute*
Figure 1. Sample of Commercially Manufactured Plastic Spacers
Cast-In-Steel-Shell Concrete Piling – Measurement and Payment

1 - Measurement

Cast-In-Steel-Shell (CISS) concrete piling that fails to reach tip elevations shown on the plans, but has been determined to be adequate and approved by the Bridge Design Structure Project Engineer and Geotechnical Services Geoprofessional, is measured along the longest side, from the tip elevation shown on the plans to the plane of cut-off elevation.

2 - Payment

Refer to BCM 49-2, Piling – Driven Piling, prior to making payment for CISS concrete piling.

2.1 Materials on Hand

When the contract special provisions qualify the material for materials on hand and it does not meet the requirements for “furnishing”, payment may be made as materials on hand at the Contractor’s request.

Steel shells and bar reinforcing steel used for CISS concrete piling are typically eligible for payment under materials on hand, but not yet incorporated in the work.

Specific instructions for materials on hand payment can be found in the Construction Manual, Section 3-906E, Materials on Hand.

2.2 Furnish and Drive Piling Contract Item Payment

Pay close attention to the breakdown of furnish and driving contract item payment for CISS concrete piling. While portions of piling, such as steel shells for CISS concrete piling, can be paid as materials on hand, they are not complete piling and cannot be paid under the furnishing contract item. When the steel shells for CISS concrete piles have been driven and the concrete and reinforcing steel have been placed to provide a complete pile, the contract item for furnishing may be paid.

Note the concrete filling material for CISS concrete piling is paid under the furnishing item while the placement of said material is paid under the driving item. This is particularly important when making item adjustments.
Cast-in-Drilled-Hole Concrete Piling – Construction

BCM 49-3.02C, Cast-in-Drilled-Hole Concrete Piling – Construction, was not issued.

Instead, information for this topic is addressed in BCM 49-3, Piling – Cast-in-Place Concrete Piling
Piling - Steel Soldier Piling

Revision and Approval

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of steel soldier piling submittals, quality assurance, materials and construction that apply to all steel soldier piling.

This process is limited to installation of steel soldier piling. Contract requirements for administering the construction of soldier pile walls are located in the Contract Specifications (CS), Section 19, Earthwork, and guidance in Section 19, Earthwork.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the CS, Section 49-4, Piling – Steel Soldier Piling, that this BCM is based on as identified in the title block above. The information in the CS typically will not be repeated in the text of this BCM.

Process Inputs

1. Submittals:
   a. Pile installation plan
   b. Drilling equipment operational capacities, if applicable
2. Materials:
   a. Form CEM-3101, Notice of Materials to be Used
   b. Form TL-0029, Report of Inspection of Material
c. Certified material test reports and certificate of compliance for structural
shape steel piling per BCM 49-2, Piling – Driven Piling

d. Concrete mix designs

3. Construction:

a. Authorized Pile Handling Work Plan required in CS, Section 49-1.01C(1),
Piling – General – Submittals – General, and per the guidance in BCM 49-1,
Piling – General

b. Authorized soldier pile wall shop drawings and calculations per guidance in
BCM 19-3.01C, Earthwork - Structure Excavation and Backfill – Submittals

c. Authorized welding quality control plan (WQCP) per guidance in BCM 11,
Welding

d. Authorized painting quality work plan per guidance in BCM 59-2, Structural
Steel Coatings - Painting Structural Steel

e. Form SC-3803, Drilled Shaft Excavation Log

f. Form SC-3805, Drilled Shaft Bottom Inspection

g. Form SC-3806, Slurry Test Record

**Procedure**

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:

a. **Benchmark** for:
   
i. Review of submittals
   
ii. Inspection and verification of materials used during construction
   
iii. Inspection of pile layout and reference elevations.

b. **Intermittent** for:
   
i. Temporary casing installation
   
ii. Field welding
   
iii. Inspection of steel soldier pile setting.

c. **Continuous** for:
   
i. Drilling
   
ii. Cleaning drilled holes
   
iii. Slurry testing
   
iv. Critical lifts/work adjacent to traffic
v. Placing concrete.

3. Before construction begins, the Structure Representative (SR) or delegate must:
   a. Perform document review of the following:
      i. Log of test borings and foundation reports.
      ii. Resident Engineer’s (RE) pending file per BCM C-2, *Using the Resident Engineer’s Pending File for Structure Work*.
      iv. *SC Winter Training* presentation from 2014 titled, 06-Soldier Pile ERS, and any other related and more current presentations.
   b. Perform the review and authorization of submittals as follows:
      i. Develop a submittal log to:
         1. Document submittal review milestones.
         2. Document conversations, review notes, and reasons for review delays.
         3. Monitor the submittal review time.
      ii. Discuss the submittal review timelines with the Bridge Design (BD) Structure Project Engineer.
      iii. Review the Contractor’s responsibilities and timelines for all submittals listed in the contract documents including:
         1. Pile installation plan
         2. Concrete backfill placement report
         3. Shop drawings for soldier pile wall per BCM 19-3.01C, *Earthwork – Structure Excavation and Backfill – Submittals*
         5. Painting quality work plan per BCM 59-2, *Structural Steel Coatings – Painting Structural Steel*
         6. Certified material test reports report and certificate of compliance for structural shape steel piling per BCM 49-2, *Piling – Driven Piling*
         7. Drilling equipment operational capacities, if applicable
      iv. During submittal review, discuss potential problem areas, unusual details, and risks with the Bridge Construction Engineer (BCE), BD Structure Project Engineer, Geotechnical Services (GS) Geoprofessional, and/or Substructure Engineer, which may include:
         1. Difficult drilling conditions
2. Groundwater and caving conditions
3. Environmental work window restrictions.

v. Verify the submittals meet the requirements of the contract documents, as follows:
1. Check for agency/utility impacts.
2. Forward the water pollution control plan addendums to the RE for authorization.

vi. Review and authorize or reject (for resubmittal) the submittals. Notify the Contractor in writing.

c. Prepare for material release and acceptance, as follows:

i. Review and discuss with the Materials Engineering and Testing Services Representative (METS Rep) any materials to be inspected and released via Form CEM 3101, Notice of Materials to be Used, and Form TL-0029, Report of Inspection of Material, and which materials are to be field released via Form SC-4102, Material Inspected and Released on Job, and Form SC-4101, Materials Release Summary. Utilize the forms to justify any materials on hand payments.

ii. For field welding of steel piling, verify the welding quality control plan and welder certification requirements have been met per CS, Section 11-2, Welding – Welding Quality Control, and guidance in BCM 11, Welding.

iii. Verify that steel soldier pile materials have been released for construction by METS using Form TL-0029, Report of Inspection of Material, and match with the orange tags collected in the field.

iv. Perform timely field verification that the materials delivered meet contract requirements, authorized submittal requirements, and were not damaged in shipping.

v. Discuss field welding requirements per AWS D1.1, Structural Welding Code – Steel, with the Contractor and METS Rep.

   1. Note that the methods to obtain the AWS D1.1 include requesting a copy from the BCE or the METS Rep, or accessing through the Engineering Workbench which requires an account login.

vi. Verify the certificates of compliance and mill certificates comply with contract requirements and file in Category 41, Report of Inspection of Material.

vii. Verify concrete mix design meet the requirements of the contract documents.

viii. Review the Construction Manual, Section 6-107, Materials Acceptance Sampling and Testing, and Table 6-1.17, Materials Acceptance Sampling
and Testing Requirements: Concrete, for steel soldier piling concrete backfill materials testing schedules.

d. Prepare for steel soldier piling production work, as follows:

i. Review the project specific Code of Safe Practices for personal protective equipment requirements and safety hazards associated with steel soldier piling construction.

ii. Verify that SC staff have completed fall protection training and have a safety harness and lanyard for work near an open hole.

1. Note that an SC Fall Protection Refresher Training can be found on the SC Online Training intranet site.

iii. Discuss the requirements of the pile installation plan with the Contractor, including:

1. Drilling sequence when soldier piles are in close proximity per the requirements of the contract documents.

2. Drilled hole alignment and required horizontal and vertical clearances around the steel soldier pile per the contract documents.

3. Handling and disposal of drill cuttings, groundwater, and drilling slurry:

   a. Coordinate environmental, water pollution control, and traffic control requirements with the RE.

   b. Verify compliance with authorized project storm water pollution prevention plan (SWPPP) or water pollution control program (WPCP).

4. Use of two tremie tubes when concrete is placed under slurry.

iv. If proposed for use, verify drilling slurry and any proposed additives are authorized for use as described in the contract documents.

v. Discuss with the RE and Contractor any existing facilities concerns and agency requirements, such as underground utilities and overhead power lines.

vi. Confirm primer coating on piles was not damaged during storage.

vii. Ensure that the Contractor provides suitable tools, such as a mirror or flashlight, to be used for inspecting the conditions of the drilled hole.

viii. Prepare steel soldier pile quantity record and layout sheet. Note that the following sheets can be used as templates:

1. Form SC-4804, Pile Quantity and Drilling Record (CIDH Piles) Sheet

2. Form SC-4806, Pile Layout Sheet

ix. Prepare the following forms:
1. **Form SC-3803, Drilled Shaft Excavation Log**
2. **Form SC-3805, Drilled Shaft Bottom Inspection**
3. **Form SC-3806, Slurry Test Record**

  x. Place reference staking hubs and provide cut elevations for concrete backfill cutoff and lean concrete backfill cutoff.

4. During Construction, the SR or delegate must:
   a. Document and photograph all equipment and tooling on the job site.
   b. Verify crane and operator certifications meet the requirements of Cal/OSHA Title 8, Chapter 4, Subchapter 4, *Construction Safety Orders*, Article 15, *Cranes and Derricks in Construction*.
   c. Verify the Contractor’s pile layout of steel soldier piling. Verify the location of the drilled hole is within tolerance specified in the contract documents.
   d. Inspect drilled holes per *Foundation Manual*, Chapter 14, *Specialty Piles and Special Considerations for Pile Foundations*.
   e. Complete **Form SC-3803, Drilled Shaft Excavation Log**. Record observations made during drilling.
   f. Evaluate whether the material from the drilled hole is consistent with the material description in the contract documents.
      i. Document deviations on **Form SC-3803** for potential identification of differing site conditions, as described below.
      ii. Discuss deviations with the GS Geoprofessional and the SC Substructure Engineer.
      iii. If the Contractor submits notification of a differing site condition, follow the procedures in the *Construction Manual*, Section 3-404, *Differing Site Conditions*.
   g. Verify plumbness of the drilled hole.
   h. Verify drilled hole cleanliness and complete **Form SC-3805, Drilled Shaft Bottom Inspection**, to document the condition of the bottom of the drilled hole.
      i. Verify drilled depth reached contract plan tip elevation.
      j. If caving holes or groundwater are encountered, verify the Contractor uses remedial methods that conform to the requirements of the contract documents.
      k. If drilling slurry is introduced into the drilled hole, verify the Contractor’s use of drilling slurry per the requirements of the contract documents.
i. Verify that drilling slurry is tested at specified intervals. Verify the Contractor documents results of slurry testing on Form SC-3806, Slurry Test Record.

1. Ensure a slurry test kit is available for sampling and testing the drilling slurry.

ii. Verify drilling slurry levels in the drilled hole are maintained as required in the contract documents.

l. Verify steel soldier pile alignment and required horizontal and vertical clearances around the steel soldier pile per the contract documents.

m. Ensure pile is secure in the hole prior to concrete backfill placement.

n. Verify the concrete mix delivered is the authorized concrete mix design.

o. Sample and test concrete materials per the requirements of the Construction Manual, Section 6-107, Materials Acceptance Sampling and Testing, Table 6-1.17, Materials Acceptance Sampling and Testing Requirements: Concrete, and as outlined in BCM 90-1, Concrete – General.

p. Verify the concrete placement method used by the Contractor will not cause segregation of the concrete.

q. Verify the use of two tremie tubes when concrete is placed under slurry:
   i. Verify the Contractor caps or plugs the concrete delivery tube prior to first discharge or concrete into the pile.
   ii. Verify the Contractor recovers the cap or plug after concrete placement begins.
   iii. Verify the Contractor maintains concrete delivery tube elevations and drilling slurry elevations as specified in the contract documents.

r. Ensure concrete backfill cutoff elevation per the contract documents. Concrete backfill should not extend above the lowest lagging elevation on each pile.

s. If temporary casing is used, verify the Contractor removes the temporary casing in accordance with the requirements of the contract documents.

t. Document all inspection, construction, and quality assurance activities, pertinent to this BCM in the daily reports per BCM C-7, Daily and Weekly Reports.

u. Complete bid item payment and materials on hand payment for the applicable steel soldier piling bid items upon successful placement of the pile concrete, including receipt of all required forms from the Contractor.

v. Document any a changes on the project plan as-builts per guidance in BCM C-6, Required Documents to be Submitted during Constructions.
5. Following construction, the SR or delegate must:
   a. File all project documentation (correspondence, submittals, materials
      acceptance documentations, completed forms, daily reports, etc.) in the
      appropriate category in the project records as specified in the Construction
      Manual, Section 5-102, Organization of Project Documents.

Process Outputs

1. Authorized pile installation plan
2. Concrete backfill placement report
3. Completed Form TL-0029, Report of Inspection of Material, and matching orange
tags
4. Completed Form SC-4101, Materials Release Summary, and Form SC-4102,
Material Inspected and Released on Job
5. Completed Form SC-3803, Drilled Shaft Excavation Log, Form SC-3805, Drilled
Shaft Bottom Inspection, Form SC-3806, Slurry Test Record, quantity record and
pile layout sheet
6. Daily reports
7. Project plan as-builts

Attachments

None
Piling – Micropiling

Revision and Approval

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for the review and authorization of micropiling submittals, conducting the micropiling preconstruction meeting, review of the contractor’s micropiling load testing, Department Acceptance activities for micropiling, micropiling materials inspection and release for construction, and micropiling construction.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 49-5, Piling – Micropiling, that this BCM is based on. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Contract work that requires micropiling
2. Submittals:
   a. Summary of the micropile subcontractor’s experience qualifications
   b. Micropiling shop drawings and calculations
   c. Installation plan
3. Materials:
   a. Form CEM-3101, Notice of Materials to be Used
4. Construction:
   a. Verification and proof load test acceptance criteria
b. Installation logs

c. Grout test results

d. Load test data

Procedure

1. All work associated with this process is charged as Project Direct – Preconstruction.

2. Inspection for this process is:
   a. Benchmark for any field work associated with authorization of submittals or field release of materials, and routine drilling.
   b. Continuous for all contractor-performed micropile load testing, drilling when problems occur, grout placement and testing, mitigation work for failed micropiling, and installation of reinforcing steel assembly.

3. Before construction begins:
   a. Review the following resources which identify the criteria for this process:
      i. Contract Documents
      ii. Log of Test Borings plan sheets and the Foundation Reports found in the Information Handout
      v. Design files in R.E. Pending File
      vi. Authorized shop drawings
      vii. Foundation Manual, Chapter 13, Micropiles, Appendix J, Micropiles, and Appendix K5, Micropile Construction Checklist
   b. Discuss potential problem areas, unusual details, and risk with the Bridge Construction Engineer, Structural Designer, Geoprofessional, such as:
      i. Difficult drilling conditions
      ii. Failing load and production testing
      iii. Environmental work window restrictions
   c. Develop a submittal log
   d. Remind the contractor of their responsibilities for all the submittals listed in the contract
e. Review submittals. Authorize or reject micropile action submittals (other than shop drawings). Notify the contractor in writing.

f. Receive shop drawings from the SC Office Associates. Provide micropiling shop drawing review comments to the Structure Designer.

g. Prepare for and conduct the micropile preconstruction meeting with the contractor per the requirements of the contract documents (refer to Foundation Manual, Appendix K5, Micropiling Construction Checklist).

h. Confirm Structure Designer authorizes or rejects micropiling shop drawings.

i. File all authorized submittals in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

j. For the preconstruction meeting:

i. Prepare an agenda. Address all issues required by the contract documents, including:

   1. Safety requirements:
      a. Cal/OSHA Title 8 CSO, and project specific requirements
      b. Underground Dig Alerts
   2. Acceptance testing
   3. Environmental requirements

ii. The meeting must include the Resident Engineer, Structure Representative, Assistant Structure Representatives, SC Substructure Engineer, Designer, Geotech, contractor’s representatives, and any subcontractors involved in micropile construction.

iii. Discuss deficiencies identified in the initial review of submittals.

iv. Discuss contingency plans for capturing risks and opportunities identified during the micropile preconstruction meeting.

v. Generate micropile preconstruction meeting minutes, including discussion of any issues, solutions, action items, and resubmittals if required.

vi. Schedule additional micropile preconstruction meetings or focus meetings if necessary.

k. For materials:

i. Review Form CEM-3101, Notice of Materials to be Used and discuss with the Materials Engineering and Testing Services (METS) Representative which micropiling materials are to be inspected and released via Form TL-0029, Report of Inspection of Material, and which micropiling materials are
to be field released utilizing Form SC-4102, Materials Inspected and Released on Job.

ii. For anticipated field welding, verify Welding Quality Control Plan and welder certification requirements have been met per BCM 11-2, Welding Quality Control, and conforms to AWS D1.1 or current code.

iii. Discuss concerns with SC Substructure Engineer, when necessary.

I. Preparing for load testing:

i. Review the Foundation Manual, Chapter 13, Micropiles, Appendix J, Micropiles, and Appendix K5, Micropile Construction Checklist, for information pertinent to load testing of micropiling.

ii. Verify grout has attained the compressive strength specified in the contract documents.

iii. Remind the contractor to notify the engineer prior to performing each load test.

iv. Verify that Department-furnished pressure cell and strain indicators (load cells) are calibrated, which will be used to verify the contractor's testing equipment. Refer to the Prestress Manual, Appendix B, Strain Indicator – Pressure Cell, for guidance.

v. Discuss with the contractor the contract requirements including micropile load data submittal, acceptance criteria and the contract requirements for failed load test.

vi. Verify that the contractor can record load test data.

m. Preparing for micropiling production work:

i. Review authorized micropiling submittals.

ii. Review the Foundation Manual, Chapter 13, Micropiles, and Appendix K5, Micropile Construction Checklist.


iv. Discuss with the R.E. and contractor any existing facilities concerns and agency requirements, such as underground utilities and overhead power lines.

v. Verify that micropiling materials have been released for construction by METS using Form TL-0029, Report of Inspection of Materials, and match with the orange tags collected in the field.

vi. Check the contractor's material storage area for environmental compliance.
vii. Prepare Quantity Record Sheet, Log Micropile Sheet, and Micropile Layout Sheet:

1. Until dedicated forms are developed, the following existing forms for piles can be modified for use:
   a. Form SC-4803, Pile Quantity & Driving Record (Driven Piles)
   b. Form SC-4805, Log Pile Sheet
   c. Form SC-4806, Pile Layout Sheet

viii. Refer to BCM 50-1, Prestressing Concrete – General, for information and links to prepare the following forms:

1. Load Cell data collection form for load verification testing (Proof Load and Verification Load testing, Load Test).
2. Grouting record form.

4. During construction:

   a. For submittals received and testing performed during construction:

      i. For each micropile, verify the contractor submits the following in accordance with the requirements of the contract documents:

         1. Micropile installation log (Informational Submittal)
         2. Grout test results
         3. Load test data

      ii. Review and authorize submittals before accepting each micropile. Reject incomplete submittals. Work with contractor to obtain missing information.

      iii. For failed verification load testing:

          1. Notify the contractor of the requirements for revised submittals as stated in the contract documents.
          2. Review and authorize revised submittal.

   iv. Discuss project-specific issues or concerns with acceptance or rejection of micropiling with the SC Substructure Engineer, Structural Designer, and Geotechnical Designer.

   v. File all authorized submittals in the in the appropriate category in the project records as specified in the Construction Manual, 5-102, Organization of Project Documents.

b. Materials:

   i. Discuss project-specific issues or concerns with micropiling materials with METS.
ii. Document all micropiling materials verification activities in the Daily Reports.

c. Construction:
   i. Verify reinforcing steel assemblies and micropile assembly lengths.
   ii. Verify micropile layout and alignment and ensure contractor used adequate means to control pile alignment.
   iii. Confirm stability of each drilled hole.
   iv. If temporary casing is used, record casing type and length.
   v. Record observations made during drilling such as material excavated, difficult drilling, missed production, etc.
   vi. Verify drilled hole cleanliness.
   vii. Verify micropile depths and ensure contract plan tip elevation has been reached.
   viii. Verify cleanliness of the reinforcing steel, and appropriate use of centralizers during placement of reinforcing steel.
   ix. Verify that all grouting equipment are in good working condition.
   x. Record grout volumes and grout pressure for each micropile. Watch for grout loss and communication between adjacent holes.
   xi. Verify quality of grout at ground surface (when the hole is full of grout).
   xii. Collect grout samples.
   xiii. Be present at the jobsite during load testing.
   xiv. Verify that the contractor’s testing equipment complies with the authorized micropiling submittals.
   xv. Verify that the contractor measures and records the micropile movements for both verification and proof loading testing per the tables in the contract documents.
   xvi. Document all inspection, construction, and quality assurance activities in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Following construction:
   a. Complete all micropiling project records.
   b. File all project documentation (correspondence, material acceptance documentation, test results, micropiling records, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.
Process Outputs

1. Submittals:
   a. Authorized micropiling submittals
   b. Micropile load test data
   c. Accepted micropiling installation logs
   d. Accepted grout test results
   e. Accepted load test data

2. Preconstruction meeting:
   a. Communication protocol
   b. Established delineation of responsibilities among all parties
   c. Micropile preconstruction meeting minutes
   d. Document risks identified during the micropile preconstruction meeting that may need to be communicated to the Caltrans Project Manager and other interested parties
   e. Action items that result from the micropile preconstruction meeting

3. Materials:
   a. Form SC-4102, Materials Inspected and Released on Job

4. Construction:
   a. Load test data
   b. Completed installation logs for each micropile
   c. Completed load test data for each micropile
   d. Completed micropile grout test reports
   e. Daily reports

Attachments

None
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Prestressing Concrete

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Contact SC Technical Team E for questions

Background

This process establishes Structure Construction (SC) responsibilities and procedures for the review and authorization of submittals and materials, quality assurance, construction, and payment for prestressing concrete as specified in the contract documents.

When working with precast concrete members additional requirements are detailed in the Contract Specifications:

- Section 51-4, Concrete Structures – Precast Concrete Members
- Section 90-4, Concrete – Precast Concrete

Before reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 50, Prestressing Concrete, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Submittals:
   a. Prestressing shop drawings
   b. Test samples (strand, bar, anchor assembly, etc.)
   c. Grouting plan
d. Daily grouting reports
e. Alternative prestressing shop drawings

2. Materials:
   a. Prestress anchorage system
   b. Prestressing steel (strand and bar)
   c. Duct vents and ties
d. Grout and grout caps
e. Corrosion inhibitor
f. Structural concrete
g. Pretensioned precast member

3. Quality Control (QC)/Assurance (QA):
   a. CEM-3101, Notice of Materials to be Used
   b. Calibration of the hydraulic jacking equipment and pressure gauges with Materials and Engineering Testing Services Representative (METS Reps), scheduled by the Contractor
c. Contractor provided calibration data for hydraulic jack and gauges
d. Notification from the Contractor for pressure testing of prestressing ducts
e. Notification from the Contractor to witness duct demonstrations
f. Notification from the Contractor for duct void investigations
g. Copy of certificate to verify technician is certified as a Level 2 Bonded Post-Tensioning Field Specialist
h. Copy of certificate to verify technician is certified as a Grouting Technician under American Segmental Bridge Institute (ASBI).

Procedure

1. All work associated with this process should be charged to the Project Direct – Construction.

2. The inspection of field work for this process is:
   a. Benchmark inspection for prestressing bearing plate assembly, strand, duct, and duct tie installation.
b. Continuous inspection for soffit, stem, and deck concrete placement near PS tendons to verify adequate concrete consolidation and prevent duct damage.
   c. Continuous inspection for duct demonstration, void investigation, pressure testing ducts, strand placement, stressing and grouting.
3. Before construction begins, the Structure Representative (SR) or delegate must:
   a. During submittal review:
      i. Verify project prestress (PS) shop drawings have been received by the SC Office Associates from the Contractor in accordance with Contract Specifications, Section 5-1.23B(2), Control of Work – Submittals – Action Submittals – Shop Drawings, in a timely manner to meet the critical path schedule. Note email address provided in step 3.a.xii.
      1. Coordinate and monitor the submittal process. Establish lines of communication regarding shop drawing reviews with Bridge Design (BD) Structure Project Engineer and METS Representative (METS Rep).
      ii. Review all contract documents pertaining to prestressing concrete.
      iii. Review the following references as required to develop an understanding of prestressing and grouting operations:
         2. Post-Tensioning Institute (PTI)
         3. American Segmental Bridge Institute (ASBI)
         5. BCM 51-4, Concrete Structures – Precast Concrete Members.
      iv. Perform an initial review of shop drawings for the proposed prestressing system and review comments with the BD Structure Project Engineer according to:
         1. Caltrans Prestress Manual:
            a. Section 2, Prestress Shop Drawings
            b. Section 8, Prestressing Operation.
      v. Verify the PS system is on the Materials and Engineering Testing Services (METS) Authorized Materials List (AML). If the system is not listed on AML, notify the METS Rep and the Contractor immediately.
      vi. Verify BD Structure Project Engineer incorporates the Structure Representative’s (SR) comments before completing shop drawing review.
      vii. Verify BD Structure Project Engineer authorizes the prestressing shop drawings, per Memo to Designers (MTD) 11-1, Prestressed Concrete – Shop Drawing Review.
      viii. Verify all reviewers from the SC staff and the Contractor have received all rejected or authorized shop drawings.
      ix. See Contract Specifications, Section 4-1.07B, Scope of Work – Value Engineering – Value Engineering Change Proposal, for alternative
prestressing system shop drawings which require a change order (CO). See Prestress Manual, Appendix A, Prestressing Systems for required information needed for approval by METS Rep for a new or modified prestress system.

x. Verify the METS Rep receives the test sample(s) and notifies of any noncompliance issues. Coordinate and monitor the test sample(s) submittal process.

xi. Review the grouting plan as part of the PS shop drawing or as a separate submittal. If received as a separate submittal, the plan must be reviewed and authorized.

xii. If prestressing materials are used in a precast (PC) concrete member, verify PS PC concrete member shop drawings are submitted to sc.office.associates@dot.ca.gov (formerly OSD Documents Unit, now SC Office Associates) as required per Contract Specifications, Section 51-4.01C(2), Concrete Structures – Precast Concrete Members – General – Submittals – Shop Drawings.

xiii. Verify receipt of the Precast Concrete Quality Control Plan in accordance with Contract Specifications, Section 90-4.01C(3), Concrete – Precast Concrete – General – Submittals – Precast Concrete Quality Control Plan.

xiv. Attend the Contractor’s PC Concrete Quality Control Meeting in accordance with Contract Specifications, Section 90-4.01D(2)(b), Concrete – Precast Concrete – General – Quality Assurance – Quality Control – Quality Control Meeting. The METS Rep, SC staff, prime contractor, and fabricator will also attend.

xv. Check the Critical Path Method (CPM) schedule as related to prestressing operation activities. Meet with the Bridge Construction Engineer (BCE) to review submittal status updates as required by the project needs. Note that the BCE is also referred to as the SC Supervisor.

b. For materials:

i. Confirm authorized PS shop drawings have been received and distributed to the Contractor, METS Rep, and SC project field staff.

ii. Confirm that the Contractor has submitted Form CEM-3101, Notice of Materials to Be Used, for all related materials and all precast members.

iii. For the material’s release procedure refer to the Caltrans Construction Manual:

   1. Figure 6-2.1, Inspection and Release Flowchart – Source Inspection.
   2. Figure 6-2.3, Inspection and Release Flowchart – Inspection at Job Site.

iv. Confirm the materials for which the METS Rep will issue Form TL-608, Notice of Materials to be Furnished.
v. Verify which materials will be field released using Form TL-28, Notice of Materials to be Inspected at Job Site and expect:
   1. Materials typically not released by the METS Rep include ducts, vent tubes, trumpets, wedges, and grout materials.
   2. Grout cement shall be field released with a Certificate of Compliance (COC).

vi. Verify the following were released by METS Rep with Form TL-0029, Report of Inspection of Material:
   1. PS anchorage system components and strands.
   2. PC concrete members (PC concrete pavement panels, deck panels, girders, etc.), the PC concrete members themselves will be released.

c. In preparation for safety issues:
   i. Review the following documents:
      1. Project specific or Division of Construction Code of Safe Practices (COSP)
      2. Safety Data Sheets (SDSs) for grout components, corrosion inhibitor, etc.
      3. Prestress Manual, Section 1, Safety.
   ii. Verify all required Personal Protective Equipment (PPE) are obtained for SC project field staff which may include appropriate eye protection, gloves, and dust masks.
   iii. Verify the Contractor provides safe access to the job site.

d. For quality assurance:
   i. Review the following documents in addition to the Prestress Manual:
   ii. Select field samples for couplers used to extend prestressing bars. Verify test results meet contract compliance.
   iii. Verify SC project field staff are trained to perform American Society for Testing and Materials (ASTM) C939 or California Test 541, Method for Flow of Grout Mixtures (Flow Cone Method).
   iv. For precast members:
      1. Verify shop drawing dimensions of PC concrete members match required field dimensions for proper fit.
2. Review the time between fabrication of the PC concrete member and proposed installation in the field. Excessive time may lead to undesired camber which needs to be mitigated before deck placement. Steps to be taken include:
   a. Discussing and coordinating scheduled installation of PC concrete girders with the Contractor and METS Rep during the PC Concrete Quality Control Meeting before the work begins per Contract Specifications, Section 90-4.01D(2)(b), Precast Concrete – General – Quality Assurance – Quality Control – Quality Control Meeting.

3. Verify METS Rep checks girder camber periodically while being stored at the fabricator’s yard and again before shipping to the jobsite.

4. During construction, the SR or delegate must:
   a. For submittals:
      i. Use the authorized prestressing shop drawing to verify materials for contract acceptance.
      ii. Confirm any additional changes (layout of ducts, bearing plates, duct ties or rebar, etc.) are implemented to:
         1. The project plans by a change order, and/or
         2. The prestressing shop drawings by the Contractor submitting a revision to the prestressing shop drawing for authorization by BD Structure Project Engineer.
   b. For materials:
      i. Review all materials for conformance with the requirements of the contract documents. For additional information on inspecting prestressing materials, see the Prestress Manual:
         1. Section 3, Prestressing Ducts
         2. Section 4, Prestressing Strands/ Bars
         3. Section 5, Anchorage Devices
         4. Section 6, Strand Wedges
      ii. Verify field released materials listed in Form TL-28, Notice of Materials to be Inspected at Job Site are released using Form CEM-4102, Material Inspected and Released on Job.
      iii. Verify that materials which have been released by METS are physically identified with an attached Form TL-0624, Inspection Release Tag (orange release tag).
      iv. Record the area (A) and Young’s Modulus (E) of the strand from the fabricator’s tags for each individual strand pack on the daily report.
      v. Verify that the values on fabricator’s tag and the COC agree.
vi. Collect the orange inspection release tag and verify the information matches with Form TL-0029, Report of Inspection of Material. Note the Lot Numbers, quantity, and date of release on the back of the orange release tag.

vii. Check condition of strand packs on delivery at job site and reject if not in contract compliance. Check storage site for adequate protection of packs and prestressing materials. Strands must be properly protected with wrappings until placement.

viii. Review condition of ducts for damage or blockage.

ix. Verify corrosion inhibitors meet contract requirements, and that product data sheet and a material SDS are provided. Determine if required rust inhibitor agent has been applied to prestressing steel.

x. Verify that the Contractor uses contract-specified mix proportions and follows manufacturer’s recommendation for any admixtures before grouting operation.

xi. For precast members:
   1. Verify all Form TL-0015, Quality Assurance - Nonconformance Reports (NCR) for PC concrete members are resolved before delivery to project site.
   2. Inspect PC concrete members for damage upon delivery to the jobsite and notify the Contractor immediately if PC concrete members are unacceptable for installation.

c. For safety:
   i. Verify all field work is performed safely according to:
      1. CAL/OSHA Construction Safety Orders, Section 1711, Reinforcing Steel and Post-Tensioning in Concrete Construction
         a. Note that these safety orders are found in the California Code of Regulations, Title 8, Chapter 4, Subchapter 4
      2. Contractor’s Injury Illness Prevention Plan (IIPP)
      3. Caltrans project specific COSP.

d. For quality assurance:
   i. For bearing plates and trumpets:
      1. Verify that block-outs are formed to the correct slope/batter and are perpendicular to the ducts as required by the contract documents.
      2. Verify reinforcing steel behind bearing plates.
      3. Verify anchor plates are the correct size.
      4. Verify that the trumpets are properly secured to the bearing plates.
   ii. During placement of rigid ducts:
1. Verify ducts and vents are placed in accordance with the requirements of authorized shop drawings and the contract documents.

2. Verify the adequacy of end anchorage formwork and the size of anchorage hardware. Plate should be fastened to the forms at the proper angle, sealed tight and secured.

3. Verify each girder contains the correct number of ducts and the correct size of ducts as called for on the shop drawings.

4. Verify duct joints for adequate grade of waterproof tape. Be sure that there are adequate ties to hold ducts from floating during placement of concrete. Stagger joints to maintain proper profile.

5. Verify final profile of rigid duct. Consider camber in forms when visually inspecting the tendon drape. The first 15 feet from the end anchorage should also be given special attention to eliminate severe angular changes. Structure cross slope and sloping exterior girders often require special attention to correctly measure the duct profile.

6. Verify installation of intermediate grout vents. Typically, grout vents are required at all high points when there is a change in profile of six inches or more.

7. Verify that snap ties, tie bolts, etc. have not been placed through or just above or below ducts, to avoid possible duct damage.

8. Discuss optional duct demonstration in the prestressing ducts with the Contractor prior to stem and soffit concrete placement. Duct demonstration requirements must follow the contract documents and include running an approved device, referred to as a torpedo, a rabbit, or a mandrel, through the ducts.

9. Verify all defects in ducts (breaks, crushed areas, etc.) have been repaired before concrete placement.

10. Verify duct tie size and spacing is in accordance with project plan and Standard Plans, Section B8-5, Cast-In-Place Post-Tensioned Girder Details.

11. Verify duct alignment and duct tie requirements at all exterior girder flares and on curved bridges; see Bridge Design Memo, BDM 5.27, Curved Cast-In-Place Prestressed Box Girders. If duct ties are not shown on project plans, and there is a significant change in horizontal alignment of duct, contact the BD Structure Project Engineer.

12. Verify the tendon openings are sealed to prevent water or debris from entering the duct.

iii. During stem and soffit concrete placement:

1. Verify that if possible, ducts are covered with an inch of concrete in the bent cap area but allow for cap rebar clearance.
2. Verify rock pockets are avoided by proper vibration of concrete, particularly around anchor plates and low areas of the duct’s path.

3. Verify no impact loading on ducts nor dropping vibrator directly on ducts.

4. Verify prestressing system alignment to see that no unusual movement takes place during concrete placement.

iv. After stem and soffit concrete placement:
1. Prior to installation of the lost deck forms, verify the Contractor performs a duct demonstration to check for any blockages that occurred during stem and soffit concrete placement. The ends of the ducts must be covered after the ducts are checked and clear of blockages. All blockages must be resolved before deck concrete placement. Sources of blockage may include:
   a. Duct dented before or during concrete placement.
   b. Form ties placed through duct or duct crushed by rebar etc.
   c. Concrete leakage into duct during concrete placement.
   d. Separation of duct sections due to inadequate fabrication.

2. Inspect the area around the anchorages and all stems for rock pockets. Voids must be repaired. Epoxy concrete or other specialty concrete mixes should not be used for repairs behind bearing plate, whether before or after stressing. See Attachment 1, Precautions During Prestressing Concrete Operations.

3. Verify damaged ducts are repaired and the ends of the ducts must be covered.

4. Verify ducts are aligned with trumpets.

v. During deck concrete placement:
1. Verify vent pipes are protected from damage.

2. Verify vent locations are marked before deck placement.

3. Ensure sufficient concrete test cylinders are taken to verify required strength before tensioning.

vi. During fabrication and placement of tendons:
1. Verify the Contractor performs a duct demonstration to confirm the ducts are free of water, damage, and debris. Remove or fix blockages so strands can be pushed or pulled through ducts.

2. Verify that when a complete tendon is on the ground, the strands must be:
   a. Free of dirt and debris before inserting the tendon through the duct.
   b. Protected from scraping or wear when pulled over dunnage.
3. Verify the strands are adequately protected from contamination and damage during tendon installation.

4. Verify strands remain free from rust before installation and grouting. See *Prestress Manual*, Section 4, for rust inspection.

5. Verify unusual angle points are avoided when placing the tendons into ducts.

6. Verify correct tendon sizes and number of strands are installed in their proper locations.

7. Consider “rust free” period and possible need for corrosion inhibitor requirement once strands installed; refer to the manufacturer recommendation for dosage.

8. Verify tendons are protected from electric welding operations. Refer to Attachment 1, *Precautions During Prestressing Concrete Operations*.

vii. Before stressing:

1. Verify posting of restricted work area signs and delineations required during stressing operation. See Cal/OSHA *Construction Safety Orders*, Section 1711, *Reinforcing Steel and Post-Tensioning in Concrete Construction*.

2. Verify concrete strengths and age meet contract requirements.

3. Verify the Contractor’s staff performing prestressing and grouting operation includes the following qualifications:
   a. For all prestressing operations, a technician that is certified as a Level 2 Bonded Post-Tensioning Field Specialist must supervise the work.
   b. For grouting only, a technician certified as a Grouting Technician through the ASBI is acceptable.

4. Verify prestressing equipment has been calibrated in accordance with the requirements of the contract documents. See METS’ authorized jack calibration list.

5. Verify the Contractor has furnished the required calibration curves for specific jack/gauge combination.

6. Secure a SC strain indicator and pressure cell (SIPC) unit and a standby unit well in advance. Verify SIPC are in good working condition. Check with the BCE for availability.

7. Understand the operational procedure for the use of SIPC. *Instructional videos* are available on the SC Intranet in the Training tab.

8. Contact the SC Equipment Manager if repairs are needed.
9. Verify stressing preparation by prepopulating the appropriate section of Form SC-4301, Post-Tensioning Field Monitoring Chart, before field operations.

10. Verify the Contractor’s theoretical prestressing steel elongations using the authorized shop drawings; refer to Prestress Manual, Appendix D, Post-Tensioning Losses and Elongations, and Appendix E, Example Calculations, for examples.

11. Verify theoretical elongations using the actual A and E values taken from the fabricator’s material properties from each released strand pack (see step 4.b.iv.). Typically, COC values are used but need to be cross referenced with the strand pack tag numbers.

12. Prepare the following:
   a. Form SC-4302, Prestress Calibration Monitoring Sheet
   b. Form SC-4302A, Prestress Calibration Gauge Pressure vs. Jacking Force

13. Discuss potential problems with the prestressing operation with the Contractor, BCE, and experienced staff before start of work. This includes adverse weather forecast and expectations on the day of stressing.

14. Verify from the contract plan the stressing is from one end, from both ends, or simultaneously from both ends. Do not change this without the approval of the BD Structure Project Engineer as this may lead to unexpected girder loading.

15. Verify the stressing sequence shown on the shop drawings with the Contractor. Not following the sequence may result in damage to the structure and is not permitted.


viii. During stressing:

1. Verify the Contractor will:
   a. Paint strands on both ends to check for slippage or strand breakage.
   b. As a safety precaution, secure areas around the dead end and live end of the stressing operation for authorized personnel only.

2. Plot at least one calibration curve per structure frame.
3. Monitor the Contractor’s jacks at the start of each day, but not necessarily while stressing every tendon. SR may require additional monitoring.

4. Verify Contractor’s hydraulic jack and gauge using the Department’s SIPC following procedures outlined in the *Prestress Manual*:
   a. Section 7, *Prestressing Jacks*
   b. Section 8, *Prestressing Operation*
   c. Appendix B, *Strain Indicator-Pressure Cell*

5. If unable to verify the Contractor’s gauge pressure within the tolerances discussed in the *Prestress Manual*, then:
   a. The Contractor must verify the pressure gauge and jack are working correctly together using required backup gauge for comparison.
   b. If the SR or BCE allows work to proceed without the SIPC, elongation must be carefully compared between theoretical and actual.

6. When using the SIPC:
   a. Verify SIPC have been calibrated for the hydraulic jack and gauge onsite. If available, a second strain indicator may be used for comparison.
   b. Only turn the unit on while monitoring the Contractor’s jack.
   c. Avoid damage to the strain indicator unit by unplugging and moving it away from the jacking equipment when not in use.

7. Discrepancies between theoretical and actual elongations that exceed 5 - 10% require the following actions:
   a. Notify the Contractor to not cut strand on any tendons.
   b. Compare elongations between adjacent tendons. Deviations exceeding 4% need an explanation.
   c. Verify theoretical elongations and compare to actual recorded elongations on Form SC-4301.
   e. Consult with the SR, BCE, and BD Structure Project Engineer as appropriate if source of discrepancies not found.
   f. Proceed only when discrepancy explained and determined acceptable by SR.

8. Continue completing the following forms, started before stressing:
a. Form SC-4301, *Post-Tensioning Field Monitoring Chart*
b. Form SC-4302, *Prestress Calibration Monitoring Sheet*
c. Form SC-4302A, *Prestress Calibration Gauge Pressure vs. Jacking Force*


10. If any anchorage hardware fails (even if the problem was corrected), call the BCE and the SC HQ Office Chief.

11. For strand breakage or slippage:
   a. Stop work and evaluate the capacity of the remaining strands.
   b. Contact the BD Structure Project Engineer to determine whether any broken or slipped strands in tendon need replacement.
   c. Contact BCE to determine if additional action is required.
   d. Discuss how to proceed with the Contractor.

12. Verify the final force in the prestressing tendons matches the force shown on the authorized shop drawings after seating, based on field monitoring and measurements. Do not over-tension the tendons or structural elements. Any variations in tendon loading from the authorized shop drawings must be approved by the BD Structure Project Engineer.

13. Allow the Contractor to cut excess strand only after tendons have been properly seated and accepted. If the Contractor cuts the strand without approval, stop work, and verify adequacy of the tendon prior to grouting.

ix. After stressing and before grouting:
   1. Review authorized grouting plan along with *Prestress Manual, Section 9, Grouting Operation*.
   2. Verify prestressing ducts meet pressure testing requirements of the contract documents.
   3. Complete *Form SC-4305, Air Pressure Field Monitoring Chart*.
   4. If air pressure test fails to meet contract requirements:
      a. Notify the Contractor of noncompliance.
      b. Require the Contractor to locate the cause of the pressure test failure.
      c. Require the Contractor to repair leaks with authorized methods.
      d. Retest ducts after repair.
   5. Verify once again that the ducts are free of water just before grouting.
6. Verify grouting operation will take place within 10 days after strand installation unless corrosion inhibitor placed.

7. Verify that there are no missing strands before placing grout caps. Do not proceed if the correct number of strands are not present since this may be due to slippage or failure.

8. Calculate theoretical grout volume for each duct.

9. Discuss with the Contractor the requirement to:
   a. Discharge two gallons of grout at the last vent.
   b. Include concrete washouts or other suitable receptacles on and off the bridge.
   c. Collect the wasted grout and verify proper disposal.

10. Verify excessive Contractor-produced vibrations are not occurring within 100 ft of the frame in which grouting is taking place.

x. During grouting operation:

   1. Verify the cement is the correct type per Contract Specifications, Section 90-1.02B(2), Concrete – General – Materials – Cementitious Materials – Cement and protected from adverse conditions such as excessive moisture. A COC is required for cement before placing the grout.

   2. Verify water for the grout is not contaminated and complies with Contract Specifications, Section 90-1.02D, Concrete – General – Materials – Water.

   3. Verify grouting equipment meets specifications and has adequate capacity for the job. Verify the Contractor has a standby grout mixer and pump.

   4. Verify grout is flowable in extreme ambient conditions. Additional measures may be required if:
      a. Temperatures approach, or are below freezing.
      b. Ambient temperatures are above 100 degrees.

   5. If grout temperatures are predicted to exceed 90 degrees:
      a. Adjust to maintain the temperatures of the grout ingredients and prevent grout from flash setting.
      b. Add ice to the water to reduce the temperature of grout.
      c. Do not use dry ice or liquid carbon dioxide (CO2) as a cooling agent.

   6. Verify pumping of grout starts within 30 minutes of mixing.
7. Verify the use of water/cement ratio not to exceed five gallons of water to one sack of cement or does not exceed manufacture’s recommendation for prepackaged grout.

8. Verify any admixtures are authorized before use.

9. Perform **California Test 541**, *Method of Test for Flow of Grout Mixtures (Flow Cone Method)* or ASTM C939, at the point of introduction and discharge of grout from the duct. Test for grout efflux time. Document test results in the daily report.

10. Verify there is continuous agitation of grout during grouting.

11. Verify grout screen size of 1/16 inch or less.

12. Monitor the grouting pressure and check if pressure:
   a. Gradually increases as the duct is filled.
   b. Has a blockage which is indicated by:
      i. A sudden jump in pressure.
      ii. Excessive pressure that reaches 150 psi.

13. If there is a blockage, notify the Contractor to:
   a. Stop injecting grout and investigate blockage.
   b. Develop a repair action plan.
   c. Resolve blockage as required to prevent any voids in the tendon before continuing to grout.

14. Verify when grouting from a series of injection points, that the grout has flowed past the next point. This is to confirm grout is flowing in one direction, and not back towards previous injection point - otherwise there is risk of creating an air pocket.

15. Verify that the actual quantity of grout placed in each duct substantially agrees with theoretical grout volumes.

16. If grout leaks or cross-grouting are observed:
   a. Notify the Contractor to stop grouting and determine the sources of leak or cross-grouting.
   b. The Contractor may consider patching girder leak and continue grouting.
   c. For cross-grouting into adjacent tendon, notify the Contractor to stop pumping grout until an acceptable resolution can be agreed upon. Resolutions must result in no remaining voids in the affected tendons.
   d. Secondary grouting by vacuum grouting may be required for unresolved blockages or grout losses; see **Contract Specifications**, Section 50-1.03B(2)(d)(ix), *Prestressing Concrete – General* –
17. Verify the consistency of the effluent grout through vents and grout caps is equivalent to the consistency of the injected grout.

18. Verify the Contractor closes the outlet valve before closing inlet valve.

19. Verify no grout leakage by briefly holding working grout pressure.

20. Verify the Contractor locks off at a minimum of 5-psi of grout pressure when the inlet valve is closed.

21. Verify excessive contractor produced vibrations are not occurring within 100 feet of the frame with grouted ducts for a period of 24 hours after grouting.


23. Verify cleanup and disposal is in accordance with the contract documents and authorized Water Pollution Control Program (WPCP)/Stormwater Pollution Prevention Plan (SWPPP).

24. Verify the Contractor submits completed daily grouting reports within 3 business days after grouting in accordance with Contract Specifications, Section 50-1.01C(7), Prestressing Concrete – General – Submittals – Daily Grouting Report. File reports in the prestress grout category contract file.

For miscellaneous items:

1. Most of the preceding inspection suggestions are also applicable to post-tensioned ground anchors, transverse bridge deck or bent cap stressing, bridge strengthening applications and vertical tie-downs. However, there may be additional inspection items that are unique to these non-box-girder applications. Inspection guidelines for these applications shall be coordinated through SC HQ and referencing the appropriate subject BCM and technical manuals.

2. On rare occasions, usually due to unforeseen emergencies, the Contractor may desire to post-tension partially completed bridges. All requests to stress partially completed bridges shall be discussed with the BCE, Area Construction Manager (ACM), and BD Structure Project Engineer.
e. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the daily reports per BCM C-7, Daily and Weekly Reports.

5. Following construction, the SR or delegate must:

a. For submittals:
   i. Verify the Contractor submits electronic copies of the as-built shop drawings in accordance with the Contract Specifications, Section 5-1.23B(2), Control of Work – Submittals – Action Submittals – Shop Drawings. Drawings received by the SC Office Associates must be routed to the project field staff for review of accuracy and completeness.

   1. On externally financed projects that are not Department designed or administered, authorization of the shop drawings rests with the Local Agency Engineer or the Consultant Designer. The SC Oversight Engineer verifies as-built shop drawings are submitted to the SC Office Associates upon completion of the contract.

   ii. Document receipt of all as-built shop drawings in the final records section of the contract files.

b. For materials:
   i. Verify payment:
      1. Refer to BCM C-9, Preparation of Progress Payment Documents, for monthly progress payments (partial payments for lump sum item).
      2. Take administration deduction for broken or slipped prestress strands.

   ii. Verify all prestress forms are accurately completed and filed in the appropriate categories of the project files in accordance with the Construction Manual.

c. For quality assurance:
   i. Complete documentation of QA activities, which include METS sample testing, physical condition of prestressing steel, verification of prestressing forces, and grout testing.

   ii. After the prestressing operation is completed at each structure for a project:
      1. Verify all deviations from the project plans are noted on the project as-built plans, and the prestress shop drawings.
      2. Verify the prestressing material information and any problems with materials is entered on Form SC-6303, Report of Completion – Bridges.

6. File all project documentation (materials acceptance documentation, correspondence, daily reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.
Process Outputs

1. Authorized prestressing shop drawings
2. Authorized test samples
3. Authorized prestressing materials
4. Authorized grouting plan
5. Authorized daily grout reports
6. Completed daily reports
8. Submitted electronic copies of the as-built shop drawings by the Contractor
9. Submitted electronic as-built shop drawings by Local Agency Engineer

Attachments

1. Attachment 1, *Precautions During Prestressing Concrete Operations*
Precautions During Prestressing Concrete Operations

Included in this attachment are considerations for:

1. Patching concrete under prestressing bearing plates
2. Electric welding of prestressing strands

1- Patching Concrete Under Prestress Bearing Plates

Epoxy tends to creep or flow under sustained high stress. Therefore, when patching or replacing concrete immediately behind a prestress bearing plate or in the bearing seat area, the repair shall not be made with material that uses epoxy as a binder. However, epoxy may be used for bonding the repair material to the existing concrete.

Extensive repairs should be re-poured rather than dry-packed. The concrete used in the repair area should have attained the strength required for the structure concrete before the stressing operation is started.

2- Electric Welding of Prestress Strands

The issue of field welding prestressing strand typically arises when contractors want to arc weld the ends of the strands together to a pulling head. Welding the ends together prevents the individual strands from slipping in the bundle when the tendon is pulled through the duct.

The main concern with electrical welding of prestress strands is that stray current from the welding procedure may arc and pit a portion of the strand far from the actual weld location. The pitting damage to the strand may adversely affect the service life and performance of the post-tensioning system.

The use of pulling grips or non-electrical based welding of the strand ends (e.g. oxyacetylene brazing, chemical, etc.) are acceptable methods for pulling long prestress strands. Pulling grips are used extensively in the electrical industry and have been successfully used to pull long prestress tendons. Regardless of the method used, all damage to the strands caused by the pulling system must be removed (cut back) from the portion to be incorporated into the final work.
Prestressing Concrete – General

BCM 50-1, *Prestressing Concrete – General*, has been posted as BCM 50, *Prestressing Concrete*. 
Prestressing Concrete – General – Submittals and Quality Assurance

BCM 51-1.01, Concrete Structures – General – Submittals and Quality Assurance, has not been posted yet.

Until it is posted, information related to this topic is found in BCMs 50-1.01C, Prestressing Concrete – General – Submittals; 50-1.01D(1-2), Prestressing Concrete – General – Quality Assurance; 50-1.01D(3), Prestressing Concrete – General – Department Acceptance.
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Click here to request previous versions       Contact SC Technical Team F for questions

Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, and department acceptance of concrete structures. Special topics include but are not limited to:

- Submittals for methacrylate crack treatment public safety plans, concrete forms, deck placement work plans, contractor-proposed precast member shop drawings, permanent steel deck forms, bonding materials, rapid strength concrete, grout, mortar, chemical adhesives, colored concrete, and hinge tiedowns.
- Quality control for rapid strength concrete and test panels.
- Department acceptance procedures for testing concrete surfaces coefficient of friction, surface smoothness, and crack intensity.

For materials acceptance, use this Bridge Construction Memo (BCM) in conjunction with:

- **BCM 90-1,** Concrete – General

For concrete placement, use this BCM in conjunction with:

- **BCM 51-1.03C-D,** Concrete Structures – General – Construction – Preparation and Placing Concrete
For additional department acceptance criteria for finishing roadway surfaces, refer to

- **BCM 51-1.03F(5-6)**, *Concrete Structures – General – Construction – Finishing Concrete – Finishing Roadway and Pedestrian Overcrossing Surfaces*

Prior to reviewing this BCM, it is essential to review the *Contract Specifications* (CS), Section 51-1.01, *Concrete Structures – General*, that this BCM is based on as identified in the title block above. Information in the CS typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Action and informational submittals related to concrete structures
2. Material samples
3. **Form CEM-3101**, *Notice of Materials to be Used*

**Procedure**

1. All work associated with this process is charged as **Project Direct – Construction**.
2. Inspection of field work for this process is:
   a. **Benchmark** for form work
   b. **Intermittent** for rebar placement
   c. **Continuous** for concrete pour.
3. Before construction begins, the Structure Representative or delegate must:
   a. Review and understand the requirements in the *contract documents* and perform the tasks as applied for each section of the CS, Section 51-1.01C, *Concrete Structures – General – Submittals*, listed below for:
      i. General:
         1. Review all submittals per contract documents. Authorize or reject action submittals in writing.
         3. If multiple submittals are turned in simultaneously, work with the Contractor on a prioritization list.
         4. Refer to and review BCM 51-1.03H, **Attachment 1**, *Bridge Deck Crack Prevention*.
         5. Determine if precast shop drawings and/or concrete form design is required. Review and authorize, or reject in writing.
ii. Permanent steel deck forms:
   1. Review and authorize or reject permanent steel deck form submittal. Notify the Contractor in writing.
   2. Refer to the Concrete Technology Manual, Chapter 5, Concrete Construction, page 5-13, Metal Decking, for guidance.

iii. Bonding materials:
   1. Discuss with the Contractor the requirements listed by the manufacturer (necessary equipment, substrate preparations, weather).
   2. Refer to the Materials Engineering and Testing Services (METS) Authorized Materials List. For previously authorized bonding material, obtain a certificate of compliance (COC) for each material shipment.
   3. Contact METS for materials not on the Authorized Materials List.

iv. Rapid strength concrete (RSC):
   1. Review and authorize or reject submittals. Notify the Contractor in writing.
      a. During review of the RSC mix design submittal, note the prequalification results that yield the age of break and opening age in hours.
   2. Review RSC work placement plan and contingency plan. Discuss both with the Contractor at the preconstruction meeting mentioned below.
      a. If the Contract does not require a preconstruction meeting, it is highly advisable to hold a pre-pour meeting with the Contractor prior to concrete placement operations. See BCM 90-1, Concrete – General, for details.
   3. Based on the application for RSC and if required per contract, ensure the following requirements are met:
      a. Contractor has a quality control (QC) manager to complete the responsibilities found in the CS.
      b. Conduct a preconstruction meeting in accordance with the CS.
      c. Construction of a mock-up:
         i. Witness mock-up casting and authorize or reject it based on the contract requirements.
         ii. Determine the opening age of RSC.

v. Drill and bond dowel - chemical adhesive:
   1. Review chemical adhesive informational submittal and verify a COC is included.
2. Collect material samples and submit to METS for testing, per contract requirements.

3. Assure weather conditions during application are within the acceptable parameters provided by the manufacturer.

vi. Colored concrete:

1. Review and authorize or reject colored concrete submittal in writing.

2. Coordinate with the Contractor and the District Landscape Architect to discuss contract color (location of referee sample).

vii. Hinge tiedowns:

1. Review and authorize or reject shop drawing submittal in accordance with the contract documents.

b. Provide METS with a copy of Form CEM 3101, Notice of Materials to be Used, for items requiring METS testing/inspection services.

c. Witness preparation and construction of test panel(s):

i. Confirm construction and finishing methods for constructing test panels meet the requirements of the contract documents and authorized submittals.

ii. Inform the District Landscape Architect that test panels have been completed and obtain their concurrence.

1. For a building project, coordination with the Structures & Engineering Services Project Architect may be required.

iii. Authorize the test panels after the Contractor meets the requirements of the contract documents.

4. During construction, the Structure Representative or delegate must:

a. Ensure that the Contractor's crews have the latest authorized submittals and verify field compliance with the same.

b. Verify conditions are consistent with the contract documents and authorized submittals.

i. If field conditions merit a change to the authorized submittals, then discuss with the Contractor and request a remedy which may involve a resubmittal.

ii. Perform material sampling and testing per the CS.

c. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the daily reports per BCM C-7, Daily and Weekly Reports.

5. Following construction, the Structure Representative or delegate must:
a. Confirm the opening age strength requirement has been met before authorizing opening of the newly placed section to traffic.

b. Implement contingency plan if necessary.

c. Determine acceptability of work in accordance with the CS by performing the following tests:

   i. Surface smoothness per California Test 547, Method of Test for Surface Smoothness Using the Bridge Profilograph. See Attachment 1, Letter to Contractor Following Surface Smoothness Testing, for additional guidance.

   ii. Coefficient of friction per California Test 342, Method of Test for Surface Skid Resistance with the California Portable Skid Test. See Attachment 2, Friction Testing of Bridge Decks, for additional guidance.

   iii. Crack intensity - review the Reinforced Concrete Construction Manual, Chapter 7, Bridge Deck Construction, which has guidance on this topic.

   iv. Plan tests in advance to ensure equipment and personnel availability.

6. File all project documentation (materials acceptance documentation, correspondence, daily reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized submittals
2. Authorized test panel(s)
3. Materials incorporated into the work conforming with contract requirements
4. Concrete placement records

**Attachments**

1. Attachment 1, Letter to Contractor Following Surface Smoothness Testing
2. Attachment 2, Friction Testing of Bridge Decks
Letter to Contractor Following Surface Smoothness Testing

All deck surfaces must be tested for surface smoothness to be assured of compliance with the Contract Specifications, Section 51-1.01D(3)(b)(ii), Concrete Structures – General – Quality Assurance – Department Acceptance – Testing Concrete Surfaces – Surface Smoothness. Note that the specifications have the following requirements:

1. Surfaces to be tested include the completed roadway surfaces of structures, approach slabs, the adjacent 50 feet of approach pavement, surfaces of concrete decks to be covered with another material, and completed concrete deck surfaces, including ramps and landings of a pedestrian overcrossing (POC).

2. Except for a POC, testing will be with a bridge profilograph in the longitudinal direction, and with a 12-foot straightedge in the transverse direction.

3. POC deck surfaces will be tested with a 12-foot straightedge in the longitudinal direction and a 6-foot straightedge in the transverse direction.

1 - Straightedging Deck Surfaces

When the Contract Specifications require the use of a straightedge to check deck surfaces, the decks must be systematically checked with a 12-foot straightedge over the entire area. This should be done as soon as the concrete curing process is complete. Any places which do not meet specifications should be marked with spray paint.

2 - Profilograph Testing of Deck Surfaces

When the Contract Specifications require the use of the bridge profilograph to check deck surfaces, the deck will be tested in accordance with California Test 547, Method of Test for Surface Smoothness Using the Bridge Profilograph. High points in excess of 0.02 foot should be marked with spray paint. It is the Contractor’s responsibility to schedule the profilograph testing operations. The Contractor shall request testing at least 10 days prior to need and must ensure that the entire area to be tested has been cleared and cleaned of all obstructions.

3 - Letter to Contractor

As soon as possible after testing the deck with the profilograph and/or the straightedge, a letter should be written to the Contractor advising that the deck has been checked for compliance with the profilograph requirements and/or the straightedge requirements. The letter should describe the specific locations that fail to meet the straightedge specifications or describe any deficiencies in meeting the profilograph specification.
The letter should state that the specific deficiencies must be corrected before the contract can be accepted. After the deficiencies have been corrected, or if the entire deck initially complies with the applicable straightedge or profilograph requirements, then write the Contractor a letter stating that the deck was checked and that it complies with the profilograph requirements and/or the straightedge requirements, whichever is applicable. See Section 3.1 below for a sample portion of a letter relative to concrete decks or concrete approach slabs which are to be covered with one inch or more of another material. See Section 3.2 below for a sample portion of a letter relative to the completed surfaces of bridge decks, approach slabs, and adjoining 50 feet of approach pavement.

The specifications allow the Engineer to point out a contract deficiency to the Contractor at any time. However, once the Engineer is completely satisfied that the deck surface complies with the specifications and has given the Contractor a letter advising them of this, it is the mark of an ethical Engineer to consider the matter closed.
3.1 Sample portion of a letter for concrete decks or concrete approach slabs which are to be covered with one inch or more of another material.

The finished surface of the deck concrete at __________________________________ Bridge No. _____ has been tested for compliance with the straightedge requirements in Sections 51-1.01D(3)(b)(ii), Concrete Structures – General – Quality Assurance – Department Acceptance – Testing Concrete Surfaces – Surface Smoothness, and 51-1.03F(5)(a), Concrete Structures – Construction – Finishing Concrete – Finishing Roadway Surfaces – General, of the Contract Specifications.

(USE EITHER)

All areas tested were found to comply with the specified straightedge requirements.

(OR)

Areas that do not meet the straightedge requirements have been marked, and are located as noted below:

(EXAMPLES)  Sta. 300+52 (5 ft to 15 ft from Right EOD)  
Sta. 301+60 (10 ft from Right EOD)  
Hinge in Span 3 (Entire bridge width)  
Transversely across longitudinal construction joint (Sta. 300+10 to 302+10)

These deficiencies must be corrected before the _____________________________ overlay is placed. (describe overlay)

Notification must be given to the Resident Engineer prior to performing the corrective action.
3.2 Sample portion of a letter for completed surfaces of bridge decks, approach slabs, and adjoining 50 feet of approach pavement.

The completed surface of <bridge deck> <approach slab> <adjoining 50 feet of approach pavement> at Bridge No. _______, Bridge Name __________________ has been tested for compliance with the profilograph requirements and the transverse straightedge requirements of Sections 51-1.01D(3)(b)(ii), Concrete Structures – General – Quality Assurance – Department Acceptance – Testing Concrete Surfaces – Surface Smoothness , and 51-1.03F(5)(a), Concrete Structures – Construction – Finishing Concrete –Finishing Roadway Surfaces – General, of the Contract Specifications.

(USE EITHER)

All areas tested were found to comply with the specified profilograph (and) (or) the transverse straightedge requirements.

(AND/OR)

The profilograph trace indicates that there are high points in excess of 0.02 foot and that the profile count exceeds 5 per hundred feet. High points in excess of 0.02 foot have been marked with spray paint. A profile trace is available for your examination at the Resident Engineer's office. The completed surface must be ground in accordance with the requirements in Contract Specifications, Section 42, Groove and Grind Concrete, until the specified smoothness tolerances are met.

(AND/OR)

Straightedging in a transverse direction indicated that the roadway surface varied more than 0.02 foot from the lower edge of a 12-foot long straightedge at the following locations:

Areas that do not meet the straightedge requirement have been marked, and are located as noted below:

(EXAMPLE) 4 feet from the left EOD between Sta. 300+00 and Sta. 300+75.

Longitudinal construction joint at center of left bridge between Sta. 300+50 and Sta. 301+10.

These deficiencies must be corrected before the contract can be accepted. Notification must be given to the Resident Engineer prior to performing the corrective action.
Friction Testing of Bridge Decks

After deck surfaces and approach slabs have been textured, the Engineer tests the coefficient of friction of the concrete surfaces under California Test 342, Method of Test for Surface Skid Resistance with the California Portable Skid Test.

1 - Newly Constructed Bridge Decks

Coefficient of friction testing should be performed on each deck. The test must be performed at a location which is representative of that portion of the deck surface exhibiting the lowest coefficient of friction. Once the representative area has been tested and shown to meet the specifications, more tests will not be required unless, in the opinion of the Structure Representative, the test results are not representative of the bridge deck skid resistance.

2 - Scheduling Skid Testing

To meet the 25-day allowance in the Contract Specifications for coefficient of friction testing and to ensure that there are no delays to the contract, the tests will have to be scheduled as soon as possible.

Coefficient of friction testing can be arranged by contacting the appropriate staff listed on the instruction tab of the Request for Portable Skid Test Form, thru Materials Engineering and Testing Services. Instructions for viewing the Skid Testing group’s schedule are also included in the instructions.

Structure Construction personnel witnessing the skid test must verify that the skid test machine has a valid calibration under California Test 114, Method of Test for Calibration of California Portable Skid Tester.
Concrete Structures – General – Construction – Preparation and Placing Concrete

Revision and Approval

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for:

- Preparation of footings for concrete placement, constructing and removing forms for concrete surfaces, and the design and installation of permanent steel deck forms.
- Placing concrete under various conditions and for different types of concrete work.

Structure concrete is a major element and component of bridge construction work. The condition of the forms has a lot to do with the aesthetics of the finished surface of the concrete, so it is important to discuss forms with the Contractor prior to installation.

Concrete is an adaptable material that is placed in a fluid state to fill a formed area and subsequently gains strength and solidifies in the formed shape. While the application varies, the best practice in each application is remarkably constant. Once the standard method of placing concrete is learned, it is easy to adapt placement to new situations.

Additional unique requirements for preparation and placing concrete are detailed in the Contract Specifications (CS), Section 90-1, Concrete - General.
Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the CS, Sections 51-1.03C, Concrete Structures – General – Construction – Preparation and 51-1.03D, Concrete Structures – General – Construction – Placing Concrete, that this BCM is based on as identified in the title block above. The information in the CS typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Authorized submittals, including:
   a. Concrete mix design
   b. Deck placement work plan
   c. Colored concrete work plan
   d. Concrete form design and materials data for each forming system
   e. Shop drawings for permanent steel deck forms

2. Completed footing excavation

3. Structure elements ready for form placement

4. Authorized locations ready for permanent steel deck form placement

**Procedure**

1. All work associated with this process is charged as **Project Direct – Construction**.

2. Inspection of field work for this process is:
   a. **Intermittent** inspection for footing excavation, and the placement and removal of forms.
   b. **Continuous** inspection for concrete placement.

3. Before construction begins, the Structure Representative (SR) or delegate must:
   a. Perform the following to verify general preparation of footings and forms:
      i. Determine whether changes in the footing dimensions or elevations are needed. If changes are needed, coordinate with the Bridge Design (BD) Structure Project Engineer and the Geotechnical Services (GS) Geoprofessional to issue a change order (CO); refer to **BCM 19-3.01A, Earthwork – Structure Excavation and Backfill – General – Summary**. Authorize CO work if needed. See **BCM 19-1.03B, Earthwork – General – Construction – Unsuitable Material**. Document changes in the as-built plans once CO work is completed.
ii. Review the *Foundation Manual*, Chapter 4, Footing Foundations, Section 4-8, *Foundation Problems and Solutions*, and the final foundation report in the Resident Engineer’s (RE) Pending File.

iii. Verify the orientation of the excavated area for footing construction.

iv. Verify methods of controlling water for the planned footing construction complies with CS, Section 13, *Water Pollution Control*.

v. Discuss with the Contractor the CS for aesthetic expectations and the use of an authorized test panel to determine acceptability. Inform the Contractor that any form deficiencies must be corrected prior to concrete placement.

b. Perform the following to verify preparation of permanent steel deck forms (PSDF):

   i. Review authorized shop drawings; refer to BCM 51-1.01, *Concrete Structures – General*.

   ii. Request assistance from the BD Structure Project Engineer for reviewing and authorizing any updates or changes to the PSDF.

   iii. Discuss design, installation, and repair requirements with the Contractor. If welding is needed, coordinate with Materials Engineering and Testing Services Representative (METS Rep).

   iv. Review Form TL-0028, *Notice of Materials to Be Inspected at Jobsite*, and Form TL-0029, *Report of Inspection of Materials*, to confirm whether the material will be source inspected, or field released. Coordinate with the METS Rep for assistance with field release of PSDF.

c. Perform the following to verify preparation for placing concrete:

   i. Review and follow safety measures in the project’s *Code of Safe Practices* (COSP).

   ii. Review the appropriate authorized submittals which may include:

      1. The authorized concrete mix design including prequalification. Refer to BCM 90-1, *Concrete – General*.

      2. The authorized deck placement work plan for concrete bridge decks. Refer to BCM 51-1.01, *Concrete Structures – General*. Verify contingency plans are included to address concrete placement issues.

      3. The authorized colored concrete work plan per CS, Section 51-1.01C(6), *Concrete Structures – General – Submittals – Colored Concrete*.

   iii. Contact the BD Structure Project Engineer to resolve any conflicts found between the project plans and field conditions.
iv. For specific structures (e.g., soil nail walls, tie-back walls, etc.), verify that all required work (such as prestressing, welding, bolting, etc.) has been completed prior to placing concrete.

v. Verify that existing concrete surfaces described to be roughened, are roughened to 1/4 inch amplitude as required by the CS.

vi. Review BCM A-1, Communicating SC Staff Responsibilities, Attachment 1, SC Staff Responsibilities for Performing Operational Activities, for staff certification of material sampling and testing procedures.

1. Verify that SC field staff have current American Concrete Institute certification. If required, request training and testing through the Bridge Construction Engineer.

vii. Verify construction layout, alignment, and grades for various bridge components comply with the contract documents. For bridge deck grades refer to the Reinforced Concrete Construction Manual, Chapter 7, Bridge Deck Construction.

viii. Verify reinforcement placement meets contract requirements and conforms to BCM 52-1, Reinforcement – General, and BCM 52-6, Reinforcement – Splicing.

ix. Perform necessary layout and planning to establish permanent reference points on the structure to determine future settlement and deflection.

x. Verify availability of curing materials prior to placing concrete. If curing compound is planned for use, verify the material complies with CS, Section 90-1.03B(3), Concrete – General – Construction – Curing Concrete – Curing Compound Method. Contact the METS Rep for assistance.

xi. Although not contractual, it is highly advisable to conduct a concrete pre-pour meeting and discuss the following with the Contractor:

1. Anticipated rate of concrete placement
2. Direction of placement
3. Equipment and labor force on site
4. Traffic control
5. Contingency plans for unforeseen events
6. Proper storm water pollution prevention plan (SWPPP) measures that need to be in place for the pour
7. Special consideration to protect epoxy coating when epoxy-coated reinforcement is exposed beyond a construction joint (for example, barrier rail reinforcement above a bridge deck).
d. Refer to and review the following references for additional information:


   ii. BCM 90-1, *Concrete - General*

4. During construction, the SR or delegate must:

   a. Verify safe access for inspection is provided by the Contractor.

   b. Verify that the Contractor follows the requirements of the authorized water pollution control program (WPCP) or SWPPP (e.g., washouts in place, plastic at hopper of pump, etc.)

   c. Verify that the Contractor follows the requirements of CS, Section 5-1.20B, *Control of Work – Coordination with Other Entities – Permits, Licenses, Agreements, and Certifications*.

   d. Verify that reinforcing steel placement is complete.


   f. Verify the following for formwork:

      i. Forms, materials, and construction meet all contract requirements. Refer to Attachment 1, *Form Panels – Industry Practice and Workmanship*.

      ii. Form dimensions and orientations as shown on the authorized concrete form design, and as required by the contract documents.

      iii. Forms remain at the desired line and grade during concrete placement.

      iv. Forms and subgrade are clean and thoroughly moistened prior to concrete placement.

      v. For locations above traffic and adjacent to environmentally sensitive areas, confirm that forms are mortar tight. If any gaps in the forms are found, have the Contractor seal the forms to protect from mortar leaks.

         1. Although not contractual, it is a highly recommended best practice to place plastic strips or similar material underneath the unsupported soffit plywood seams above traffic openings used by the public as well as environmentally sensitive areas (e.g., waterways.) Refer to Attachment 1, *Form Panels – Industry Practice and Workmanship*, for further details including a project photo (Figure 4, *Plastic Placed Under Soffit Plywood Seams Over Traffic Openings*).

   g. Perform the following for permanent steel deck forms:

      i. If field released, inspect the forms and document field release using Form CEM 4102, *Material Inspected and Released on Job*. Request assistance from METS Rep for field releasing this material.

iii. Inspect galvanized surfaces to make sure they are not damaged before installation. If they are damaged, the Contractor must repair them per the CS, Section 75-1.02B, *Miscellaneous Metal – General – Materials – Galvanizing*.

iv. Verify that forms are placed per the authorized shop drawings and the CS.

h. Perform the following in preparation for and during concrete placement:

i. Review the *Construction Manual*, Chapter 4, *Construction Details*, Section 4-5103, *During the Course of Work*.

ii. Verify that the forms and subgrade are clean and thoroughly moistened prior to concrete placement.

iii. Verify the authorized concrete mix design is delivered. Check the proportioning of the mix design components.


   1. Consider the item to be poured to determine the number of cylinders to sample. For example, it may be desirable on stem and soffit as well as deck pours, to prepare extra cylinders to verify that the concrete obtains the required strength prior to post-tensioning.

v. Perform sampling and testing of concrete in accordance with the CS, Section 90-1.01D, *Concrete – General – Quality Assurance*. Refer to *BCM 90-1, Concrete – General*, for more information.

   1. Use *Form TL-0101, Sample Identification Card*, when concrete samples are shipped to a local material testing laboratory or the Sacramento METS Laboratory, for testing.

vi. Monitor the placement of concrete for segregation, form leaks or blowouts, and consolidation. Refer to the *Reinforced Concrete Construction Manual*, Chapter 5, *Concrete*.

   1. If a form blowout occurs during concrete placement, verify that damage to the forms and reinforcement is repaired prior to resuming concrete placement.

vii. Verify concrete finishing meets contract requirements and is in accordance with *BCM 51-1.03F(1-4), Concrete Structures – General – Construction – Finishing Concrete*, and *BCM 51-1.03F(5-6), Concrete*.

viii. Verify concrete curing meets contract requirements and complies with BCM 51-1.03H, Concrete Structures – General – Construction – Curing Concrete Structures, and CS, 90-1.03B(3), Concrete – General – Construction – Curing Concrete – Curing Compound Method.

1. Consult with the METS Chemical Testing Lab for questions related to curing compounds.

ix. For curing bridge deck surfaces, refer to BCM 51-1.03H, Attachment 1, Bridge Deck Crack Prevention, for specific information on minimizing bridge deck cracks.

x. For horizontal construction joints between girder stems and decks, verify that the surfaces of fresh concrete are roughened to 1/4 inch minimum amplitude. Refer to Attachment 2, Stem to Deck Construction Joints.

xi. For other horizontal construction joints, verify freshly placed concrete is consolidated, and is not troweled to a smooth finish.

xii. For colored concrete, verify that concrete delivered matches the color authorized in the work plan.

i. Verify removal of all forms, except forms permitted to remain in place, per the contract documents, such as lost deck forming for cast-in-place box girders. Ensure that forms are removed without damaging in-place concrete. Visually inspect for damage, unsound concrete, and rock pockets by using a rock pick. Request, review, and authorize a concrete repair plan from the Contractor.

j. Verify construction joints are prepared for subsequent pour:

i. Verify the construction joint surfaces are abrasive blast cleaned before placing fresh concrete against them to remove surface laitance, curing compound, and other foreign materials.

k. Document all inspection, construction, and quality assurance activities pertinent to this BCM in the daily reports, per BCM C-7, Daily and Weekly Reports.

5. Following construction, the SR or delegate must:

a. Refer to BCM 51-1.03H, Concrete Structures – General – Construction – Curing Concrete Structures, for curing concrete structures.

b. Refer to CS, Section 90-1.01D(5)(a), Concrete – General – Quality Assurance – Compressive Strength – General, for concrete not meeting the compressive strength requirements, and guidance on deductions from concrete payment or rejection of in-place concrete.
c. Record updates and changes to the as-built project plans, as outlined in BCM C-6, Required Documents to be Submitted During Construction.

6. File all project documentation (correspondence, materials acceptance documentation, daily reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Daily reports and photograph records
2. Completed concrete elements conforming to the requirements of the Contract
3. Test results, reports, and documented changes on as-built project plans.

**Attachments**

1. Attachment 1, Form Panels – Industry Practice and Workmanship
2. Attachment 2, Stem to Deck Construction Joints
Form Panels – Industry Practice and Workmanship

For other than exposed surfaces, form panels may consist of surfaced lumber, plywood, steel, and in some cases synthetic materials, depending on the type of construction and the surface finish required. For exposed surfaces, the degree of care taken by the Contractor when building forms often determines the amount of subsequent work needed to obtain the required finished surface. Below are some acceptable industry practices:

1. Form panels that have minor damage or are damaged (damaged corners, holes, delamination, and scars) after installation, and cannot reasonably be replaced, may be repaired when using acceptable methods and materials, such as wood fillers, resin products (Bondo), and wood or cork plugs.

2. Expanding foam may be used to ensure forms are placed flush against concrete in areas around columns and abutments. Care must be taken when determining the product’s expansion capabilities. Excess foam that protrudes into the concrete section must be trimmed off.

3. Acceptable materials to form the exterior girder and soffit radius sweep may include steel, polyvinyl chloride (PVC), or 1/8 inch veneer plywood sheeting. All materials must be adequately supported at the joist and throughout the spans to prevent the development of discontinuities between form panel sections during concrete placement.

4. New plywood next to old plywood will produce an unacceptable non-uniform concrete surface. One method proven successful to age the new forming material is to apply cement and water paste, allow the paste to dry, and then remove it. The dried cement paste absorbs the fresh wood sugar from the new plywood and ages the wood so that the finished concrete will have a color and texture similar to the color and texture of the seasoned plywood forms.

5. Prefabricated soffit forming panels (gang forms) are sometimes used with conventional falsework systems. These prefabricated soffit forming panels typically consist of an 8 foot wide and up to 40 foot long panel comprised of plywood nailed to 2 x 8 joists. See Figure 1. The use of prefabricated soffit panels has proven to be a reliable and efficient falsework soffit forming system.

6. When the soffit gang form panels are erected onto the falsework stringers they are typically placed with a gap between each panel. This gap aids in the erection and removal of the panel system. This gap is bridged with a form filler panel (filler strip of plywood), as illustrated in Figure 2. Figure 3 depicts a typical completed soffit that was formed with gang forms.
7. Building paper must not be used to patch cracks or holes in “lost deck” forms. Metal or wood is acceptable, provided it does not infringe on the required deck thickness.

8. Forms must be mortar tight. Metal sheeting, plastic (visqueen), spray foam, caulking, or other materials can be acceptable for this application. Although not contractual, it is a highly recommended best practice to place plastic strips or similar material underneath the unsupported soffit plywood seams above traffic openings used by the public. See Figure 4 for an illustration of this proactive
9. Pieces of reinforcing steel may be cast into the interior faces of bridge box girder stems to support “lost deck” forms. When these pieces of reinforcing are used, they should be no larger than a no. 6 ¾-inch-diameter bar and must be at least 1 inch clear from any permanent reinforcing.

10. Poor workmanship and materials can lead to undesirable results. Common examples of this are:
   a. Loose form filler strips (e.g., form filler strips that are not firmly nailed to the joist).
   b. Damaged and warped panels from overuse.
   c. Newly placed plywood forming sheets next to seasoned sheets.
   d. Non-uniform filler strip widths.
   e. Non-uniform form line patterns. Skewed bridges exacerbate this.

All of the above can be successfully mitigated with the timely inspection and verification of these acceptable industry practices.
Stem to Deck Construction Joints

In 2010, Structure Maintenance and Investigations (SM&I) discovered horizontal shear failure between the stem to deck interface in both T-Beam and Box Girder cast-in-place reinforced concrete structures. The shear failure in some cases progressed enough to warrant bridge replacement.

The Division of Engineering Services (DES) Reinforced Concrete Committee evaluated this issue with the objective of increasing horizontal shear capacity at the girder stem to deck interface. In addition to other changes in design practice and procedures, it was concluded that horizontal shear capacity across the stem to deck interface increases significantly when the construction joint is intentionally roughened to a minimum amplitude of 1/4 inch. To help assure that proper attention is given to the critical construction joint between the girder stem and the deck, the Contract Specifications have been amended.

Figures 1 and 2 depict acceptable roughened surfaces. A handheld garden rake was used to obtain the roughened surface in these examples.

Figure 1. Example of Acceptable Roughened Surface
During the roughening operation, care should be exercised to avoid the following:

- Excessive dislodging of coarse aggregates when using the roughening tool.
- Floating or trowelling of the top surface of the stem, forcing coarse aggregate into the paste, and making the surface too smooth.
- Excessive vibration causing the cement paste to rise and cover coarse aggregates.

In addition to the above, it is also extremely important that the surface of the construction joint be abrasively cleaned per the Contract Specifications, prior to placement of deck concrete. All laitance, curing compound, and loosened particles of concrete must be removed.

A rough and clean construction joint can go a long way in assuring the structural integrity throughout the life of the bridge.
Concrete Structures – General – Miscellaneous Construction

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Background

This process identifies Structure Construction (SC) responsibilities and procedures for general miscellaneous concrete construction, including:

1. Paint the bridge name and number on the structure, temporary bumpers at the ends of bridges, and bell recesses structure-pipe interface
2. Placing mortar
3. Drill and grout or drill and bond dowels into concrete structures
4. Nonskid abrasive finish
5. Drains in walls and existing decks
6. Utility facilities
7. Concrete headers and steel plates
8. Diaphragm bolsters
9. Hinge tiedowns

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications (CS), Section 51-1.03E, Concrete Structures – General – Miscellaneous Construction, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.
Process Inputs

1. Form CEM-3101, Notice of Materials to be Used
2. Contractor scheduled construction activities
3. Authorized submittals

Procedure

1. All work associated with this process is charged as Project Direct – Construction
2. Inspection of field work for this process is:
   a. Intermittent inspection for miscellaneous construction activities
   b. Continuous for hinge tiedown stressing
3. Before construction begins:
   a. Obtain copy of authorized submittals and shop drawings.
   b. Review BCM 51-1.01, Concrete Structures – General.
   c. Review manufacturer recommendation for authorized materials.
   d. Review Caltrans Code of Safe Practices, manufacturers recommendations, and any applicable Safety Data Sheets for anticipated field operations and materials to be used.
   e. Ensure availability of calibrated stressing equipment (for hinge tiedowns).
   f. Contact Materials Engineering and Testing Services Materials Representative for assistance when contractor submits materials which are not on the Authorized Materials List, for use on the project.
   g. Review Attachment 1, Miscellaneous Construction for Concrete Structures, for additional information on Placing Mortar, Drill and Bond Dowels, Drill and Grout Dowels and Drill and Bond Dowels (Chemical Adhesive).
4. During construction:
   a. For miscellaneous construction of concrete structures, the following general requirements include:
      i. For Structure Identification:
         1. Verify the location, correct nomenclature in stencil preparation, and size of lettering when the contractor paints the bridge name, number, year constructed, and bent number.
         2. Verify that bent lettering is placed 10 feet above roadway, finished grade, or water surface elevation.
3. Verify that barrier lettering is placed at two thirds of the height of the barrier.

4. Verify the contract requirements are met as specified in CS:
   
   b. Section 83-1.03D, *Railings and Barriers – General – Construction – Miscellaneous Construction*, for bridge identification on the bridge barrier.

ii. For temporary bumpers:
   1. Prior to allowing equipment or machinery across a bridge or at-grade culvert, verify temporary bumpers (typically wood) are installed to protect the concrete edge.

iii. When pipes enter the structure, either:
   1. Verify the pipe is cast into the structure, or
   2. Verify a bell shape recess at the entry point is cast and filled with mortar after the pipe is placed.

b. For placing mortar:
   i. Verify cleanliness and dryness of concrete surfaces to be in contact with mortar; verify proper placement and curing of the mortar.
   
   ii. Verify the contract requirement for placing mortar as specified in the CS:
       1. Section 51-1.02F, *Concrete Structures – General – Materials – Mortar*
       2. Section 90-1.03B, *Concrete General – Construction – Curing Concrete*

   c. For Drill and bond dowels:
      i. Prior to use, verify the bonding material delivered to project matches authorized submittal.
      
      ii. Verify size, depth, and location of drilled holes for dowels.
      
      iii. If rebar congestion prevents per plan installation of dowels, discuss with designer, and apply approved corrective measures.
      
      iv. Obtain a certificate of compliance for each shipment of bonding material.
      
      v. Verify application of bonding material in accordance with manufacturer’s instructions.
      
      vi. After setting and curing period, check all dowels to verify bonding.
vii. Verify the contract requirements are met for repairing rejected holes that will not be encased in concrete, with bonding material as specified in CS, 51-1.02C, *Concrete Structures – General – Materials – Bonding Materials*

d. For drill and grout dowels:
   i. Prior to use, verify the cementitious material delivered to project:
      1. Matches the authorized informational submittal regarding drill and grout dowels
   ii. Verify size and location of drilled holes for dowels.
   iii. If rebar congestion prevents per plan installation of dowels, discuss with designer and apply approved corrective measures.
   iv. Inspect placement of grout, dowels, and curing method.
   v. After curing period, check all dowels to verify bonding.

e. For drill and bond dowel chemical adhesive system:
   i. Prior to use, verify the chemical adhesive material delivered to project matches authorized submittal and conforms to CS Section 51-1.02H, *Concrete Structures – General – Materials – Chemical Adhesives*.
   ii. If installing dowels in new concrete, verify that the concrete has cured for at least 28 days.
   iii. Verify size and location of drilled holes for dowels.
   iv. If rebar congestion prevents per plan installation of dowels, discuss with designer, and apply approved corrective measures.
   v. Verify application of chemical adhesive material in accordance with manufacturer’s instructions.
   vi. After curing, check all dowels to verify bonding.

f. For nonskid abrasive finish:
   i. Prior to concrete placement, discuss nonskid abrasive finish requirements with the contractor and verify materials are available.
   ii. Verify grit particles are uniformly spread at required rate over a troweled surface and properly impressed into the surface.

g. For drains in walls:
   i. Prior to concrete placement, verify tubing required for drain holes is securely situated in forms at required size and intervals with required end coverings.
ii. Verify that hydrostatic pressure relief holes are installed properly.

h. For deck bleeder drains:
   i. Discuss proposed deck bleeder drain locations with the Resident Engineer (R.E.) prior to locating the deck drains.
   ii. Verify that materials to be used comply with the requirements in CS 51-1.02J, Concrete Structures – General – Materials – Miscellaneous Materials.
   iii. Avoid locations where drainage falls on traffic or environmentally sensitive areas from the deck bleeder drain.
   iv. Verify the proper installation sequence of drains with respect to the placement of the deck seal and Hot Mix asphalt.

i. For utility facilities:
   i. Coordinate utility installation activities with the District Utility Coordinator, R.E., contractor, utility owner, and other potential stakeholders.
   ii. Verify accessories for utility facilities to be embedded in concrete are provided to the contractor and installed prior to concrete placement.

j. For concrete headers and steel plates:
   i. Field verify location of headers and steel plates.

k. For diaphragm bolsters:
   i. If using structural shotcrete, refer to BCM 53-2, Shotcrete – Structural Shotcrete.
   ii. Verify aggregates are 3/8-inch combined aggregate gradation and complies the contract requirements in the CS, 90-1.02C(4)(d), Concrete – General – Material – Aggregates – Aggregate Gradation – Combined Aggregate Gradation

l. For hinge tiedowns:
   i. Conduct a pre-activity meeting with the contractor.
   ii. Verify construction sequence and timeline are followed.
   iii. Observe, verify, and document hinge tiedown stressing.
   iv. Monitor hinge displacement and make appropriate adjustments prior to hinge and adjacent superstructure casting.

m. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Following construction:
a. File all project documentation (correspondence, materials acceptance documentation, test results, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

Process Outputs

1. Completed miscellaneous construction items complying with contract requirements
2. Material certifications and completed daily reports
3. For projects with Hinge tiedowns - documentation of stressing procedure

Attachments

Attachment 1, Miscellaneous Construction for Concrete Structures
Miscellaneous Construction for Concrete Structures

The Contract Specifications, Section 51-1.03E, Concrete Structures – General – Construction – Miscellaneous Construction, contains twelve unique sections of information for concrete from Placing Mortar to Hinge Tiedowns. This attachment includes additional information for Placing Mortar, Drill and Bond Dowels, Drill and Grout Dowels and Drill and Bond Dowels (Chemical Adhesive).

1. When Placing Mortar:

   Small concrete holes and recesses are filled with dry pack mortar. The mixing ratio is 1.0 parts cement to 2 parts sand. Use minimum amount of water needed to moisten the mortar so it sticks together. For best results verify these recommended steps are followed for placing mortar:
   
   a. Clean the area to be patched with stiff brush, removing loose and non-concrete materials, flush with water and allow the area to become surface dry.
   
   b. Area being repaired is mortar tight.
   
   c. Tightly pack the mortar with a suitable tamping device in half-inch increments until the recess is filled.
   
   d. Cure with water method for 72 hours.

2. When Drilling and Bonding Dowels:

   a. Drilled holes are a half-inch larger than the nominal dowel diameter. Adjacent concrete must not be damaged when drilling, including concrete below the drill bit; heavy handed drilling can lead to spalling.
   
   b. Verify that the contractor located the dowel holes away from the rebar. If positive location of rebars is required prior to drilling, the use of a profometer (rebar locator) may be necessary.
   
   c. Visually inspect dowel drilling operations for cleanliness of drilled hole, dowel placement and stabilization, concrete preparation and placement (bonding material must completely fill the drilled hole), required curing and post cure acceptance inspection. Magnesium phosphate is not cured. Curing inhibits the release of gas that in turn delays the hardening process.

3. When Drilling and Grouting Dowels:
a. Drilling operations are the same as with *Contract Specifications*, 51-1.03E(3), *Concrete Structures – General – Construction – Miscellaneous Construction – Drill and Bond Dowels* except the hole is 1/4 inch larger than the nominal dowel diameter.

b. Inspect the drilling and preparation, placement of grout and dowel, stabilization of dowel, and cure as in *Contract Specifications*, 51-1.03E(3).

4. When Drilling and Bonding Dowels (Chemical Adhesive):

   a. Drilling operations are similar to *Contract Specifications*, 51-1.03E(3), except the dowels are installed per manufacturer’s instructions. If questions arise concerning hole diameter and depth, coordinate solution with Structures Design.

   b. Inspect the drilling and preparation, required dowel preparation, placement of adhesive, and stabilization of placed dowel. Cure is not required.
Concrete Structures – General – Finishing Concrete

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for finishing concrete, including ordinary surface finish, Class 1 surface finish, and Class 2 surface finish.

Concrete surface finish is what the travelling public and other interested parties see, and they judge the quality of the structure based on the quality of the concrete surface finish.

Process Inputs

1. Authorized Concrete Mix Design
2. Contractor’s Forming System workplans
3. Contractor’s Concrete Placement Plan

Procedure

1. All work associated with this process is charged as Project-Direct – Construction.
2. Inspection of field work for this process is:
   a. Intermittent inspection
3. Before construction begins:
   b. Discuss with the Contractor the factors which affect the final finishing of concrete surface (Form design, materials, method of construction, concrete mix design, mitigations for any potential severe weather, etc.).
c. Discuss applicable surface finish criteria (Ordinary, Class 1 or Class 2) and locations where each applies with the Contractor.

d. Discuss with the Contractor the proposed means and methods for achieving each surface finish requirements.

e. Discuss the Contractor’s concrete placement, curing concrete, and forms removal plans since these activities contribute to the final surface finish.

4. During construction:
   a. Verify safe access for inspection is provided by the Contractor.
   b. Verify pour rate and ensure proper concrete consolidation.
   c. Verify concrete for exposed surfaces have been consolidated, struck off, and properly cured.
   d. Monitor concrete forms for potential failure. Verify failures are repaired before finishing concrete placement.
   e. When forms are removed, verify concrete is cured properly, inspect concrete surfaces, and if there are rock pockets, mark the limits of rock pockets that require removal and replacement of concrete.
   f. Verify that ordinary surface finish has been complete.
   g. Verify that Class 1 or Class 2 surface finishes are applied per the location per contract requirements.
   h. In the field, request a test area for Class 1 and Class 2 surface finishes to be used as the acceptance criteria.
   i. Document and elevate any disagreement on surface finish to be resolved as soon as possible.
   j. Structure Representative discuss and agree on surface finish with Bridge Construction Engineer to limit any potential claims.
   k. Verify that the entire area achieves the required Class 1 or Class 2 surface finish.
   l. Document with photos from various angles.

5. Following Construction:
   a. Discuss lesson learned with the Contractor and staff.
   b. Document all inspection, construction, and quality assurance activities in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.
   c. Calculate and make payment to the Contractor.

**Process Outputs**

1. Finished Concrete Surface:
a. Customers: All interested parties
b. Customer Expectations: Aesthetically pleasing, meets contract requirements

2. Daily Reports:
   a. Customers: Districts
   b. Customer Expectations: Prompt and accurate

3. Photos:
   a. Customers: All interested parties
   b. Customer Expectations: Awards, marketing, news, lesson learned, etc.

Attachments

None
Concrete Structures – General – Construction – Finishing Concrete – Finishing Roadway and Pedestrian Overcrossing Surfaces

Revision and Approval

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for:

- Finishing roadway surfaces of structures, including establishment of elevation control points, checking clearances to concrete finishing machines, and smoothness and crack intensity requirements.
- Applying longitudinal surface texture to roadway surfaces of structures. Longitudinal surface textures for roadway surfaces are used to improve surface drainage and reduce travel noise. Longitudinal surface texturing is achieved using the grooving and grinding method or longitudinal tining method.
- Finishing pedestrian overcrossing structures, including establishment of deck elevation control points, and verifying ADA requirements.

Use this Bridge Construction Memo (BCM) in conjunction with the following:

- BCM 51-1.01, Concrete Structures – General
- BCM 51-1.03(C-D), Concrete Structures – General – Construction – Preparation and Placing Concrete.
Prior to reviewing this BCM, it is essential to review the *Contract Specifications*, Sections 51-1.03F(5), Concrete Structures – General – Construction – Finishing Concrete – Finishing Roadway Surfaces, and 51-1.03F(6), Concrete Structures – General – Construction – Finishing Concrete – Finishing Pedestrian Overcrossing Surfaces, that this BCM is based on as identified in the title block above. The information in the *Contract Specifications* typically will not be repeated in the text of this BCM.

**Process Inputs**

1. “4-scale” drawings and corresponding MicroStation (.dgn) files
2. Submittals

**Procedure**

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:
   a. Benchmark for field surveying.
   b. Intermittent during form construction, while rails and headers for finishing equipment are being set, and while finishing concrete.
   c. Continuous during Bidwell grading, concrete placement, inspection of longitudinal tining, and during grinding and grooving operations.

3. Before construction begins the Structure Representative (SR) or delegate must:
   b. Review Attachment 1, Quieter Bridge Deck Construction.
   c. For Pedestrian Overcrossings review the *Permanent Pedestrian Facilities ADA Compliance Handbook*.
   d. Review and authorize the submittals, including:
      i. Falsework shop drawings
      ii. Deck placement work plan
      iii. Concrete form design and materials data for each forming system, if requested.
      iv. Shop drawings for precast concrete members.
   e. Attend the pre-concrete placement meeting to discuss the deck placement work plan per the *Reinforced Concrete Construction Manual*, Chapter 7.
f. Verify that reference stakes/temporary benchmark elevations have been established by the Caltrans Surveying group in accordance with the Contractor survey requests.

4. During construction the SR or delegate must:
   a. Before concrete placement:
      i. Using the “4-scale” drawings and in accordance with the SC Bridge Construction Survey Manual, establish elevation control points on formwork and/or deck dowels for the Contractor’s use, spaced no less than 8 feet longitudinally and 24 feet transversely to the structure centerline or layout line, with permanent marker and/or duct tape.
      
      ii. For bridge deck surfaces to be textured under the grinding and grooving method, ensure that 1/4-inch has been added to the finished grade to account for the required amount of sacrificial cover. Bridge deck drains and other permanent fixtures must be set at the finished grade without this added 1/4-inch figure.

      For pedestrian overcrossings, check longitudinal and cross slopes for Americans with Disabilities Act (ADA) compliance with ADA Federal Standards for Pedestrian Overcrossing (POC). Refer to the following for guidance:

      1. Permanent Pedestrian Facilities ADA Compliance Handbook
      2. Design Information Bulletin 82-06, Pedestrian Accessibility Guidelines for Highway Projects
      3. Construction Manual, Section 4-73, Concrete Curbs and Sidewalks

      iii. Discuss contract requirements for surface finishing and texture and the Contractor’s means and methods for attaining proper surface finishes.

      iv. Observe the Contractor test-run of the surface finishing equipment (Bidwell grading) along the length of section to be poured to verify that vertical and horizontal clearances meet contract requirements, such as:

         1. Clearances to embedded items such as deck drains, falsework blockouts, etc.

         2. Visually check Bidwell rails for profile smoothness.

      v. For bridge deck surfaces to be textured under the grinding and grooving method, locate loop detectors and/or other sub-deck utilities and verify that the clearance is sufficient to avoid impact from grinding operations.

   b. During and after concrete placement:
      i. Verify that the concrete surface has been struck off to the established grades.
ii. Verify that concrete cure is being implemented timely and per contract requirements; refer to BCM 51-1.03H, Concrete Structures – General – Construction – Curing Concrete Structures, for guidance.

iii. Verify that concrete finishing and texturing is performed per contract requirements.
   1. Note that on POC deck surfaces, a broom finish is applied perpendicular to the path of travel.

iv. Perform initial smoothness testing and verify that the bridge deck surfaces comply with contract requirements for crack intensity per BCM 51-1.01, Concrete Structures–General, before grinding operations begin.

v. Inspect grinding and grooving operations and perform additional smoothness testing per BCM 51-1.01.

vi. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Following construction, the SR or delegate must:
   a. Verify that completed bridge/pedestrian overcrossing deck surface textures meet contract requirements for smoothness, crack intensity, texture, and friction coefficient.
   b. Use the appropriate check list from the Permanent Pedestrian Facilities ADA Compliance Handbook to verify compliance with ADA.
   c. For pedestrian facilities, complete the Resident Engineer Section of Form CEM-5773, Americans with Disability Act (ADA) Project Compliance Certification, with the assistance of the District ADA Officer. Verify that the RE files a completed copy of the form in the project records and sends the form with attachments to the email address at the end of the form.

6. File all project documentation (materials acceptance documentation, correspondence, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Deck elevation control points with spacing as required by the contract documents.

2. Completed bridge deck surface textures that comply with specifications, provides a smooth ride with no aesthetic deficiencies, and meets smoothness, crack intensity, and coefficient of friction requirements.
3. Finished Pedestrian Overcrossing deck surface

4. Completed form CEM-5773, *Americans with Disability Act (ADA) Project Compliance Certification*

**Attachments**

1. [Attachment 1], *Quieter Bridge Deck Construction*
Quieter Bridge Deck Construction

Quiet pavement strategies produce traffic noise reduction benefits over time without compromising safety, ride quality, and durability of pavement surfaces. The noise emitted from the highway system has become a subject of complaint and environmental impact to residents, specifically to those in urban areas. The primary traffic sources of generated noise are classified into three categories: propulsion, aerodynamics, and tire/pavement interface. At highway speed the dominant noise is generated at the tire/pavement interface. Engineers throughout the world have been researching methods to reduce the noise impacts of highway systems beyond building sound barriers. These methods include improvement of the roadway pavement types and textures to reduce tire/pavement interface noise.

The previous standard bridge deck texturing method used by California Contractors was transverse texturing which proved to be significantly louder than longitudinally tined Portland Concrete Cement (PCC) pavement measured by the On-Board Sound Intensity (OBSI) method. Experience has shown that Contractors aggressively texture the bridge deck to ensure meeting the specified minimum coefficient of friction value. Aggressive texturing often results in a uniformly unbalanced or uneven surface known as *shingling* which further increases the vehicle tire noise.

Quiet Pavement Research (QPR) has shown that traffic noise can be minimized by incorporating quiet pavement strategies in construction practices at little or no additional cost. QPR has found that for rigid pavement including bridge decks *longitudinal grinding and grooving*, or *longitudinal tining* are two textures that can be used to reduce tire noise. Research has found that these two methods produce less tire/pavement interface noise than the transverse texturing method previously used on most California bridge decks. The texturing is almost identical to that used on PCC pavement highways. Tire noise measured by the OBSI method on California bridge decks that are transversely textured range from 105 decibels (dB) to 112 dB. For comparison, tire noise measurements for *longitudinal tining* range from 103 dB to 105 dB, for *longitudinal grinding and grooving* range from 100 dB to 103 dB, and for *flexible pavement* range from 95 dB to 105 dB. An increase in 10 dB is perceived as double the noise to the human ear. Grinding has reduced the tire noise on bridge decks by as much as 10 dB and has been used as an interim measure to remedy noisy transversely textured bridge decks.

*Longitudinal grinding and grooving* of PCC roadways and bridge decks produce adequate coefficient of friction results for bridge decks. Grinding is typically used to remedy surfaces that do not meet friction requirements. The primary purpose of the longitudinal grooving applied to the ground surface is to increase water channeling below the tire.
The Contract Specifications, Section 40-1.03H(3), Concrete Pavement – General – Construction – Finishing – Final Finishing, requires an initial texture created with a burlap drag or broom device which produces striations parallel to the centerline. The purpose of the initial texture is to slightly roughen the surface to achieve the required friction. This is also necessary to achieve the required friction on longitudinally tined bridge decks. Similar to grooving, the primary purpose of longitudinal tining is to increase water channeling below the tire.

There are many polyester concrete bridge decks in service on the state highways today that have been tined longitudinally. The longitudinally tined polyester concrete bridge deck surfaces have resulted in lower than expected tire noise compared to a transversely tined bridge deck and have easily exceeded the minimum friction requirement. Figure No. 1 is an example of a longitudinally tined polyester concrete bridge deck surface.

For more information on quieter pavement technology see report Bridge Deck Tire Noise Research.

**New Practice**

All new bridge deck projects advertised after January 1, 2011, include the Standard Special Provision (SSP), Bridge Deck Surface Texture. This specification provides the following two options for bridge deck texturing:

1. Longitudinal grinding and grooving
2. Longitudinal tining

The requirements for bridge decks which address smoothness, friction and crack intensity remain unchanged.

A longitudinal tined texture can easily be accomplished on a bridge deck. Longitudinal tining machines are commercially available but are not mandatory. The longitudinal tining machine will accommodate a bridge deck with a variable cross slope, a crown, or superelevation. The Contractor may propose another technique or device to achieve the requirements of the specification.

Following are construction aspects that should be ensured when using the longitudinal grinding and grooving option and the longitudinal tining option:

**Longitudinal Grinding and Grooving Option**

- The bridge deck thickness will be increased 1/4 inch.
• The concrete mix design must meet the specification requirements for cementitious material and quality aggregates to ensure the deck surface durability.
• The bridge deck drains, and other permanent fixtures should be set to the final grade per the contract plans.
• All recessed areas that will not be accessible by the grinding blades such as the area adjacent to bridge deck drains should be hand textured longitudinally to match adjacent concrete, while the concrete is wet.
• The 18 inches of bridge deck surface adjacent to the barrier rail will be inaccessible by the grinding blades. This area should be hand textured longitudinally to match adjacent concrete, while the concrete is wet.
• Figure No. 2 is an example of a bridge deck surface using the longitudinal grinding and grooving option.

**Longitudinal Tining Option**

• The Contractor must drag burlap or a light broom longitudinally in advance of the tining operation to ensure that the surface friction is adequate. Attention should be paid to the texture operation to ensure the burlap or other tools used to roughen the surface in front of the tining operation are evenly weighted and produces a flat roughened surface.
• The concrete mix design must meet the specification requirements for cementitious material and quality aggregates to ensure the deck surface durability.
• The concrete mix design water content and corresponding slump is important to ensure the specified tining texture can be achieved and is consistent.
• Ensure that the concrete will be delivered timely per the specifications. It is desirable to place as much deck as possible for each longitudinal tining pass to minimize starts and stops in the tining pattern.
• Close attention must be paid to the concrete consistency to ensure the finish tines or intrusions are consistent with the requirements of the specifications.
• Ensure the finishing tools (tine, burlap, broom, etc.) are properly adjusted and kept clean.
• Each tine should be a rectangular shape and the width should be between 3/32” and 1/8”.
• The tining should produce a negative intrusion into the surface and not produce any positive texture.
• Ensure the tining spaces are evenly spaced at 3/4”. 
• Ensure the depth of the tining is between 3/16" and 1/8". Note: The distance from the edge of a quarter to the top of President Washington's head is about 1/8".

• Figure No. 3 is an example of a PCC bridge deck using the longitudinal tining option.

• Figure No. 4 is an example of a tining tool used for the longitudinal tining option.

• Grinding for smoothness, when necessary per Contract Specification, Section 51-1.03F(5)(a), Concrete Structures – General – Construction – Finishing Concrete – Finishing Roadway Surfaces-General, is still required.

Attention to all the details associated with placing the bridge deck concrete will result in a higher quality bridge deck that is quieter.

**Special Situations**

A bridge may be in a noise sensitive area if it is adjacent to a residential area, hospital, school, park, or hotel. For projects within a noise sensitive area, defined by the Division of Pavement Management, Pavement Policy Bulletin (PPB) 09-02, Quieter Pavement Strategies for Noise Sensitive Areas, and identified in Standard Special Provisions (SSP), Section 51-1.03F (5)(b)(i), Concrete Structures- General – Construction – Finishing Concrete – Finishing Roadway Surfaces – Bridge Deck Surface Texture – General, the district may request that only the longitudinal grinding and grooving option be specified. If a bridge project is in a noise sensitive area and the SSP is not in place, or to address any other quiet bridge deck questions or concerns, contact SC HQ Office Associate for assistance.

![Figure No. 1: Example of Longitudinally Tined Polyester Concrete Bridge Deck Surface.](image-url)
Figure No. 2: Example of a PCC Bridge Deck Using the *Longitudinal Grinding and Grooving* Option.
Figure No. 3: Example of a PCC Bridge Deck Using the Longitudinal Tining Option.

Figure No. 4: Example of the Tining Tool used for the Longitudinal Tining.
Concrete Structures – General – Construction – Concrete Surface Textures

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<td>Original Issue</td>
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Background

This process establishes Structure Construction (SC) responsibilities and procedures for concrete surface textures, including submittal review and authorization, test panel authorization, and construction.

Concrete surface textures are generally viewed as an architectural improvement to a structure. While concrete surface textures are generally not structural in nature, they are usually included at the request of, funded by, and therefore always important to project stakeholders.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 51-1.03G, Concrete Structures – General – Construction – Concrete Surface Textures, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Contract work requiring architectural treatment including:
   a. Fracture Rip Texture
   b. Ripped Texture
   c. Other architectural treatments
2. Test panels for each type of concrete surface textures

Procedure

1. All work associated with this process should be charged to Project Direct-Construction, unless otherwise directed.

2. Inspection of field work for this process is:
   a. Continuous inspection for concrete placement.
   b. Intermittent for inspection of finished concrete surface texture.

3. Before installing concrete form liners:
   a. Discuss the following concrete surface texture requirements with the contractor:
      i. The architectural treatment types specified. Concrete surface texture may be fractured rib texture as specified in the Standard Specifications or fractured rip texture, ripped texture, scored texture, chipped texture, and others as specified in the Special Provisions.
      ii. The requirements for test panel(s) including the size of the test panel. See Contract Specifications, Section 51-1.01D(2)(c), Concrete Structures – General – Quality Assurance – Quality Control – Test Panels.
      iii. Requirements and expectations for Class 1 surface finish of concrete. Refer to BCM 51-1.03F(1-4), Concrete Structures – General – Finishing Concrete.
      iv. Methods for achieving acceptable concrete finish.
   b. Coordinate the review of the contractor’s work plan to achieve concrete surface texture specified with HQ/District Architect for concurrences. This review includes form liners, methods of obtaining the ripped textures of surfaces, and other architecture features specified.
   c. Coordinate construction of test panel(s) with the contractor. Note the method and conditions of constructing the test panels. This helps the production surfaces match the authorized test panel surfaces.
   d. Coordinate with HQ/District Architect and other interested parties for reviewing the test panel(s).
   e. Authorize the test panel(s) when all interested parties concur with the resulting test panel concrete surface texture.
   f. Confirm placement of architecture treatment on forms meets contract requirements and complies with all manufacturer instructions.
Prior to forming each alignment (e.g., patterned wall alignment), work with the contractor to verify architecture treatment layouts.

4. During concrete placement:
   a. Refer to BCM 51-1.03(C-D), Concrete Structures – General – Construction – Preparation and Placing Concrete, for guidance.

5. After concrete placement:
   a. Verify specified concrete surface texture has been attained as follows:
      i. Confirm form liners released properly without damage to the concrete surface texture.
      ii. Verify repair of damaged concrete surface textures complies with the repair plan. Refer to the Concrete Technology Manual, Chapter 6, Structure Concrete Repair and Rehabilitation.
      iii. Reject damaged form liners to prevent damaged forms from being reused for future concrete pours.
   b. Verify that form liners are properly assembled and maintained in accordance with the manufacturer’s instructions (e.g., form release agents, cleaning agent used to dissolve form release agents after every 5th use, adhesives, etc.).
   c. Document all inspection, construction, and quality of assurance activities pertinent to this BCM, in the Daily Reports, per BCM C-4.04, Daily and Weekly Reports.
   d. After all work associated with concrete surface textures is complete and found acceptable, the test panel can be discarded.

6. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized test panel(s)
2. Finished concrete surface textures

**Attachments**

None
Concrete Structures – General – Construction – Curing Concrete Structures

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for curing concrete structures, including authorization of curing methods for each component of concrete structures.

Application of the appropriate method for curing concrete structures is essential for concrete to attain the required strength, regulate heat of hydration, and prevent surface cracking.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications (CS), Section 51-1.03H, Concrete Structures – General – Construction – Curing. The information in the CS typically will not be repeated in the text of this BCM.

Process Inputs

1. Form CEM-3101, Notice of Materials to be Used
2. Certificate of Compliance for each batch of curing compound per CS, Section 90-1.01C(5), Concrete – General – General – Submittals – Curing Compound
3. Safety Data Sheet (SDS) Data for curing compound materials
4. Authorized deck placement work plan
5. Stormwater Pollution Prevention Plan/Water Pollution Control Plan (SWPPP/WPCP) authorized submittals

**Procedure**

1. All work associated with this process is charged as [Project Direct – Construction](#).

2. Inspection of field work for this process is:
   - **Continuous** inspection while curing compound is being applied.
   - **Intermittent** inspection for other methods of curing.

3. Before construction begins:
   a. Review the following documents:
      i. **Contract Specifications:**
         1. Section 90-1.01C(5), *Concrete – General – Submittals – Curing Compound*
         2. Section 90-1.01D(6), *Concrete – General – Quality Assurance – Curing Compound*
         3. Section 90-1.03B, *Concrete – General – Construction – Curing Concrete*, for the four methods of curing structure concrete.
         4. Section 51-1.01C(1), *Concrete Structures – General - Submittals – General*, for information related to a deck placement work plan.
      
      ii. **Construction Manual:**
         1. Chapter 4, *Section 4-9001B (3) Curing Concrete*
         2. Chapter 4, Section 4-9001B (4) *Protecting Concrete*
         3. Chapter 6, *Section 6-107, Materials Acceptance Sampling and Testing*, which contains information on sample types and frequencies.
         4. Chapter 6, *Section 203, Manufactured or Fabricated Materials and Products Acceptance*
      
      iii. The section titled, *Curing Concrete*, in Chapter 5, *Concrete Construction*, of the *Concrete Technology Manual*
      
      iv. The authorized deck placement work plan.
      
      v. Form CEM-3101, *Notice of Materials to be Used*, for curing materials listed.
      
      vi. Safety Data Sheet for curing compound materials.
      
      vii. Authorized SWPPP/WPCP
b. Check for adverse weather forecast prior to concrete placement (e.g., high temperature, rain that can affect concrete finishes, etc.).

c. Discuss concrete curing methods and requirements with the contractor, including inclement weather conditions. Refer to CS, Section 90-1.03B.

i. Discuss contingencies to address potential equipment failures related to severe environmental conditions such as high winds.

d. Collect a Certificate of Compliance (COC), including required test results, for curing compound materials delivered to the jobsite. Complete Form SC-4102, Material Inspected and Released on Job, and file with COC in project records.

i. Coordinate with Materials Engineering and Testing Services Representative (METS Rep) for any questions about the curing compound.

e. Field sample curing compound when material is questionable. Check with the METS Rep for the correct curing compound sample canister or container. Send sample to METS through Chemistry.Branch@dot.ca.gov.

4. During Construction:

a. Verify newly placed concrete for CIP structures (except for bridge deck) are cured using the water method or the forms-in-place method per the CS, Section 90-1.03B.

b. If forms are removed before the end of form-in-place curing period for CIP structures (except bridge deck), assure that forms are not removed earlier than 24 hours after concrete placement. In addition, concrete must be cured the remainder of the curing period with one of the authorized curing methods in the CS, Section 90-1.03B.

c. For Bridge Decks, confirm that the contractor is following the authorized deck placement plan and take corrective action as necessary to assure compliance.

d. Verify that curing compound is:

i. Mixed at low speeds to completely redisperse settled or separated solids in containers before use. For additional information refer to the CS, Section 90-1.03B(3), Concrete – General Construction Curing Concrete – Curing Compound Method.

ii. Field sample if the material is questionable.

iii. Applied at nominal rate of 150 sq ft/gal with power-operated spraying equipment. Hand spray equipment are used when authorized by the Engineer.
e. When curing structure by water method, verify that the contractor keeps the concrete surface wet throughout the curing period, including weekends and holidays. See Attachment 1, Bridge Deck Crack Prevention, for information and project photos that depicts changes introduced by the revised CS for concrete decks. Review and ensure that contractor complies with authorized SWPPP/WPCP to prevent discharge of water from curing operation.

f. Refer to the CS for unique requirements of curing bridge decks constructed with Rapid Strength Concrete (RSC).

g. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. File all project documentation (correspondence, materials acceptance documentation, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Curing compound certificate of compliance
2. Properly cured concrete structures
3. Daily Reports

**Attachments**

Attachment 1: Bridge Deck Crack Prevention
To prevent early-age bridge deck cracking, the Division of Engineering Services Concrete Committee, and the Bridge Preservation Committee, over a 14-year period, developed new Contract Specifications (CS) for concrete bridge decks, including deck overlays. The new CS were implemented in 2016. It was anticipated that the new CS may reduce the estimated $50,000,000 spent annually to seal deck cracks.

This attachment provides an overview of factors affecting early age bridge deck cracking as well as a breakdown of the CS changes to the concrete mix design and curing requirements for concrete bridge decks. Project photos are included to illustrate how the CS changes are implemented in the field.

**Minimizing Early Age Concrete Bridge Deck Cracks**

One of the primary factors affecting concrete durability is concrete shrinkage and the resultant cracking that serves as a pathway for corrosive materials like de-icing salts. The CS place limits on shrinkage by requiring that the contractor-proposed concrete mix designs for bridge decks and approach slabs include AASHTO (American Association of State Highway and Transportation Officials) T160, 28-day shrinkage test results as part of the mix design. Overall shrinkage in the forms of autogenous and drying shrinkage is collectively limited by the CS to 0.032 percent for bridge decks and 0.05 percent for approach slabs per the CS, Section 90-1.02A, Concrete – General – Materials – General. The review process does not end with the mix design check. The Structure Representative must verify that concrete delivered to the project is consistent with the approved concrete mix design, as variations in aggregate gradation, cleanliness value, sand equivalence, cementitious material content, and water-cement ratio can significantly increase the amount of shrinkage that will occur after the concrete has hardened.

Cracking that occurs before concrete has set is referred to as plastic cracking. Concrete finishing and curing operations can directly affect the development of plastic cracks; this type of cracking occurs on concrete surfaces as the top layer dries and shrinks quicker than the moist inner concrete. Initially, bleed water rises within fresh concrete until it reaches the surface and evaporates, but as the internal water supply is depleted, the bleed water flow diminishes. Surface drying starts when the evaporation rate exceeds the bleed rate. Usually associated with warm weather concreting, plastic cracking can occur whenever the shrinkage strain exceeds the surface strength. Unless additional moisture is provided to the surface, plastic cracks can appear. Plastic cracks are shallow, usually less than 2 inches deep, irregular in pattern, and spaced about 1 to 3 feet apart. In any 500 sq ft portion of a new deck surface, if there are more than 50 feet of cracks having a width at any point of over 0.02 inch, the contractor is required to treat the deck with methacrylate resin per the CS, Section 51-1.01D(3)(b)(iv), Concrete Structures – General – Quality Assurance – Department Acceptance – Testing Concrete Surfaces – Crack Intensity. An example of plastic cracks on the bridge deck surface is shown in the Figure 1.
Bridge Deck Crack Prevention

Figure 1. Example of Plastic Cracks on the Bridge Deck Surface

Figure 5-22 in Chapter 5, Concrete Construction, of the 2013 SC Concrete Technology Manual, is an Evaporation Rate Nomograph from the American Concrete Institute (ACI) 308, Standard Practice for Curing Concrete, which relates the following environmental factors to determine the evaporation rate:

1. Air temperature.
2. Relative humidity.
3. Concrete temperature.
4. Wind velocity.

When the nomograph originated in the mid-1960s, bleed water typically replaced surface water until evaporation rates increased to about 0.2 pounds per square foot per hour where surface drying began to occur. The seven precautions listed below were developed to counteract plastic cracking and should be contemplated by the contractor as part of the concrete placement plan.

1. Ensure aggregate stockpiles are maintained in the saturated surface dry condition.
2. Ensure surfaces that come into contact with fresh concrete, like forms and subgrade, are thoroughly moistened prior to placement.
3. Erect temporary windbreaks to reduce wind velocity over the concrete surface.
4. Erect temporary sunshades to reduce concrete surface temperatures.
5. Cool the mixing water and aggregates in extreme conditions to keep the fresh concrete temperature low.
6. Reduce time between placing and start of curing, by eliminating delays during construction.

7. Use water fogging sprays to maintain high humidity and surface moisture.

Because of advancements in concrete technology, the threshold for precautionary measures can occur at a much lower evaporation rate. For example, if a high range water reducing admixture is used, the water/cement ratio will be reduced and the final set time could be extended; the result is that the amount of water that can bleed to the surface will be reduced, the time when fresh concrete is exposed to plastic cracking is extended, and the risk of plastic cracking is increased. Another example is the situation where an ultrafine supplementary cementitious material (SCM) like silica fume is included in the concrete mix. Ultrafine SCMs block the capillaries that bleed water would normally follow to reach the surface, so the amount of bleed water that reaches the surface is reduced and the risk of plastic cracking is increased.

The CS, Section 51-1.03H, Concrete Structures – General – Construction – Curing Concrete Structures, describes the specific curing methods for bridge decks including unique requirements for bridge decks constructed with rapid strength concrete. Except for those constructed with rapid strength concrete, cure the top surface of bridge decks by misting and the water method using a curing medium. At the end of the curing period, the curing medium is removed and curing compound is applied to the top surface of the bridge deck. The water cure CS require the application of water as a fine mist to maintain bridge deck surface moisture until curing medium is applied.

For the best results, mist should be finely atomized water which gradually falls to the bridge deck. A good indication that the water spray is appropriately atomized is that the particles descend at approximately 1 foot per second. Misting should be sprayed from an upwind position over the bridge deck, not onto the deck, raising the humidity in the air above the deck. As the spray falls to the bridge deck, the objective is to maintain a surface sheen but avoid runoff, which would erode the surface.

At the end of the curing period, the curing medium is removed and curing compound is applied to the deck surface during the same work shift. Curing compound is applied at a nominal rate of 150 square feet per gallon, such that there is uniform coverage without any thin areas or surface runs, by a power-operated spraying device. The curing compound does not preclude the possibility of plastic cracking, as shown in Figure 2.
Bridge Deck Crack Prevention

**Contract Specification Changes and Curing Requirements for Bridge Decks**

To follow are three changes for concrete mix designs in the CS:

1. Section 90-1.01C, *Concrete – General – Submittals*, added the submittal of polymer fibers.
2. Section 90-1.02A, *Concrete – Materials – General*, revised the shrinkage limitations for bridge deck concrete from 0.045 percent to 0.032 percent.
3. Section 51-1.02B, *Concrete Structures – General – Materials - Concrete*, added the requirement for polymer fibers and a shrinkage reducing admixture.

When first implemented in the field, the polymer fibers were delivered to the jobsite and added to the concrete mixer. Figure 3 is an example of polymer fibers in bags, as delivered to the jobsite. Fibers were spread on tables to loosen clumps then into drums prior to introducing them to the mix. Figure 4 depicts two types of polymer fibers.

In recent years, the process changed to the fibers being introduced to the mix at the concrete plant. This is the preferred method as it allows them to be thoroughly blended into the mix without the risk of going over the allowed mixing time or drum revolutions. Care should still be taken at the plant to loosen fibers prior to being added to the mix. Failure of doing so can result in clumps in the mix as discharged. See Figure 10 for examples.
Bridge Deck Crack Prevention

Figure 3. Polymer Fibers on the Jobsite

Macrofibers

Microfibers

Figure 4. Macrofibers and Microfibers

To follow are two changes for curing the bridge deck in the CS:

1. Section 51-1.01C(1), Concrete Structures – General – Submittals – General, revised the requirements of the deck placement plan for bridge decks to require the concrete bridge deck is kept damp by misting immediately after finishing the concrete surface.

2. Section 51-1.03H, Concrete Structures – General – Construction – Curing Concrete Structures, was revised to specify bridge decks must be cured by
Bridge Deck Crack Prevention

misting before using the water method with the curing medium. At the end of the curing period, remove the curing medium and apply curing compound no.1 to the top surface of the deck as outlined in the CS.

The following is a checklist to assist in verifying the CS changes are followed:

1. Verify the deck placement plan for concrete bridge decks is submitted. The plan must provide means and method for ensuring that the deck is kept damp by misting immediately after finishing.

2. Verify the top surface of bridge decks is cured first by misting, followed by the water method using a curing medium. See Figures 5-9.

3. Verify that misting is continuous with an atomizing nozzle, forming a mist, not a spray. See Figures 6-7.

4. Verify that the contractor continues to mist until the curing medium has been placed and the application of water for the water method has started as outlined in the CS, Section 90-1.03B(2), Concrete – General – Construction – Curing Concrete – Water Method. It is advisable to pre-wet the curing medium to avoid wicking moisture from the deck concrete. See Figure 7.

5. Do not allow the removal of the curing medium and application of curing compound until after 7 days of water curing. See Figure 8.

6. Verify curing compound no. 1 is used and must be applied during the same work shift when the curing medium is removed as outlined in the CS, Section 90-1.03B(3), Concrete – General – Construction – Curing Concrete – Curing Compound Method. See Figure 9.

Figure 5. Placing concrete and an up-close view of concrete mix
Bridge Deck Crack Prevention

Figure 6. Spray misting top of concrete

Figure 7. Continue misting while curing medium for water method is placed
Bridge Deck Crack Prevention

Figure 8. Continue water method curing for 7 days
Since implementing the new CS to add polymer fibers, one issue found on recent projects is clumps of unmixed fiber. Polymer fibers are added to concrete delivery truck at the jobsite. When the concrete in the delivery truck is not mixed properly this can result in clumps of unmixed fibers. These unmixed clumps would not be visible until the concrete deck is ground and grooved. Refer to Figure 10.
Bridge Deck Crack Prevention

Figure 10. Clumps of unmixed fiber before and after grinding and grooving the deck.
Concrete Structures – Joints

BCM 51-2, *Concrete Structures – Joints*, has not been posted yet.

Until it is posted refer to:

- **BCM 135-2.0**, *Bridge Deck Expansion Joints and Joint Seals*, and
- **BCM 135-2.1**, *Release and Reporting of Values for Type Joint Seal*
Concrete Structures – Bearings – Elastomeric Bearing Pads

BCM 51-3.02, Concrete Structures – Bearings – Elastomeric Bearing Pads, has not been issued yet.

Until BCM 51-3.02 is issued refer to the Contract Specifications, Section 51-3.02, Concrete Structures – Bearings – Elastomeric Bearing Pads, for contract requirements for this topic.
Concrete Structures – Precast Concrete Members

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for:

- Review and authorization of precast concrete member submittals, including girders, closure wall panels, box culverts, and deck panels. Review and authorization of shop drawings for precast concrete members, under this process, is usually performed in conjunction with Materials Engineering and Testing Services (METS) and coordinated with the METS Representative (MR).

- Coordinating inspection and release of precast concrete members with the MR. The MR generally administers fabrication of precast concrete members at the fabrication site. Precast concrete members are released for construction from the fabrication site via Form TL-0029, Report of Inspection of Material.

- Fabrication, delivery, storage, and handling of precast concrete members. Precast concrete members are generally fabricated at a precasting plant and the inspection of fabrication of these members is generally performed by the MR. Therefore, close coordination with the MR is necessary.

- Construction of precast concrete members. Precast concrete members are generally utilized for accelerated bridge construction (ABC) and in locations where temporary support structures are impractical. There are many aspects of precast concrete girder construction that must be addressed, including deflection, staging, bracing, and member splicing.
Additional unique requirements for this BCM are detailed in:

- **BCM 50-1, Prestressing Concrete – General**

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the *Contract Specifications*, Section 51-4, *Concrete Structures – Precast Concrete Members*, that this BCM is based on, as identified in the title block above. The information in the *Contract Specifications* typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Form **CEM-3101, Notice of Materials to be Used**
2. Precast concrete member shop drawings
3. Casting schedule
4. Certificate of compliance for precast culverts
5. Girder erection work plan
6. **Form TL-38, Inspection Request**

**Procedure**

1. All work associated with this process is charged as **Project-Direct – Construction**.
2. Inspection of field work for this process is:
   a. **Benchmark**: for delivery of precast concrete members.
   b. **Intermittent**: for installation of precast concrete member.
   c. **Continuous**: for installation of major precast concrete elements near traffic.
3. Before construction begins:
   a. Review the following references:
      i. RE Pending File (Designer Notes and 4-Scale Deck Contours)
      ii. *Concrete Technology Manual, Chapter 3, Review of Concrete Mix Designs*
      iii. **Construction Manual**:  
         1. Chapter 4, *Construction Details, Subsection 4-9004, Precast Concrete*
         2. Chapter 6, *Sampling and Testing, Subsection 6-203A, Source Inspection*

v. *Memo to Designers 9-3, Widening Existing Bridges*, and *Memo to Designers 11-1, Prestressed Concrete – Shop Drawing Review*

vi. *Contract Specifications*, Section 90-4, Concrete – Precast Concrete, for documents required prior to fabricating precast members (i.e. Test data, Daily Temperature data, Precast Concrete Quality Control Plan, Quality Control Meeting, etc.)
b. Discuss responsibilities for fabrication of precast concrete members with the MR. Include the following topics in the discussion:

i. Procedures for processing Non-Compliant Reports (NCRs), which are issued by METS for resolving inconsistencies between the authorized precast concrete member shop drawings and the fabricated precast member.

ii. The Critical Path Method (CPM) schedule includes fabrication and erection of precast concrete members.

iii. The fabrication schedule.

iv. The requirement that the contractor must submit Form TL-38, *Inspection Request*.


vi. Anticipated date of precast concrete member delivery to the job site.

vii. Precast fabrication requirements.

viii. Delivery, handling, and storage of precast concrete members with the contractor.

ix. Time-dependent precast concrete member deflection, grade adjustments, and bearing pad thickness with the contractor.

x. Precast concrete member splicing requirements with the contractor, if applicable.

xi. Protection of protruding prestressing strand, and/or exposed reinforcing steel during stage construction, if applicable.

xii. Establish a project specific inspection plan and communication protocols between Structure Representative, Assistant Structure Representative(s), and Materials Representative.

c. For precast concrete girders:
i. Verify information is correct on Form CEM-3101, *Notice of Materials to be Used*.

ii. Review and authorize or reject the shop drawings, verify drawings include anticipated deflection calculations, that materials are on the [Authorized Materials List](#) and maintain a submittal log to ensure timely review.

iii. Coordinate review and authorization of Precast Concrete Quality Control Plan with METS. Notify the contractor in writing.

iv. Ensure that the MR is invited to the Quality Control Meeting. Refer to the *Contract Specifications*, Section 90-4.01D(2)(b), *Prestressing Concrete – Precast Concrete – General – Quality Assurance – Quality Control – Quality Control Meeting*.

v. Verify that a Precast Concrete Report is submitted to the engineer before the precast concrete members are shipped to the jobsite. Coordinate the review of this report with METS for compliance and acceptance. Refer to the *Contract Specifications*, Section 90-4.01C(5), *Prestressing Concrete – Precast Concrete – General – Submittals – Precast Concrete Report*.

vi. Discuss requirements for the precast concrete girder erection work plan with the contractor, with special attention for traffic locations and railroads.

vii. Review and authorize or reject the precast concrete girder erection work plan. Notify the contractor in writing.

4. During construction:

   a. Request verification of all precast concrete member camber values and other controlling dimensions from the MR prior to the release of the precast members.

   b. Ensure that precast concrete members delivered to the project site have been properly released by METS before being incorporated into the work. If concrete members are delivered without a METS release, coordinate with the MR and verify member is fit for purpose prior to field release.

   c. Collect Form TL-0624 (Orange tags) from the precast concrete members, verify the Orange tags match the Form TL-0029, *Report of Inspection of Material*, attach the Orange tags to Form TL-0029, and file.

   d. Verify precast concrete members are delivered, handled, and stored in accordance with the requirements of the contract documents and the authorized shop drawings.

   e. Verify precast concrete members are erected in accordance with the requirements of the contract documents and authorized erection work plan.
f. Verify precast concrete members are spliced in accordance with the requirements of the contract documents.

g. Verify top of precast concrete girders do not reduce the bridge deck thickness after erection.

h. Hold safety meeting in conjunction with the contractor before delivery and installation. Refer to Cal/OSHA Title 8, Subchapter 4, Construction Safety Orders:

   i. Article 24, Fall Protection
   ii. § 1711, Reinforcing Steel and Post-Tensioning in Concrete Construction
   iii. § 1712, Requirements for Impalement Protection

   i. Track quantities for the monthly payment estimates.

   j. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Following construction:

   a. Review and follow as-built guidelines in BCM C-6, Required Documents to be Submitted During Construction.

6. File all project documentation (materials acceptance documentation, correspondence, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Precast concrete members fabricated and installed in conformance with contract requirements

2. Authorized precast concrete member submittals

3. Submittal logs

4. Form TL-0029, Report of Inspection of Material, with attached orange tags

5. Daily Reports

**Attachments**

None
Concrete Structures – Approach Slabs

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, materials, construction, and payment for new and replacement of existing structural concrete approach slabs and paving notch extensions.

This process includes paving notch extensions, structure excavation, placement of drainage systems, and permeable base for approach slabs.

Additional unique requirements for structure approach slabs are detailed in:

- **BCM 51-1.03F(5-6), Concrete Structures – General – Finishing Roadway Surfaces – Bridge Deck Surface Texture.**
- **BCM 51-1.01, Concrete Structures – General**

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 51-5, Concrete Structures – Approach Slabs, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. **Form CEM-3101, Notice of Materials to be Used**
2. Submittals
Procedure

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:
   a. Benchmark, for demolition, excavation, and rebar placement.
   b. Continuous for concrete placement.

3. Before construction begins:
   a. Review the contract documents and as-built plans.
   c. Review the Field Engineer Training, Section 07, Approach Slab to Punch List, for details and photographs of approach slab components discussed in this BCM.
   d. Verify materials to be used for approach slabs and paving notch extensions comply with the requirements of the contract documents.
   e. For existing structures, review existing structure profile grades and make appropriate adjustments to the new approach slab grade if needed.
   f. Discuss the removal plan.
   g. Discuss inspection and release of materials with the Materials Engineering and Testing Services (METS) Representative.
   h. Review and authorize or reject submittals. Notify the contractor in writing.
   i. For approach slabs to be constructed with Rapid Strength Concrete (RSC), review the Contract Specifications, Section 51-1.01C(4), Concrete Structures – General – General – Submittals – Rapid Strength Concrete, for submittal requirements including a contingency plan for issues such as:
      i. RSC or paving notch concrete not setting up.
      ii. Large voids, unmarked utilities and other differing site conditions encountered under existing slab.
      iii. Incorrect rebar cage.
   j. Witness placement of the trial slab per Contract Specifications, Section 51-5.01D(2)(b), Concrete Structures – Approach Slabs – General – Quality Assurance – Quality Control – Rapid Strength Concrete, and verify contract requirements are met, including strength at age of break. Confirm the contractor has verified existing field conditions.
4. During construction:
   a. Discuss and follow the project Code of Safe Practices.
   b. Verify the profile grade established by the contractor.
   c. Set up pre-pour meeting and discuss with the contractor the pour and contingency plan.
   d. Where the future concrete barrier has utility pull boxes, verify that the extra reinforcement needed around the boxes is in place.
   e. Verify that approach slab drainage pipes and geodrain are placed per contract documents.
   f. Follow contract documents and manufacturer’s requirements for bonding materials and RSC.
   g. Field release materials in accordance with Construction Manual, Section 6-2, Sampling and Testing – Acceptance of Manufactured or Fabricated Materials and Products.
   h. Provide direction to the contractor on how to proceed if differing site conditions are encountered. Implement a Change Order to cover the work.
   i. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Following construction:
   a. Verify approach slab smoothness per California Test 547, Method of Test for Operation of Bridge Profilograph and Evaluation of Profiles. Review the SC Profilograph Online Training for guidance.
   b. Coordinate skid testing with METS per California Test 342, Method of Test for Surface Skid Resistance with the California Portable Skid Tester.
   c. Verify repairs are performed on any areas that fail to meet the requirements of California Tests 342 and 547.

6. File all project documentation (materials acceptance documentation, correspondence, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized submittals
2. Rapid Strength Concrete Trial Slabs
3. CTM 342 and CTM 547 test results

Attachments

None
Concrete Structures – Mass Concrete

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, materials, and construction for mass concrete elements.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 51-6, Concrete Structures – Mass Concrete, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Contract work requiring mass concrete
2. Submittals required by the Contract Specifications for mass concrete

Procedure

1. All work associated with this process is charged as Project Direct – Construction.
2. Inspection of field work for this process is:
   a. Benchmark for inspection of components of contractor’s thermal control system prior to concrete placement.
   b. Continuous during mass concrete placement.
3. Before construction begins:
a. Review the following to gain a better understanding of what mass concrete is, what the concerns are, what controls are necessary, etc.:


iii. Bridge Design Memo 5.13, *Mass Concrete Prediction Nomograph*

b. Review BCM 51-1.03 (C-D), *Concrete Structures – General – Construction – Preparation and Placing Concrete*.

c. Review contract documents for location of structural elements with mass concrete requirements. *Attachment 1, When the Mass Concrete Specification Applies*, includes examples of how the location of mass concrete is called out in the *Special Provisions*.

d. Verify that all structural elements large enough to be classified as mass concrete are identified in the contract documents. Coordinate with the Resident Engineer (R.E.) to issue a Change Order (C.O.) if mass concrete specifications are required but not identified.

e. Review and authorize the contractor’s thermal control plan.

f. Review the mass concrete mix design in accordance with BCM 90-1, *Concrete – General*.

g. Discuss with the contractor how they intend to obtain an average daily air temperature.

h. Discuss contingencies with the contractor in the event of thermal control system failure during concrete placement.

i. Review with and ensure that the Assistant Structure Representative understands the authorized thermal control plan.

j. If submitted, review the Value Engineering Change Proposal (VECP) submitted by the contractor for adding or removing mass concrete specifications for structural elements. Consult the Structure Designer and Materials Engineering and Testing Services (METS) Representative for assistance with the review and authorization of the VECP. Coordinate with the R.E. to issue a C.O. if the VECP is authorized. Refer to the *Contract Specifications*, Section 4-1.07, *Scope of Work – Value Engineering*, for more information on VECPs. Get concurrence from the district construction deputy director if the VECP is unacceptable, as per *Construction Manual*, Section 3-405, *Value Engineering*.

4. During construction:

   a. Verify compliance with the authorized thermal control plan submittal:
i. Coordinate and conduct a pre-pour meeting with all parties involved.

ii. Coordinate with the contractor to verify that the primary and redundant sets of temperature monitoring sensors are functioning prior to the concrete pour.

iii. Coordinate with the contractor to witness pressure test(s) for the cooling system, if applicable, immediately prior to the concrete pour.

iv. Verify that thermal control pipes, sensors, and wire runs are secured prior to the concrete pour and throughout concrete placement.

b. Be present throughout the concrete pour to monitor temperature readings at the concrete delivery vehicle and within the forms, in addition to typical inspection duties during concrete pours in accordance with BCM 51-1.03(C-D), *Concrete Structures – General – Construction – Preparation and Placing Concrete*.

c. Review the contractor’s daily progress reports and temperature data (informal submittal) for temperature gradient compliance with authorized submittal.

d. Reject mass concrete elements that do not comply with the temperature acceptance criteria. Request a mitigation plan from the contractor. Consult with the Structure Designer and the METS Representative for the possibility of rejected element being fit for purpose:

i. For replaced elements, review the contractor’s modified thermal control plan submittal.

ii. If mitigation plan is authorized, verify and documents that the corrective action is completed as planned.

e. For mechanical cooling systems, verify that all cooling pipes have been grouted after concrete placement has been completed and the monitoring period has elapsed with no issues.

f. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per *BCM C-7, Daily and Weekly Reports*.

g. Take daily progress photos and file in Category 14 of the project files.

5. Following Construction:

a. Compute payment quantities for mass concrete bid items as described in the contract documents and provide these quantities to the R.E.

b. Complete as-built plans per *BCM C-6, Required Documents to be Submitted During Construction*. 


6. File all test results and Daily Reports in the appropriate category in the project records as specified in the *Construction Manual, 5-102, Contract Administration – Organization of Project Documents*.

**Process Outputs**

1. Authorized Thermal Control Plan submittal
2. Mass Concrete element integrated into the structure
3. Contractor Daily Progress Reports including daily temperature data

**Attachments**

[Attachment 1](#), *When the Mass Concrete Specification Applies*. 
When the Mass Concrete Specification Applies

This attachment details how the contract identifies when the requirements for *Contract Specifications*, Section 51-6, *Concrete Structures – Mass Concrete*, applies. The contract plans do not reference or note mass concrete. It is specified in the:


- *Special Provisions* for other locations as shown in:
  - Figure 1, *Excerpt from Contract 03-1E0604*, for the Simmerly Slough Bridge, Bridge No. 16-0055.
  - Figure 2, *Excerpt from Contract 10-3A66U4*, which has one bridge and one retaining wall.

![Figure 1. Special Provisions for Contract 03-1E0604.](image1)

![Figure 2. Special Provisions for Contract 10-3A66U4.](image2)
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Reinforcement – General

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, materials, construction, and payment for reinforcement.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 52-1, Reinforcement – General, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Submittals required by the Contract Specifications for reinforcement, such as:
   a. Shop drawings for temporary support system and design calculations
   b. Manufacturer information and recommendations:
      i. Certified mill test report
      ii. Certificate of Compliance (COC)
   c. Contractor’s request to substitute welded wire reinforcement for bar reinforcement

Procedure

1. All work associated with this process is charged as Project Direct – Construction.
2. Inspection of field work for this process is:
   a. **Benchmark** for work associated with reinforcement deliveries, reinforcement layout, and pre-form installation.
   b. **Intermittent** for placement of reinforcement which requires inspection at regular intervals such that the work is progressively checked to identify problems in a timely fashion.

3. Before construction begins:
   a. Review contract plans and look for potential conflicts with electrical components, drainage components, prestressing components, and access openings.
   b. Review **Cal/OSHA Title 8**, paying special attention to:
      i. **Construction Safety Orders, Title 8, CCR §1712, Requirements for Impalement Protection**, which states that all exposed rebar (shorter than 6’) must be covered or fenced off.
      ii. **Construction Safety Orders, Title 8, CCR §1670, Personal Fall Arrest Systems, Personal Fall Restraint Systems and Positioning Devices**, which states that all work surfaces that are 7 ½ ft or higher workers must be protected by guard railing or by other means.
   c. Review the RE Pending file to verify reinforcement quantities considering that the contract requires the quantities covered by certificates of compliance to match the total project quantities. Knowledge of the reinforcement quantities per structure element will also aid in the development of a concrete/reinforcement ratio (pay factor) to use on monthly pay estimates. Also look for potential errors in reinforcement pay quantities that may require a change order.
   d. Review the **Construction Manual, Chapter 4, Section 4-52, Reinforcement**.
   e. Review and authorize temporary support shop drawings, which are required when an assemblage of bar reinforcing steel exceeds 20 feet in height. Temporary support plans must include sufficient detail to ensure stability of reinforcing cages during all phases of construction. The plan must also include provisions for keeping stable the column cage and forms during the transition from one stage to the next as well as a list of all equipment to be utilized to handle the erection. Perform engineering review of the temporary support submittal to verify compliance with:
      i. **Cal/OSHA §1711, Reinforcing Steel and Post-Tensioning in Concrete Construction (e) Stability Requirements for Vertical and Horizontal Columns, Walls, and Other Reinforcing Assemblies.**


v. Review the *Reviewing Guy Wire Plans* to assist in reviewing guy wire plans. This handbook includes an introduction, requirements, sequence and installation procedures, how to perform an initial review, design analysis, railroad, construction, safety, and sample calculations.

4. During Construction:
   a. Field verify that the delivered and placed reinforcement conforms to the contract documents. For example:
      i. For reinforcement delivery verify the delivery includes the certificate of compliance (COC) and certified mill test reports, and the reinforcement markings, coatings, and steel grade match the COC.
      
      ii. For reinforcement layout and placement, verify spacing, orientation, clearances, bar cleanliness, and that dobie dimensions provide specified clearance prior to installation:
         1. For rebar spacing guidelines, including spacing of bundled reinforcing bars, refer to *Attachment 5*, *Spacing Guidelines for Reinforcing Steel Bars*.
         
      iii. For pre-form installations (i.e., column casings, stem form, and barrier rail) verify all reinforcement has been correctly placed and is complete.
      
   b. For guidance refer to:
      
      i. *Attachment 1*, *Reinforcing Steel Hook Detail*, to verify the dimensions and configurations of reinforcement steel hooks.
      
      ii. *Attachment 2*, *Identification of Reinforcing Steel Bars*, to verify that the reinforcement markings match the fabricator’s marks listed on the COC.
      
      iii. *Attachment 3*, *Reinforcing Steel Bar Chart*, to calculate clearances and reinforcement weights.
      
      iv. *Attachment 4*, *Welded Wire Reinforcement*, to review and authorize or reject for resubmittal, the contractor’s request to substitute welded wire reinforcement for reinforcing bars, as allowed by the *Contract Specifications* for certain applications. Notify the contractor of authorization or rejection in writing. Note that substitutions for epoxy coated reinforcing bars is not allowed by the *Contract Specifications*. 
v. Attachment 5, *Spacing Guidelines for Reinforcing Steel Bars*, to verify adequate spacing of reinforcing steel bars, including bundled bars.

c. Check that all of Cal/OSHA requirements (e.g., impalement hazards, fall protection) are adhered to in the field.

d. Collect COCs ahead of incorporating the material into the work as soon as possible after reinforcement delivery. File COCs in job files and include the COC numbers with monthly pay estimate sheets and Material on Hand (MOH) Payments. For questions regarding reinforcing steel, COC’s, releases, reinforcement shortages, and current quality issues, contact the Materials Engineering and Testing Services (METS) representative for advice. METS can also help with MOH payments by confirming the existence of reinforcing steel quantities at the fabricator yard, which is necessary for processing monthly MOH payments.

e. Pay attention to potential reinforcement conflicts with items such as prestress ducts, utilities, drainage systems, electrical pull boxes, and others. If there is a hard conflict between reinforcement and another element, contact Structure Design prior to making any field adjustments, to avoid compromising the design intent.

f. Reject non-conforming work and notify the contractor for remediation.

g. Review project site to verify that the authorized temporary support system will work within the existing field conditions and stage construction configurations; if conflicts are found, request necessary revisions. Any deviation from authorized shop drawings require resubmittal as specified in *Contract Specifications*, Section 5-1.23B(1), *Control of Work – Submittals – Action Submittals – General*.

h. After each inspection inform the Structure Representative and contractor of your findings. Verify that necessary corrections are completed prior to concrete placement.

5. Following Construction:

a. Once concrete is poured make payments for reinforcing steel quantities placed. It is highly advisable to keep a rebar log throughout the project, to ensure that all payments made have corresponding COCs. Refer to *BCM C-9, Preparation of Progress Payment Documents*.

b. Document reinforcing splices on the as-built plans per *BCM C-6, Required Documents to be Submitted During Construction*.

6. File all material acceptance project documentation (material acceptance documentation, correspondence, Daily Reports, etc.) in the appropriate category in the project records as specified in the *Construction Manual, Section 5-102, Organization of Project Documents*. 
Process Outputs

1. Certificates of compliance (authorized form)
2. Authorized substitution of welded wire reinforcement
3. Authorized temporary support system shop drawings
4. Placement of reinforcement according to project plan
5. Payment

Attachments

Attachment 1: Reinforcing Steel Hook Detail
Attachment 2: Identification of Reinforcing Steel Bars
Attachment 3: Reinforcing Steel Bar Chart
Attachment 4: Welded Wire Reinforcement
Attachment 5: Spacing Guidelines for Reinforcing Steel Bars
Reinforcing Steel Hook Detail

The Standard Specifications require that reinforcing steel hooks and bends conform to the provisions of the Building Code Requirements for Structural Concrete published by the American Concrete Institute (ACI).

Figure 1, *Recommended Industry Practice for Detailing Reinforcing Materials*, is from the Concrete Reinforcing Steel Institute (CRSI), *Manual of Standard Practice*, and conforms to the ACI 318 code requirements for standard hook details.
Figure 1. Recommended Industry Practice for Detailing Reinforcing Materials
Identification of Reinforcing Steel Bars

ASTM specifications for reinforcing steel require identification marks to be rolled into the surface of the bars.

Figures 1-10 are from Chapter 1 and Appendix A of the Manual of Standard Practice of the Concrete Reinforcing Steel Institute (May 2003). These reproduced pages illustrate the mill identification marks and other symbols designating size and grade of the reinforcing steel.
1.7. Identification Marks—ASTM Standard Reinforcing Bars

The ASTM specifications for reinforcing bars require identification marks to be rolled into the surface on one side of the bar to denote the Producer's mill designation, bar size, type of steel, and minimum yield designation. Grade 60 [420] bars show these marks in the following order:

1st—Producing Mill (usually a letter)
2nd—Bar Size Number (#3 through #11, #14, #18 [#10 through #57])
3rd—Type of Steel:
   S for Billet-Steel (A615/A615M)
   W for Low-Alloy Steel (A706/A706M)
   R for Rail-Steel (A996/A996M)
   A for Axle-Steel (A996/A996M)

4th—Minimum Yield Strength Designation

A mark for minimum yield designation or grade is required for Grade 60 [420] and Grade 75 [520] bars only. Grade 60 [420] bars can either have one single longitudinal line (a grade line) or the number 60 [4] (a grade mark). Grade 75 [520] bars can either have two grade lines or the grade mark 75 [5].

A grade line is smaller and is located between the two main longitudinal ribs which are on opposite sides of all bars rolled in the United States. A grade line must be continued through at least 5 deformation spaces, and it may be placed on the same side of the bar as the other markings or on the opposite side.

Grade 40 [300] and 50 [350] bars are required to have only the first three identification marks. No grade mark or grade line for minimum yield strength is required.

VARIATIONS: Bar identification marks may also be oriented to read horizontally (at 90° to those illustrated). Grade mark numbers may be placed within separate consecutive deformation spaces to read vertically or horizontally.

*See Appendix A for complete identification marks of Grade 60 [420] reinforcing bars produced by all U.S. Producers. The marks, listed alphabetically by producing mill, include the identification requirements of ASTM and the deformation pattern used by each mill.

Figure 1. Excerpt from Chapter 1, Material Specifications for Reinforcing Bars
Identification of Reinforcing Steel Bars

Figure 2. Excerpt from Chapter 1, Material Specifications for Reinforcing Bars, continued
Identification of Reinforcing Steel Bars

Figure 3. Excerpt from Appendix A: United States Manufacturers Listed Alphabetically
Identification of Reinforcing Steel Bars

Figure 4. Excerpt from Appendix A: United States Manufacturers Listed Alphabetically continued
Identification of Reinforcing Steel Bars

Figure 5. Excerpt from Appendix A: United States Manufactures Listed Alphabetically continued
Identification of Reinforcing Steel Bars

Figure 6. Excerpt from Appendix A: United States Manufacturers Listed Alphabetically continued
Identification of Reinforcing Steel Bars

**Figure 7. Excerpt from Appendix A: United States Manufacturers Listed Alphabetically continued**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Grade Marking</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROCKY MOUNTAIN STEEL MILLS</td>
<td>W</td>
<td>Coiled bars #3 through #5 only</td>
</tr>
<tr>
<td>SHEFFIELD STEEL</td>
<td>S</td>
<td>Bars #13 through #43 only</td>
</tr>
<tr>
<td>SILVER, INC., W.</td>
<td></td>
<td>Bar #3 only</td>
</tr>
<tr>
<td>SILVER, INC., W.</td>
<td></td>
<td>Grade mark line on opposite side</td>
</tr>
<tr>
<td>STRUCTURAL METALS, INC.</td>
<td>S</td>
<td>Bars #10 through #19 only</td>
</tr>
<tr>
<td>STRUCTURAL METALS, INC.</td>
<td>W</td>
<td>Bars #10 through #19 only</td>
</tr>
<tr>
<td>TAMCO</td>
<td></td>
<td>Bars #13 through #36 only</td>
</tr>
<tr>
<td>TAMCO</td>
<td></td>
<td>Bars #43 and #57 only</td>
</tr>
</tbody>
</table>

Note: CRSI mill members are in boldface with the CRSI logo at the top right corner.
Identification of Reinforcing Steel Bars

APPENDIX A

U.S. MANUFACTURERS OF GRADE 60 [420] CONCRETE REINFORCING BARS

ASTM and AASHTO Specifications require that all reinforcing bars be identified by permanent, mill imprinted markings.

22 TAMCO
(Rancho Cucamonga, CA)

W
Bars #13 through #36 only

22 TAMCO
(Rancho Cucamonga, CA)

W
Bars #43 and #57 only

23 TXI CHAPARRAL STEEL
(Midlothian, TX)

S
Bars #10 through #36 only
Grade mark line on opposite side

23 TXI CHAPARRAL STEEL
(Midlothian, TX)

W
Bars #10 through #36 only
Grade mark line on opposite side

Note: CRSI mill members are in boldface with the CRSI logo at the top right corner.

Figure 8. Excerpt from Appendix A: United States Manufacturers Listed Alphabetically continued
Identification of Reinforcing Steel Bars

APPENDIX A

U.S. MANUFACTURERS OF GRADE 60 [420] CONCRETE REINFORCING BARS

CONTACT INFORMATION FOR CRSI MILL MEMBERS

2. AMERISTEEL
   Charlotte Steel Mill Division
   6601 Lakeview Rd
   Charlotte, NC 28213
   Tel: (704) 596-0361
   Fax: (704) 597-5031
   Web: www.ameristeel.com

   AMERISTEEL
   Jacksonville Steel Mill Division
   Hwy 217 & Yellow Water Rd
   Baldwin, FL 32234
   Tel: (904) 266-4261
   Fax: (904) 266-4244
   Web: www.ameristeel.com

   AMERISTEEL
   Knoxville Steel Mill Division
   1919 Tennessee Ave
   Knoxville, TN 37950
   Tel: (865) 546-5472
   Fax: (865) 637-8293
   Web: www.ameristeel.com

   AMERISTEEL
   West Tennessee Steel Mill Division
   801 AmeriSteel Rd
   Jackson, TN 38305
   Tel: (901) 422-4247
   Fax: (901) 422-4247
   Web: www.ameristeel.com

3. AUBURN STEEL COMPANY, INC.
   Auburn Division
   25 Quarry Rd
   Auburn, NY 13021
   Tel: (315) 253-4561
   Fax: (315) 253-5377
   Web: www.austeel.com

   AUBURN STEEL COMPANY, INC.
   Lemont Division
   New Ave at Ceco Rd
   Lemont, IL 60439
   Tel: (630) 243-0012
   Fax: (630) 243-0031
   Web: www.austeel.com

5. BIRMINGHAM STEEL CORP.
   Alabama Steel Division
   2301 Shuttlesworth Dr
   Birmingham, AL 35234
   Tel: (205) 252-8777
   Fax: (205) 250-7465
   Web: www.birminghamsteel.com

   BIRMINGHAM STEEL CORP.
   Illinois Steel Division, Joliet Rolling Mill
   927 Collins
   Joliet, IL 60432
   Tel: (815) 774-6145
   Fax: (815) 774-6105
   Web: www.birminghamsteel.com

   BIRMINGHAM STEEL CORP.
   Illinois Steel Division, Kankakee Plant
   972 East 4500 North Rd
   Bourbonnais, IL 60914
   Tel: (815) 937-3131
   Fax: (815) 939-5599
   Web: www.birminghamsteel.com

6. BORDER STEEL, INC.
   P.O. Box 12843
   El Paso, TX 79913
   Tel: (915) 886-2000
   Fax: (915) 886-2118
   Web: www.bordersteel.com

7. CASCADE STEEL ROLLING MILLS, INC.
   3200 Northeast Highway 99W
   McMinnville, OR 97128
   Tel: (503) 472-4181
   Fax: (503) 434-5739
   Web: www.schn.com

Figure 9. Excerpt from Appendix A: United States Manufacturers Listed Alphabetically continued
### U.S. MANUFACTURERS OF GRADE 60 [420] CONCRETE REINFORCING BARS

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Address</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. MARION STEEL COMPANY</td>
<td>912 Cheney Ave, Marion, OH 43302</td>
<td>Tel: (740) 383-4011</td>
</tr>
<tr>
<td></td>
<td>Fax: (740) 383-6429</td>
<td>Web: <a href="http://www.marionsteel.com">www.marionsteel.com</a></td>
</tr>
<tr>
<td>14. NORTH STAR STEEL COMPANY</td>
<td>Beaumont Mill, PO Box 2390, Beaumont, TX 77704</td>
<td>Tel: (409) 769-1978</td>
</tr>
<tr>
<td></td>
<td>Fax: (409) 769-1978</td>
<td>Web: <a href="http://www.cargillsteel.com/carnss">www.cargillsteel.com/carnss</a></td>
</tr>
<tr>
<td>19. SHEFFIELD STEEL CORP.</td>
<td>2300 South Hwy 97, Sand Springs, OK 74063</td>
<td>Tel: (918) 245-1335</td>
</tr>
<tr>
<td></td>
<td>Fax: (918) 245-9343</td>
<td>Web: <a href="http://www.sheffieldsteel.com">www.sheffieldsteel.com</a></td>
</tr>
<tr>
<td>21. STRUCTURAL METALS, INC.</td>
<td>Arkansas Mill, PO Box 1147, Magnolia, AR 71753</td>
<td>Tel: (870) 234-8703</td>
</tr>
<tr>
<td></td>
<td>Fax: (870) 234-8706</td>
<td>Web: <a href="http://www.steelnet.org/cmc">www.steelnet.org/cmc</a></td>
</tr>
<tr>
<td>22. TAMCO</td>
<td>12459 Arrow Hwy, Rancho Cucamonga, CA 91739</td>
<td>Tel: (909) 899-0660</td>
</tr>
<tr>
<td></td>
<td>Fax: (909) 899-1910</td>
<td>Web: <a href="http://www.nucor.com">www.nucor.com</a></td>
</tr>
</tbody>
</table>

Figure 10. Excerpt from Appendix A: United States Manufacturers Listed Alphabetically continued
Reinforcing Steel Bar Chart

Figure 1, *Table of Reinforcing Steel Bar Dimensions*, contains bar sizes that reflects both English and Metric (SI) units of the ASTM reinforcing bar standards.

Note that A615 and A706 specifications are currently in use; the A305 specification existed from 1947 to 1968. For older structures, it is prudent to anticipate varieties of reinforcing bars such as square bars.
# Reinforcing Steel Bar Chart

![Reinforcing Steel Bar Chart](chart.png)

**Figure 1. ASTM Standard Reinforcing Bars**

<table>
<thead>
<tr>
<th>BAR SIZE</th>
<th>ENGLISH</th>
<th>METRIC</th>
<th>CROSS SECTIONAL AREA (in²)</th>
<th>WEIGHT (lbs/ft)</th>
<th>NOMINAL DIAMETER (inches)</th>
<th>PERIMETER (inches)</th>
<th>APPROX DIAMETER OUTSIDE DEFORMATIONS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td># 3</td>
<td># 10</td>
<td>0.11</td>
<td>0.376</td>
<td>0.375</td>
<td>1.178</td>
<td>0.4375</td>
<td></td>
</tr>
<tr>
<td># 4</td>
<td># 13</td>
<td>0.20</td>
<td>0.668</td>
<td>0.500</td>
<td>1.571</td>
<td>0.5625</td>
<td></td>
</tr>
<tr>
<td># 5</td>
<td># 16</td>
<td>0.31</td>
<td>1.043</td>
<td>0.625</td>
<td>1.963</td>
<td>0.6875</td>
<td></td>
</tr>
<tr>
<td># 6</td>
<td># 19</td>
<td>0.44</td>
<td>1.502</td>
<td>0.750</td>
<td>2.356</td>
<td>0.875</td>
<td></td>
</tr>
<tr>
<td># 7</td>
<td># 22</td>
<td>0.60</td>
<td>2.044</td>
<td>0.875</td>
<td>2.749</td>
<td>1</td>
<td></td>
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<tr>
<td># 8</td>
<td># 25</td>
<td>0.79</td>
<td>2.670</td>
<td>1.000</td>
<td>3.142</td>
<td>1.125</td>
<td></td>
</tr>
<tr>
<td># 9</td>
<td># 29</td>
<td>1.00</td>
<td>3.400</td>
<td>1.128</td>
<td>3.544</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td># 10</td>
<td># 32</td>
<td>1.27</td>
<td>4.303</td>
<td>1.270</td>
<td>3.99</td>
<td>1.4375</td>
<td></td>
</tr>
<tr>
<td># 11</td>
<td># 36</td>
<td>1.56</td>
<td>5.313</td>
<td>1.410</td>
<td>4.43</td>
<td>1.625</td>
<td></td>
</tr>
<tr>
<td># 14</td>
<td># 43</td>
<td>2.25</td>
<td>7.650</td>
<td>1.693</td>
<td>5.306</td>
<td>1.875</td>
<td></td>
</tr>
<tr>
<td># 18</td>
<td># 57</td>
<td>4.00</td>
<td>13.600</td>
<td>2.257</td>
<td>7.088</td>
<td>2.5</td>
<td></td>
</tr>
</tbody>
</table>

Welded Wire Reinforcement

Shotcrete applications, slope paving, and other structure related items may require the use of welded wire fabric.

Chapter 2
Welded Wire Reinforcement (WWR)

2.1 Introduction
This chapter presents information for specifying and detailing welded wire reinforcement (WWR) used in building, highway, bridge, pile, and other types of construction. Information on epoxy coated, galvanized and stainless-steel welded wire reinforcement appear in Sections 2.6, 2.7, and 2.8 respectively, in this chapter.

2.2 ASTM Specifications
Welded wire reinforcement consists of wires welded together at their intersections in a square or rectangular configuration. WWR must conform to ASTM A1064 whether made from plain wire, deformed or ribbed wire, or a combination of both. (ASTM A1064 replaced the previous A82 plain wire, A188 plain wire WWR, A496 deformed wire and A497 deformed wire WWR specifications). A1064 requires tensile, reduction of area (for plain wire only) and bend tests on the reinforcement. Additionally, shear tests are required on the welded intersections. A minimum yield strength of 65,000 psi is required for plain WWR and a minimum 70,000 psi for deformed WWR. A1064 specification details the requirements for the wires used for manufacturing welded wire reinforcement.

Welded wire reinforcement can be produced with high-strength wires of minimum yield strengths of 80,000 psi. Higher minimum yield strengths allow the use of less material in certain applications. Welded wire reinforcement can be fabricated to make beam stirrups and column ties, box culverts, and other applications.

2.3 WWR Style Identification
Plain wire is denoted by the letter ”W” and deformed wire by the letter ”D”. The letter is followed by number indicating the cross-sectional area in hundredths of a square inch.

Welded wire reinforcement is usually shown on project drawings with the abbreviation WWR followed by the inch-spacing of longitudinal then transverse wires, and last by the sizes of the longitudinal then transverse wires.

Examples of style designation (see Figure 2-1) are:
6 x 12 W16.0/W8.0 Grade 65 for plain WWR;
6 x 12 D16.0/D8.0 Grade 70 for deformed WWR.
These designations identify a style of WWR in which:
- Spacing of longitudinal wires = 6 inches
- Spacing of transverse wires = 12 inches
- Longitudinal wire size = W16.0, D16.0
- Transverse wire size = W8.0, D8.0

A deformed WWR style would be designated in the same manner with the appropriate D number, wire spacing and size.

It is important to note that the terms “longitudinal” and “transverse” are related to the method of WWR manufacture and have no reference to the orientation of the wires with respect to the orientation of the reinforced concrete structure.

2.4 Specifying Welded Wire Reinforcement
The Architect/Engineer’s selection of welded wire reinforcement styles should include production considerations as well as steel area requirements. Maximum economies in production and handling can be achieved by utilizing repetition of styles and duplication of sheet dimensions to the fullest extent possible.

Welded wire reinforcement is manufactured in the form of rolls and sheets. Rolls are commonly stocked in W1.4 to W2.9 for plain WWR and D1.4 to D2.9 for deformed WWR. Roll widths can vary from 5 to 8 feet. Lengths vary with application and convenience of handling and shipping. Most commonly stocked sheets vary from 5 to 8 feet wide. Welded wire reinforcement sheet widths to 13 feet can be manufactured. “W” or “D” sizes from 1.4 (0.134 dia.) to 31.0 (0.628 dia.), even up to 45.0 (0.757 dia.) are available. Welded wire reinforcement sheets greater than 8”-8” wide require permits commonly issued by state highway departments. Contact the WWR producer for complete size, width and length capabilities.

Development lengths and lap splice lengths for WWR must be specified by the Architect/Engineer in accordance with the ACI 318 Code.

Certain styles of WWR as shown in Table 2-1 have been recommended by the Wire Reinforcement Institute as common styles. However, producers of WWR can meet specific steel area requirements when ordered for designated projects, or in some localities, may be available from producer inventory.

2.5 Detailing Welded Wire Reinforcement
The quantity of welded wire reinforcement detailed and supplied should include the net area shown on the project drawings or required in the project specifications plus sufficient material to include lap splices.

Also, the “Grade” (minimum yield strength) of the wire should be included in the description appearing after “W” or “D” size designation.

2.5.1 Width
Width is defined as the center-to-center distance between the outside longitudinal wires. Overall width is defined as the width plus side overhangs.

The side overhangs of transverse wires should be no greater than one inch unless otherwise specified by the Architect/Engineer. Transverse wires may be specified to have a specific overhang or no overhang (flush sides).

Figure 1. Chapter 2, Welded Wire Reinforcement, Sections 1 to 2.5.1
Welded Wire Reinforcement

Table 2-1 Common Styles of Welded Wire Reinforcement

<table>
<thead>
<tr>
<th>Style</th>
<th>Area, (in.²/ft)</th>
<th>Weight, (lb/100 ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“W” or “D” Available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 x 4 - W1.4 x W1.4</td>
<td>0.042</td>
<td>31</td>
</tr>
<tr>
<td>4 x 4 - W2.0 x W2.0</td>
<td>0.060</td>
<td>44</td>
</tr>
<tr>
<td>4 x 4 - W2.9 x W2.9</td>
<td>0.087</td>
<td>62</td>
</tr>
<tr>
<td>4 x 4 - W3.1 x W3.1</td>
<td>0.093</td>
<td>65</td>
</tr>
<tr>
<td>4 x 4 - W4.0 x W4.0</td>
<td>0.120</td>
<td>88</td>
</tr>
<tr>
<td>6 x 6 - W1.4 x W1.4</td>
<td>0.028</td>
<td>21</td>
</tr>
<tr>
<td>6 x 6 - W2.0 x W2.0</td>
<td>0.040</td>
<td>30</td>
</tr>
<tr>
<td>6 x 6 - W2.9 x W2.9</td>
<td>0.058</td>
<td>42</td>
</tr>
<tr>
<td>6 x 6 - W4.0 x W4.0</td>
<td>0.080</td>
<td>58</td>
</tr>
<tr>
<td>6 x 6 - W4.2 x W4.2</td>
<td>0.084</td>
<td>60</td>
</tr>
<tr>
<td>6 x 6 - W4.4 x W4.4</td>
<td>0.088</td>
<td>63</td>
</tr>
<tr>
<td>6 x 6 - W4.7 x W4.7</td>
<td>0.094</td>
<td>68</td>
</tr>
<tr>
<td>6 x 6 - W7.5 x W7.5</td>
<td>0.150</td>
<td>108</td>
</tr>
<tr>
<td>6 x 6 - W8 x W8</td>
<td>0.160</td>
<td>115</td>
</tr>
<tr>
<td>6 x 6 - W8.1 x W8.1</td>
<td>0.162</td>
<td>116</td>
</tr>
<tr>
<td>6 x 6 - W8.3 x W8.3</td>
<td>0.166</td>
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<tr>
<td>12 x 12 - W8.3 x W8.3</td>
<td>0.083</td>
<td>63</td>
</tr>
<tr>
<td>12 x 12 - W8.8 x W8.8</td>
<td>0.088</td>
<td>66</td>
</tr>
<tr>
<td>12 x 12 - W9.1 x W9.1</td>
<td>0.091</td>
<td>69</td>
</tr>
<tr>
<td>17 x 12 - W8.4 x W6.4</td>
<td>0.094</td>
<td>71</td>
</tr>
<tr>
<td>12 x 12 - W15 x W15</td>
<td>0.150</td>
<td>113</td>
</tr>
<tr>
<td>12 x 12 - W16 x W16</td>
<td>0.160</td>
<td>120</td>
</tr>
<tr>
<td>12 x 12 - W16.6 x W16.6</td>
<td>0.166</td>
<td>125</td>
</tr>
<tr>
<td>12 x 12 - W17.1 x W17.1</td>
<td>0.171</td>
<td>128</td>
</tr>
</tbody>
</table>

2.6 ASTM Specification for Epoxy-Coated Wire and Welded Wire Reinforcement

Epoxy-coated wire and welded wire reinforcement are used in reinforced concrete construction as a corrosion protection system.

The ASTM specification A884 covers the epoxy coating of plain and deformed steel wire, and plain and deformed welded wire reinforcement. The specification includes requirements for the epoxy-coating material; surface preparation of the steel prior to application of the coating; the method of application of the coating; the limits on coating thickness; and acceptance tests to ensure that the coating was properly applied. All damaged areas of coating on the wires, which occur during manufacture and handling to the point of shipment to the jobsite, have to be repaired (touched-up) with patching material.

2.7 ASTM Specification for Zinc-Coated (Galvanized) Steel Welded Wire Reinforcement

Galvanized welded wire reinforcement is used in reinforced concrete construction as a corrosion protection system.

The ASTM specification A1060 covers the zinc-coating (galvanizing) of plain and deformed welded wire reinforcement. The specification includes requirements for the mass (weight) and thickness of the coating, finish and adherence of the coating, and acceptance tests to ensure that the coating was properly applied. Rust formations on the cut ends and at welded intersections are inherent characteristics of this material and should not be cause for rejection. Prior to shipment, all coating defects (except those noted above) should be repaired (touched-up) with a zinc-rich formulation.

2.8 ASTM Specification for Stainless-Steel Welded Wire Reinforcement

Stainless-steel welded wire reinforcement is used as concrete reinforcement for applications requiring corrosion resistance.

The ASTM specification A1022 covers stainless-steel wire and welded wire reinforcement for hot-rolled, drawn or rolled, plain or deformed, or a combination of deformed and plain wire. Stainless-steel wire for welded wire reinforcement is generally at a 75 ksi yield strength however other strength levels can be manufactured and should be by agreement between the purchaser and manufacturer.

2.9 Rust

All carbon steel reinforcement for concrete, whether it is wire, welded wire reinforcement, or reinforcing bars, is subject to some degree of rusting before use. Research data has shown that a normal amount of rust increases the bond between the reinforcement and the concrete.

Example Calculations:

6 x 6 - W4.0/W4.0

Long. Wires (Table 2-2(a)) = 29.92

Trans Wires (Table 2-2(b)) = 28.11

Total = 58.03 = 58 lb/100 ft²

2.5.2 Length

Welded wire reinforcement in roll form can be manufactured in various lengths, up to the maximum weight per roll convenient for handling. The length of rolls can vary with individual manufacturing practices of the producer. Typical lengths are 100, 150, and 200 feet. Roll or sheet length is defined as the length, tip-to-tip, of longitudinal wires. This length is commonly, but not necessarily, a whole multiple of the transverse wire spacing.

The sum of the two end overhangs on either rolls or sheets are commonly equal to one transverse wire space, however exceptions do occur. Unless otherwise specified, each end overhang equals one-half of a transverse wire space.

Figure 2. Chapter 2, Welded Wire Reinforcement continued, Sections 2.5.1 to 2.9
Welded Wire Reinforcement

2.10 Handling, Shipping and Unloading

Welded wire reinforcement (WWR) is manufactured and shipped in two forms: rolls and sheets. If shipped in roll form, multiple rolls, generally from 7 to 18 depending on style and weight, are bundled together for efficient handling. Individual rolls are securely tied so uncurling will not occur when the bundle bands are cut. Welded wire reinforcement sheets are bundled in quantities, depending on size and weight, then shipped to either the customer location or to a customer jobsite. Most sheet bundles will weigh between 2,000 and 5,000 pounds.

Sheets are commonly bound together in bundles using wire, wire rod, or steel strapping. Rolls are bundled together using steel or plastic strapping. It is important to note that the wire, wire rod, steel or plastic strapping being utilized is for the sole purpose of holding the bundled rolls and/or bundled sheets together during transit and should never be used for lifting or handling.

Sheets are commonly manufactured by flipping alternate sheets allowing the sheets to “nest.” This allows for a greater number of sheets per bundle and the stacking of these “flipped” sheets provides additional stability during storage and transit.

Common pieces of equipment used for handling welded wire reinforcement are forklifts, overhead cranes and mobile cranes. Whenever welded wire reinforcement bundles require lifting equipment to unload in the plant or on the jobsite, extreme caution should be exercised and all safety regulations and practices must be observed.

End overhang — The sum of the end overhangs should equal one transverse wire space. Unless otherwise specified by the Architect/Engineer, each end overhang equals one-half of a transverse space.

Side overhangs may be varied as required and do not need to be equal. Overhang lengths are limited by overall sheet width.

Industry Method of Designating Style:
Example: 6 x 12—W16/W18
Longitudinal wire spacing—6 in. Longitudinal wire size—W18
Transverse wire spacing—12 in. Transverse wire size—W8

Figure 2-1 Style Designation of Welded Wire Reinforcement.

Figure 3. Chapter 2, Welded Wire Reinforcement continued, Section 2.10
## Table 2-2(a) Unit of Weight of Longitudinal Wires For Welded Wire Reinforcement

<table>
<thead>
<tr>
<th>Wire Size W or D</th>
<th>Nom. Dia. (in.)</th>
<th>Weight (lb/100 ft²) of Longitudinal Wires Per Inch Spacing (Based on 5° x 20° Sheet with 1” Side Overhang)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>45.0</td>
<td>0.757</td>
<td>948.00</td>
</tr>
<tr>
<td>31.0</td>
<td>0.828</td>
<td>653.48</td>
</tr>
<tr>
<td>30.0</td>
<td>0.818</td>
<td>632.40</td>
</tr>
<tr>
<td>28.0</td>
<td>0.807</td>
<td>590.24</td>
</tr>
<tr>
<td>26.0</td>
<td>0.757</td>
<td>548.08</td>
</tr>
<tr>
<td>24.0</td>
<td>0.753</td>
<td>505.92</td>
</tr>
<tr>
<td>22.0</td>
<td>0.529</td>
<td>463.76</td>
</tr>
<tr>
<td>20.0</td>
<td>0.505</td>
<td>421.60</td>
</tr>
<tr>
<td>18.0</td>
<td>0.476</td>
<td>379.44</td>
</tr>
<tr>
<td>16.0</td>
<td>0.451</td>
<td>337.28</td>
</tr>
<tr>
<td>14.0</td>
<td>0.422</td>
<td>295.12</td>
</tr>
<tr>
<td>12.0</td>
<td>0.391</td>
<td>252.96</td>
</tr>
<tr>
<td>11.0</td>
<td>0.374</td>
<td>231.80</td>
</tr>
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<td>10.5</td>
<td>0.366</td>
<td>221.34</td>
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<tr>
<td>10.0</td>
<td>0.357</td>
<td>210.80</td>
</tr>
<tr>
<td>9.5</td>
<td>0.348</td>
<td>200.26</td>
</tr>
<tr>
<td>9.0</td>
<td>0.339</td>
<td>189.72</td>
</tr>
<tr>
<td>8.5</td>
<td>0.329</td>
<td>179.18</td>
</tr>
<tr>
<td>8.0</td>
<td>0.319</td>
<td>168.64</td>
</tr>
<tr>
<td>7.5</td>
<td>0.309</td>
<td>158.10</td>
</tr>
<tr>
<td>7.0</td>
<td>0.299</td>
<td>147.56</td>
</tr>
<tr>
<td>6.5</td>
<td>0.289</td>
<td>137.02</td>
</tr>
<tr>
<td>6.0</td>
<td>0.276</td>
<td>126.48</td>
</tr>
<tr>
<td>5.5</td>
<td>0.265</td>
<td>115.94</td>
</tr>
<tr>
<td>5.0</td>
<td>0.252</td>
<td>105.40</td>
</tr>
<tr>
<td>4.5</td>
<td>0.239</td>
<td>94.86</td>
</tr>
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<td>4.0</td>
<td>0.226</td>
<td>84.32</td>
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<td>3.5</td>
<td>0.211</td>
<td>73.78</td>
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<tr>
<td>3.0</td>
<td>0.192</td>
<td>63.38</td>
</tr>
<tr>
<td>2.5</td>
<td>0.162</td>
<td>44.02</td>
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<tr>
<td>2.0</td>
<td>0.134</td>
<td>23.76</td>
</tr>
</tbody>
</table>

**NOTE:** This table should be used for estimating purposes only. Actual weight of WWF will vary from those shown above, depending on the width of rolls or sheets and lengths of overhang. No allowance is made in this table for the extra weight of reinforcement required for lap splices.

---

Figure 4, Unit of Weight of Longitudinal Wires for Welded Wire Reinforcement

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Manual of Standard Practice

Welded Wire Reinforcement

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CONCRETE REINFORCING STEEL INSTITUTE

BRIDGE CONSTRUCTION RECORDS & PROCEDURES MANUAL

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Welded Wire Reinforcement

Table 2-2(b) Unit of Weight of Transverse Wires for Welded Wire Reinforcement

<table>
<thead>
<tr>
<th>Wire Size W or D</th>
<th>Nom. Dia. (in.)</th>
<th>Weight (lb/100 ft²) of Transverse Wires Per Inch Spacing (Based on 5&quot; x 20&quot; Sheet with 1&quot; Side Overhang)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>45.0</td>
<td>0.757</td>
<td>948.66</td>
</tr>
<tr>
<td>31.0</td>
<td>0.628</td>
<td>653.52</td>
</tr>
<tr>
<td>30.0</td>
<td>0.618</td>
<td>632.44</td>
</tr>
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<td>28.0</td>
<td>0.597</td>
<td>590.28</td>
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<tr>
<td>26.0</td>
<td>0.575</td>
<td>548.12</td>
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<tr>
<td>24.0</td>
<td>0.553</td>
<td>505.95</td>
</tr>
<tr>
<td>22.0</td>
<td>0.529</td>
<td>463.79</td>
</tr>
<tr>
<td>20.0</td>
<td>0.505</td>
<td>421.63</td>
</tr>
<tr>
<td>18.0</td>
<td>0.479</td>
<td>379.46</td>
</tr>
<tr>
<td>16.0</td>
<td>0.451</td>
<td>337.30</td>
</tr>
<tr>
<td>14.0</td>
<td>0.422</td>
<td>295.14</td>
</tr>
<tr>
<td>12.0</td>
<td>0.391</td>
<td>252.98</td>
</tr>
<tr>
<td>11.0</td>
<td>0.374</td>
<td>231.89</td>
</tr>
<tr>
<td>10.0</td>
<td>0.357</td>
<td>210.81</td>
</tr>
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<td>9.0</td>
<td>0.348</td>
<td>200.27</td>
</tr>
<tr>
<td>8.0</td>
<td>0.339</td>
<td>189.73</td>
</tr>
<tr>
<td>7.5</td>
<td>0.329</td>
<td>179.19</td>
</tr>
<tr>
<td>7.0</td>
<td>0.319</td>
<td>168.65</td>
</tr>
<tr>
<td>6.5</td>
<td>0.288</td>
<td>137.03</td>
</tr>
<tr>
<td>6.0</td>
<td>0.270</td>
<td>126.49</td>
</tr>
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<td>5.5</td>
<td>0.252</td>
<td>115.95</td>
</tr>
<tr>
<td>5.0</td>
<td>0.239</td>
<td>105.41</td>
</tr>
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<td>4.5</td>
<td>0.226</td>
<td>94.87</td>
</tr>
<tr>
<td>4.0</td>
<td>0.211</td>
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<td>3.5</td>
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<td>3.0</td>
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<td>0.162</td>
<td>44.07</td>
</tr>
<tr>
<td>2.1</td>
<td>0.134</td>
<td>29.76</td>
</tr>
</tbody>
</table>

**NOTE:** This table should be used for estimating purposes only. Actual weights of WWR will vary from those shown above, depending on the width of rolls or sheets and lengths of overhang. No allowance is made in this table for the extra weight of reinforcement required for lap splices.

Figure 5. Unit of Weight of Transverse Wires for Welded Wire Reinforcement
Welded Wire Reinforcement

Table 2-3 Cross-Sectional Area and Weight of Welded Wire Reinforcement

<table>
<thead>
<tr>
<th>Wire Size W or D</th>
<th>Nom. Dia. (in.)</th>
<th>Nom. Wt (lb/ft)</th>
<th>Area (in.²/ft) Per Wire Spacing (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45.0</td>
<td>0.757</td>
<td>1.530</td>
<td>2.700  1.800  1.350  0.900  0.675  0.540  0.450</td>
</tr>
<tr>
<td>31.0</td>
<td>0.628</td>
<td>1.054</td>
<td>1.858  1.239  0.929  0.619  0.465  0.372  0.310</td>
</tr>
<tr>
<td>30.0</td>
<td>0.618</td>
<td>1.020</td>
<td>1.800  1.200  0.900  0.600  0.450  0.360  0.300</td>
</tr>
<tr>
<td>28.0</td>
<td>0.597</td>
<td>0.952</td>
<td>1.680  1.120  0.840  0.560  0.420  0.336  0.290</td>
</tr>
<tr>
<td>26.0</td>
<td>0.575</td>
<td>0.884</td>
<td>1.568  1.039  0.779  0.519  0.390  0.312  0.260</td>
</tr>
<tr>
<td>24.0</td>
<td>0.553</td>
<td>0.816</td>
<td>1.441  0.961  0.721  0.480  0.360  0.288  0.240</td>
</tr>
<tr>
<td>22.0</td>
<td>0.529</td>
<td>0.748</td>
<td>1.319  0.879  0.659  0.440  0.330  0.264  0.220</td>
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<td>20.0</td>
<td>0.505</td>
<td>0.680</td>
<td>1.202  0.801  0.601  0.401  0.300  0.240  0.200</td>
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<td>18.0</td>
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<td>0.612</td>
<td>1.081  0.721  0.541  0.380  0.270  0.216  0.180</td>
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<td>16.0</td>
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<td>0.959  0.639  0.479  0.320  0.240  0.192  0.160</td>
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<td>0.720  0.480  0.360  0.240  0.180  0.144  0.120</td>
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<td>0.374</td>
<td>0.659  0.439  0.330  0.220  0.165  0.132  0.110</td>
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<td>0.357</td>
<td>0.631  0.421  0.316  0.210  0.158  0.126  0.105</td>
</tr>
<tr>
<td>10.0</td>
<td>0.357</td>
<td>0.340</td>
<td>0.601  0.400  0.300  0.200  0.150  0.120  0.100</td>
</tr>
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<td>0.348</td>
<td>0.323</td>
<td>0.571  0.380  0.285  0.190  0.143  0.114  0.095</td>
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<td>9.0</td>
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<td>0.306</td>
<td>0.542  0.361  0.271  0.181  0.135  0.108  0.090</td>
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<tr>
<td>8.5</td>
<td>0.329</td>
<td>0.289</td>
<td>0.510  0.340  0.255  0.170  0.128  0.102  0.085</td>
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<td>0.272</td>
<td>0.480  0.320  0.240  0.160  0.120  0.096  0.080</td>
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<td>7.5</td>
<td>0.309</td>
<td>0.255</td>
<td>0.450  0.300  0.225  0.150  0.112  0.090  0.075</td>
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<td>7.0</td>
<td>0.299</td>
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<td>0.421  0.281  0.211  0.140  0.105  0.084  0.070</td>
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<td>6.5</td>
<td>0.288</td>
<td>0.221</td>
<td>0.391  0.261  0.195  0.130  0.098  0.078  0.065</td>
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<td>6.0</td>
<td>0.276</td>
<td>0.204</td>
<td>0.359  0.239  0.179  0.120  0.090  0.072  0.060</td>
</tr>
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<td>5.5</td>
<td>0.265</td>
<td>0.187</td>
<td>0.331  0.221  0.165  0.110  0.083  0.066  0.055</td>
</tr>
<tr>
<td>5.0</td>
<td>0.252</td>
<td>0.170</td>
<td>0.299  0.200  0.150  0.100  0.075  0.060  0.050</td>
</tr>
<tr>
<td>4.5</td>
<td>0.239</td>
<td>0.153</td>
<td>0.269  0.179  0.135  0.090  0.067  0.054  0.045</td>
</tr>
<tr>
<td>4.0</td>
<td>0.226</td>
<td>0.136</td>
<td>0.241  0.160  0.120  0.080  0.060  0.048  0.040</td>
</tr>
<tr>
<td>3.5</td>
<td>0.211</td>
<td>0.119</td>
<td>0.210  0.140  0.105  0.070  0.052  0.042  0.035</td>
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<td>2.9</td>
<td>0.192</td>
<td>0.099</td>
<td>0.174  0.116  0.087  0.058  0.043  0.035  0.029</td>
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<td>2.1</td>
<td>0.162</td>
<td>0.071</td>
<td>0.124  0.082  0.062  0.041  0.031  0.025  0.021</td>
</tr>
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<td>1.4</td>
<td>0.134</td>
<td>0.048</td>
<td>0.085  0.056  0.042  0.028  0.021  0.017  0.014</td>
</tr>
</tbody>
</table>

NOTES:
1. The above listing of plain and deformed wire sizes represents wires normally selected to manufacture welded wire reinforcement to specific areas of reinforcement. Other wire sizes not shown above are available upon request.
2. The nominal diameter of a deformed wire is equivalent to the diameter of a plain wire having the same weight per foot as the deformed wire.
3. The ACI 318 Code requirements for tension development lengths and tension lap splice lengths of welded wire reinforcement are not included in this chapter. These design requirements are covered in "Reinforcing Bar Anchorage and Splices" available from CRSI. For additional information, see "Manual of Standard Practice - Structural Welded Wire Reinforcement" and "Structural Detailing Manual", both published by the Wire Reinforcement Institute.

Figure 6. Cross-Sectional Area and Weight of Welded Wire Reinforcement
Spacing Guidelines for Reinforcing Steel Bars

Use the table in Figure 1 for preferred minimum spacing of reinforcing bars, including spacing of bundled bars with various configurations. Note that the vertical configuration of bundled bars allows for reduced spacing, which may prove useful to reduce congestion in bridge bent caps with bundled bars to reduce congestion.

Figure 1. Excerpt from Section 13 – Reinforcement, of Caltrans Bridge Design Details, November 1992 (no longer published)
Reinforcement – Epoxy-Coated Reinforcement and Epoxy-Coated Prefabricated Reinforcement

Revision and Approval

<table>
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<th>Revision</th>
<th>Date</th>
<th>Nature of Changes</th>
<th>Approved By</th>
</tr>
</thead>
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<td>0</td>
<td>12-22-2022</td>
<td>Original Issue</td>
<td>Richard Foley</td>
</tr>
</tbody>
</table>

Click here to request previous versions   Contact SC Technical Team F for questions

Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, materials, and construction of epoxy-coated reinforcement and epoxy-coated prefabricated reinforcement.

Review and authorization of epoxy-coated reinforcement submittals under this process are typically performed in conjunction with Materials Engineering and Testing Services (METS) and coordinated with the METS Representative.

Additional unique contract requirements that supplement this process are detailed in Contract Specifications (CS), Section 52-1, Reinforcement – General, and additional guidance is contained in BCM 52-1, Reinforcement – General.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the CS, Section 52-2, Reinforcement – Epoxy-Coated Reinforcement and Epoxy-Coated Prefabricated Reinforcement, that this BCM is based on as identified in the title block above. The information in the CS typically will not be repeated in the text of this BCM.
Process Inputs

1. Contract work requiring the use of epoxy-coated reinforcement or epoxy-coated prefabricated reinforcement

2. Submittals required by the CS including:
   a. Test samples for:
      i. Epoxy powder
      ii. Patching material for epoxy coating repair
      iii. Epoxy-coated reinforcement
      iv. Epoxy-coated prefabricated reinforcement
   b. Certificate of compliance for:
      i. Each shipment of epoxy-coated or epoxy-coated prefabricated reinforcement
      ii. Each shipment of patching material

3. Form CEM-3101, Notice of Materials to be Used

Procedure

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:
   a. Benchmark for review and authorization of epoxy-coated and prefabricated epoxy-coated reinforcement delivered to the jobsite.
   b. Intermittent for storage, handling, and installation of epoxy-coated and prefabricated epoxy-coated reinforcement.

3. Before construction begins, the Structure Representative (SR) or delegate must:
   a. Review the contract documents to:
      i. Identify the locations where epoxy-coated reinforcement is required.
   b. Review various American Society for Testing and Materials (ASTM) specifications, including D3963, A884, and A934, referenced in the CS. These specifications can be accessed using Accessing ASTM/AASHTO Instructions link in the Field Resources tab on the SC Intranet, and provide specific requirements on handling and job site practices for epoxy-coated reinforcement.
   c. Review unique storage and handling requirements of epoxy-coated reinforcement as outlined in the CS, and in the Construction Manual (CM), Section 4-5203, During the Course of Work.
i. Note that the CS requires compliance with various ASTM specifications referenced in Step 3.b., which include topics such as:

1. Storage requirements including storing above ground on cribbing
2. Time limits and protective storage measures if stored for more than two months
3. Tolerance for damaged coating and rejection criteria
4. Prohibition of flame cutting reinforcement
5. Use of coated tying wire
6. Use of nonmetallic, resilient vibrator heads.

d. Review Form CEM-3101, Notice of Materials to be Used.

e. Review the following topics with the Contractor at the preconstruction conference and/or before the start of any work requiring epoxy-coated reinforcement:

i. Locations where epoxy-coated reinforcement is required.

ii. Materials and corrosion protective coverings that must be on the METS Authorized Materials List.

iii. Unique storage and handling requirements of epoxy-coated reinforcement as outlined in the CS and in the Construction Manual (CM), Section 4 - 5203, During the Course of Work.

iv. Method and material for patching to be used for repairing epoxy coating on reinforcement, and suitability for field applications. Obtain manufacturer’s data of patching material for review.

v. General material sampling and testing requirements. (Note that the METS Representative should be consulted to confirm whether the Contractor’s vendor/supplier of epoxy-coated reinforcement is in the Authorization to Deliver program (AD), which will determine the need for field sampling and testing). Requirements to submit the following test samples to METS and obtain authorization for use prior to reinforcement fabrication:

1. Epoxy powder
2. Patching material
3. Epoxy-coated reinforcement and epoxy-coated prefabricated reinforcement

vi. Requirement to transport test samples to METS laboratory.

f. If the epoxy-coated vendor is not in the AD, coordinate with the METS Representative to verify that all required test samples were received and tested. Verify results meet CS requirements by either:
i. Accessing results through Data Interchange for Materials Engineering (DIME)

ii. Contacting the METS Representative.

4. During construction, the SR or delegate must:

a. Verify material inspection, testing and release depending on the AD status as follows:

i. If the Contractor’s vendor is in the AD as described in step 3.e.v., collect certificates of compliance and/or METS Form TL-0624, Inspection Release Tag (orange tag) for each shipment of epoxy-coated or prefabricated epoxy-coated reinforcement, and any patching material, when they arrive to the job site. File the above documents in job records.

ii. If the Contractor’s vendor is not in the AD, verify that the Contractor prepares test samples for each shipment of epoxy-coated and prefabricated epoxy-coated reinforcement. Coordinate and confirm with the METS Representative to determine what sampling and testing is required.

1. Verify that the Contractor arranges for transport of test samples to METS for testing per the contract requirements, which are detailed in ASTM D3963. Special handling of epoxy coated reinforcement per ASTM D3963 is required to ensure the epoxy coating is not damaged.

2. Send samples with completed Form TL-0101, Sample Identification Card as specified in the CM, Section 6-103, Field Sampled Material Identification for Testing.

3. Obtain test results from METS Representative or DIME, and notify the Contractor in writing.


b. Verify job site storage of epoxy-coated reinforcement conforms to the requirements of the CS, the CM, Section 4-5203, During the Course of Work, and the applicable ASTM specifications as mentioned in step 3.b. and 3.c.

c. Verify handling and installation of epoxy-coated and prefabricated epoxy-coated reinforcement is in accordance with the requirements of the contract documents; for example:

i. Plastic coated wire ties are typically specified for epoxy coated reinforcements. Check the Special Provisions, and/or Procedure step 3.c.i.

ii. Epoxy-coated reinforcement is coated with a light green coating and can be field-bent.
iii. Epoxy-coated prefabricated reinforcement is coated with a gray or purple coating and is not permitted to be field-bent.

d. Verify authorized patching material is used for field repair of epoxy coating and conforms to manufacturer’s instructions.

e. Verify that all mechanical butt splices and butt welds on epoxy-coated reinforcing steel are protected from corrosion, with a corrosion protection system that is on the METS Authorized Material List for corrosion protection coverings.

f. Verify that the corrosion protective system is used in accordance with manufacturer and Caltrans requirements. Ensure the cover is installed as a continuous piece with sufficient diameter and length to achieve an adequate seal and bond length. The cover must be free of dirt, grease, sharp edges, tears, or pinholes. After the cover is heated as specified, verify that it extends a minimum of 2 inches onto the epoxy-coated reinforcing steel.

g. Verify vibrators used to consolidate concrete containing epoxy-coated reinforcing steel have a resilient covering to prevent damage to the epoxy coating. Refer to CS, 51-1.03D(1), Concrete Structures – General – Construction – Placing Concrete – General.

i. Note that this is also required by the applicable ASTM as mentioned in step 3.b. and 3.c.

h. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the daily reports per BCM C-7, Daily and Weekly Reports.

5. Following construction, the SR or delegate must:

a. File all project documentation (correspondence, materials acceptance documentation, daily reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized epoxy-coated and epoxy-coated prefabricated reinforcement submittals and test results

2. Daily reports

**Attachments**

None
Reinforcement – Splicing

Revision and Approval

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Nature of Changes</th>
<th>Approved By</th>
</tr>
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<td>0</td>
<td>01-21-2022</td>
<td>Original Issue</td>
<td>Richard Foley</td>
</tr>
</tbody>
</table>

Click here for previous versions Contact SC Technical Team F for questions

Background

This process establishes Structure Construction (SC) responsibilities for submittals, quality assurance, materials, and construction of bar reinforcement splices, including lap splices, service splices and ultimate butt splices.

Review and authorization of splice qualifications and testing under this process is performed in conjunction with Materials Engineering and Testing Services (METS) and coordinated with the METS Representative (MR).

- BCM 11-1, Welding – General
- BCM 11-2, Welding – Welding Quality Control
- BCM 52-1, Reinforcement – General

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 52-6, Reinforcement - Splicing, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Contract work that requires splicing bar reinforcement
2. Submittals required by the Contract Specifications for splicing bar reinforcement
Procedure

1. All work associated with this process is charged as Project Direct Construction.

2. Inspection of field work for this process is:
   a. Intermittent for splice incorporation into the work except mechanical splice.
   b. Continuous for mechanical splice installation and splice sampling for Quality Assurance/Quality Control (QA/QC) testing.

3. Before construction begins:
   a. Review Contract Documents for:
      i. Specifications requirements for any bar reinforcement splices and sampling and testing.
      ii. Contract plans for restriction of splice locations.
   c. Review Attachment 1, Reinforcement Splices.
   d. Review California Test 670, Method of Tests for Mechanical and Welded Reinforcing Steel Splices.
   e. Contact the METS Representative (MR) to:
      i. Inform the MR that the project has service or ultimate splices.
      ii. Discuss splice sampling and testing procedures and responsibilities with the MR.
   f. Discuss with the contractor, Quality Control Manager (QCM), rebar subcontractor, the representative for the authorized laboratory, and the MR about:
      i. The ultimate and service butt splice specification.
      ii. The sampling procedures and acceptance criteria.
   g. Review and authorize contractor submittals by checking the following items:
      i. Verify the contractor has assigned a QCM.
      ii. Verify the independent testing laboratory chosen by the contractor for splice testing is on the Authorized Laboratory List:
         1. If information is not available to verify this, contact the MR for assistance.
      iii. Verify the manufacturer for Ultimate Hoops is on the Authorized List for Resistance Welding Fabricators.
iv. Verify that the mechanical splice system chosen by the contractor for use is on the Authorized List of Couplers for Reinforcing Steel.

v. Verify that the prequalification of operators and procedures for mechanical splices meet the requirements of the contract documents.

vi. Verify that the Splice Prequalification Report submitted by the contractor conforms to the requirements of the Contract Documents.

vii. Verify the welder and Welding Procedures Qualifications submitted by the contractor conforms to the requirements of the Contract Documents. Refer to BCM 11-1, Welding – General and BCM 11-2, Welding – Quality Control for information on welding requirements.

viii. Verify that Weld Flash Removal Process complies with the contract documents.

4. During construction:
   a. Collect all material certifications and verify they meet the requirements of the contract documents.
   b. For lap splices:
      i. Calculate the minimum required lap splice using field verified dimension and grade of the reinforcing bar.
      ii. Measure the lap splice length in the field and verify that the minimum required lap splice length has been met.
      iii. Verify lap splicing is staggered in accordance with the Contract Documents. For bridge deck construction transverse bars see the Outline of Field Construction Practices, Section 29, Deck Rebar.
      iv. Verify clearance to adjacent bars and lap splice requirements of bundled bars, which can be challenging for congested and/or large diameter reinforcing steel. Note the limitation in the Contract Specifications, Section 52-6.03B, Reinforcement – Splicing – Construction – Lap Splicing, for reinforcing bar diameter and lap splices.
   c. For service splices and ultimate butt splices:
      i. Review Attachment 1, Reinforcement Splices.
      ii. Verify location of splices meets the requirements of the contract documents; for example, identify no-splice zones.
      iii. Verify that the operators are prequalified per the authorized submittals and that their certifications are current.
      iv. Verify that the equipment and procedures used conform to the manufacturer’s recommendations and contract documents, for example:
1. For mechanical splices requiring a torque wrench, verify the calibration date and torque setting of the wrench.

v. Perform visual inspection of the production of splices.

vi. Select the appropriate number of splices to be sampled from the production lots for Quality Control and Quality Assurance Testing.

vii. Prepare splicing samples in accordance with Attachment 1, including a completed Form TL-0101, Sample Identification Card, for QA test samples.

viii. Review the Splicing Quality Control Test Reports submittal and the QA testing reports from METS and authorize or reject splices in accordance with contract documents.

ix. Work with the contractor for resampling and retesting for as required, in the event of failed tests.

x. Verify splices are staggered per the requirements of the contract documents.

d. Verify concrete cover at splices meets the requirement of contract documents.

e. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Following construction:

a. Document the reinforcing splices on the as-built plans per BCM C-6, Required Documents to be Submitted During Construction.

6. File all materials testing documentation/results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual, 5-102, Organization of Project Documents. A list of items to be recorded in the job files include:

a. The contractor's submitted plan designating the splicing QCM and testing laboratory.

b. Laboratory Qualification (record of verification by the Structure Representative).


d. Test reports submitted by the splicing QCM.

e. Summary record of production test (Attachment 1).

f. Test results of sample splices sent to METS.

g. Records indicating the resolution of any failed QA test results.
h. Certification of compliance.

**Process Outputs**

1. Authorized submittals
2. Daily Reports
3. Documented location of splices on as-built plans. Test results and reports

**Attachments**

[Attachment 1, *Reinforcement Splices*]
Reinforcement Splices

This attachment provides general contract administration guidance for service splice and ultimate butt splice of reinforcement in accordance with the 2018 Contract Specifications, 52-6, Reinforcement – Splicing. Sections included are:

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Glossary of Terms

**Affected Zone** – Portion of the reinforcing bar where any properties of the bar, including the physical, metallurgical, or materials characteristics, have been changed by fabrication or installation of a splice. The weld and one (1) inch adjacent to the weld is part of the affected zone.

**Authorized Laboratory** – Independent testing laboratory not employed or compensated by any subcontractor or subcontractor's affiliate providing other services for the contract and authorized by the Department to perform the required testing of the sample splices.
**Authorized Material List** – A list of products prequalified for use on California Department of Transportation projects. Mechanical couplers for both service and ultimate splice systems on this list are authorized for use.

**Complete Joint Penetration** (CJP) – groove weld is a groove weld that extends completely through the thickness of components joined. The primary purpose for the use of the CJP groove welds is to transmit the full load-carrying capacity of the structural components they join.

**Lot of Splices** – One hundred and fifty (150) or fraction thereof, of the same coupler model for each bar size, deformation pattern and hoop diameter.

**Operator and Procedure Prequalification** – A requirement of the splice prequalification report. Splice operators and procedures must be certified. Splice test samples must be prepared and tested no more than two (2) years before the submittal.

**Production Service Splice Test Samples** – Four splices prepared in the same manner (i.e., equipment, procedures, position, and operator) as the splices incorporated into the final work. Four samples are selected for every lot of splices and are tested by the authorized laboratory.

**Production Ultimate Butt Splice Test Samples** – Four splices removed from each lot of completed splices. After being notified, the engineer randomly selects the four (4) splice test samples to be removed by the contractor from the completed lot and places tamper-proof markings or seals on them. Except for hoops, the engineer selects splice test samples at the job site. Splice test samples must comply with **California Test 670, Method of Tests for Mechanical and Welded Reinforcing Steel Splices.**

**Quality Assurance (QA) Splice Samples** – Four additional splice test samples prepared or removed for QA testing at the Caltrans Materials Engineering and Testing Services (METS) Laboratory. The samples are prepared or removed concurrently with the first production lot and at one other randomly selected for every five (5) additional production lots (or portion of) thereafter.

**Resistance-Butt-Weld** – A type of butt-welding commonly used to produce column hoop reinforcement. A machine holds both ends of the hoop together and passes a large electrical current through the bar which creates enough heat to fuse the two ends together completing the process.

This type of welding is not covered by the American Welding Society (AWS) code and therefore does not require any of the Non-Destructive Testing (NDT) or Certified
Welding Inspector (CWI) requirements. The current *Contract Specifications* requires that the fabricator must be on the Authorized Material List.

**Service Splice** – A mechanical or welded butt splice that meets the current requirements of the *Contract Specifications (CS)*\(^1\) (i.e., tensile strength of 80 ksi and slip).

**Splice Prequalification Report** – A report that documents the contractor’s proposed splicing system.

**Splicing Quality Control Manager (QCM)** – Contractor designated person who is responsible for both field and administrative work regarding the quality of all service splices or ultimate butt splices.

**Ultimate Butt Splice** – A mechanical or welded butt splice that meets current requirements of CS\(^2\) (i.e., slip test and rupture in the reinforcing bar outside of the affected zone and show visible necking as specified in California Test 670, Necking, Option I or Rupture anywhere and neck as specified in California Test 670, Necking, Option II).

## What to do Prior to the Start of Any Splice Work

### Preconstruction Meeting

Although not required by the contract, if needed, recommend holding a preconstruction meeting with the contractor to discuss the service splices and ultimate butt splices requirements. The sampling and acceptance criteria are different for these types of splices. It is important that all parties involved understand the specification requirements.

At the meeting, the contractor should have present their splicing QCM, rebar subcontractor, and the representative for the Authorized Laboratory. If possible, a representative from METS should attend the preconstruction meeting. A suggested partial list of items to discuss at the preconstruction meeting is:

---


• Splicing QCM’s responsibility to inspect the lots of splices for conformance with the specifications and manufacturer’s recommendations prior to sampling.

• Splice Prequalification Reports, production, and quality assurance (QA) sampling and testing requirements.

• How samples of ultimate butt splices will be selected from a completed lot of splices that have been assembled for the final time.

• The contractor’s method of designating and making the lots available for sampling.

• The engineer’s method of random sample selection.

• Labeling and shipping of the samples.

• Result reporting, time allowed, and engineer approval.

Splice System Prequalification

The Contract Specifications require that both service and ultimate splice systems be prequalified, for every job, prior to use. The contractor must select a splice system from the Caltrans Authorized List of Couplers for Reinforcing Steel. If the proposed system is not on the prequalification list, contact METS at (916-227-7253) to verify the latest approved splice systems.

Splice Prequalification Report

For each splice type to be used in the work, the contractor must submit a Splice Prequalification Report for service splices and ultimate butt splices that includes:

• Copy of the coupler manufacturer’s product literature giving complete data on the splice material and installation procedures.

• Names of the operators who will be performing the splicing.

• Descriptions of the positions, locations, equipment, and procedures that will be used in the work.

• Certifications from the fabricator for operator and procedure prequalification including the certified test results from the authorized laboratory for the prequalification splice test samples. For each bar size of each splice type to be used, each operator must prepare two (2) prequalification splice test samples and two (2) additional prequalification splice test samples if using splices dependent on bar deformations.

• Splice test samples must have been prepared and tested no more than two (2) years before the submittal of the splice prequalification report. Splice test samples and testing must comply with the production testing requirements.
What To Do During Splice Production Work

Sampling of Production Splices

The sampling procedures and testing criteria are different for ultimate butt and service splices. Ultimate butt splices are far more critical to the structure’s seismic performance. Hence, the sampling and testing requirements are more stringent compared to service splices.

Ultimate Splice Sampling Procedures

The contractor’s splicing QCM will notify the engineer when a designated lot of splices is complete and has been inspected. Four samples of production splices from each lot will be selected by the engineer for testing.

Production sample splices are required to be randomly selected from a completed lot. Selecting from a completed lot means that samples will be removed after final splicing has been made. Splices that are unassembled for transportation or other reasons are not considered completed and would require resampling when assembled for the final time.

The intent of the ultimate butt splice specification is to sample splices as close as possible to the in place completed work, which may or may not entail removing splices from bars after they have been tied in their final location. For example, if the main longitudinal reinforcement of a column was spliced together and assembled on the ground prior to full height erection, the straight bar sample production splices could be selected prior to cage assembly. If splices are made vertically at the job site in or above their final positions for bar reinforcement of columns or cast-in-place (CIP) concrete piles, instead of removing the splice test samples from the completed lot, it is acceptable to prepare the samples as specified for service splice test samples provided testing as specified for ultimate butt splices is performed.

Similarly, in most cases, the selection of production samples for welded hoops can be done prior to cage assembly.

All production sample splices removed from the work must be repaired or replaced. The Department does not require ultimate butt splice testing on repaired splices from a lot unless an additional ultimate butt splice test is required on the same lot of splices. If this additional test is required, the engineer may select any repaired splice for the additional test.

The sample length must comply with California Test 670.
Service Splice Sampling Procedures

The Contract Specifications require the contractor to prepare four splice test samples from each lot of completed splices. The service splice samples must be prepared in the same conditions as the production service splices. The same operator, equipment, position, and procedures must be used when preparing service splice samples. The sample length must comply with California Test 670.

Quality Assurance Testing

Quality assurance (QA) testing is a requirement of the ultimate butt and service splice specifications. Quality assurance tests are always performed concurrently with the first production test. After the first QA test, at least one out of every five additional production tests (or portion of) thereafter will be accompanied by an additional QA test. A random selection method must be used to designate both QA lots and QA sample splices. Below is a table that illustrates the number of QA tests required for a given amount of splice lots.

<table>
<thead>
<tr>
<th>Number. of Lots</th>
<th>Number of Accumulative QA Tests Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2-6</td>
<td>2</td>
</tr>
<tr>
<td>7-11</td>
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</tr>
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<td>12-16</td>
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<td>17-21</td>
<td>5</td>
</tr>
<tr>
<td>22-26</td>
<td>6</td>
</tr>
</tbody>
</table>

To obtain samples for the QA test, four (4) sample splices will be made concurrently with the production test samples. These sample splices do not have to be removed from a completed lot of splices.

The contractor may encase splices in concrete before receiving notification of the QA test results from the engineer. However, the contractor will not be relieved of the responsibility for incorporating material into the work that complies with the contract.

Tamper Proof Markings and Sample Shipping

To ensure that the sample splices are not tampered with, all samples (i.e., pre-job, production, and quality assurance) must have a tamper proof marking applied to them. Field personnel should apply the marking. Examples of tamper proof markings are:

- Rubberized paint. This will show any re-gripping or disassembly of the splices. See Figure No. 1.
- A digital photo of the splice sent to the lab for comparison.
• Alternative marking systems can be considered with METS concurrence.

All samples must be identified pre-job, production, or job QA and be accompanied with Form **TL-0101, Sample Identification Card**. See Figure No. 2. Both pre-job and quality assurance ultimate butt splice test samples need to be shipped to METS at 5900 Folsom Boulevard, Sacramento 95819, (916) 227-7251. The Structure Representative should discuss the method of shipment with METS.

![Production Sample Splices with rubberized paint used as a tamper proof marking system. Associated control bars are no longer required by the Contract Specifications.](image)

**Figure 1.** Production Sample Splices with rubberized paint used as a tamper proof marking system. Associated control bars are no longer required by the *Contract Specifications*. 
When completing Form **TL-0101**, ensure that all items are completed. If incomplete, it could delay METS ability to issue test results. Specific items to consider are:

- Contact information for the person that did the sampling is needed to answer potential questions.
- Email or Fax number is used for METS to send the test results to expedite obtaining results.
- Include with the couplers:
  - A copy of the Material Test Report (MTR) for the heat number of the bar reinforcing steel
  - The MTR for the lot number of couplers represented by the samples. METS cannot issue test results without this information.
  - A copy of the certificate of compliance for the bar reinforcing steel represented by the samples.
METS cannot issue test results without this information.

Also, the sample record can be created through METS Data Interchange for Materials Engineering (DIME) system. Dime is the web application to communicate the sample information and test data between external labs and Caltrans. User can track and view all test data of the project. For more information, contact the METS Representative.

**Splice Acceptance Requirements**

**Slip Test Requirement**

Except for mechanical lap, welded, or hoop splices, test one (1) of the four (4) splice test samples for total slip. If the slip test result complies with the total slip value requirement specified in the *Contract Specifications*, proceed to perform the tensile and/or rupture tests.

If the splice test sample exceeds the total slip value specified in the *Contract Specifications*, test the three (3) remaining test samples for total slip. If any of the three (3) remaining test samples exceed the specified total slip value, the Department rejects all splices in the lot.

**Other Requirements for Service Splice**

Service splices must develop a minimum tensile strength of 80,000 psi.

Acceptance:

- If only one (1) splice test sample complies with the requirements, the Department rejects all splices in the lot.
- If only two (2) splice test samples comply with the requirements, perform one (1) additional service splice test consisting of four new splice test samples on the same lot of splices. This additional test must consist of tensile testing four (4) splice test samples, randomly selected by the engineer and removed from the lot of completed splices. If any of the four (4) splice test samples from this additional test do not attain the specified minimum tensile strength, the Department rejects all splices in the lot.
- If three (3) or more splice test samples comply with the requirements, the Department accepts all splices in the lot.

---

Other Requirements for Ultimate Butt Splice

Ultimate butt splices must meet one of the following requirements:

1. Rupture in the reinforcing bar outside of the affected zone and show visible necking as specified in California Test 670, *Method of Tests for Mechanical and Welded Reinforcing Steel Splices, Necking* (Option I).

2. Rupture anywhere and neck as specified in California Test 670, Necking (Option II).

Acceptance:

- If only one (1) splice test sample complies with the requirements, the Department rejects all splices in the lot.
- If only two (2) of the four splice test samples comply with the requirements, perform one (1) additional ultimate butt splice test consisting of four new splice test samples on the same lot of splices. If any of these four (4) new splice test samples do not comply with the specified requirements, the Department rejects all splices in the lot.
- If three (3) or more splice test samples comply with the requirements, the Department accepts all splices in the lot.

Figure No. 3 depicts terms used in California Test 670.

![Diagram of Ultimate Butt Splice](image)

**Figure 3.** Passing Tensile Tested Ultimate Coupler. Note the bar rupture outside the affected zone and the visible signs of necking.
Mechanical Splice Acceptance Procedure Flow Chart

Figure No. 4 is a flow chart summarizing the Mechanical Splice Acceptance Procedure.

Figure 4. Mechanical Splice Acceptance Procedure Flow Chart.
Review Time

The Contract Specifications include a review time for production and quality assurance tests. To avoid costly delays, it is important to respond to the contractor in writing within the time required in the Contract Specifications as shown in the table below.

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Review Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Sample Tests</td>
<td>Three business days to review each production test report submitted by the QCM.</td>
</tr>
<tr>
<td>Quality Assurance</td>
<td>Three business days upon receipt of the samples by METS.</td>
</tr>
<tr>
<td></td>
<td>Two extra business days per each simultaneous submittal.</td>
</tr>
</tbody>
</table>

What To Do After Completion of Splice Production Work

Review Reports

The contractor provides the following submittals to the engineer for review:

- Splice Quality Control Test Report
- Splice Rejection Mitigation Report
- Radiographic Film Developing Process Records (when welding is involved)

After completion and acceptance of the bar splices, ensure that the locations of the splices are noted in the as-built plans per BCM C-6, Required Documents to be Submitted During Construction, and that all the submittals and test reports are filed in the project records.

Testing Requirement Clarifications for Welded Butt Splices

To follow is information to clarify test requirements for welded butt splices:

1. For Resistance-Butt-Welded Splices (welded hoops):
   - Slip test is not required.
   - Destructive testing is required.
• Radiographic testing is not required.

2. For Complete Joint Penetration (CJP) butt-welded splices (except welded hoops):
   • Slip test is not required.
   • Destructive testing is required for both service and ultimate butt splices.
   • Radiographic testing is not required whenever butt-welded splices are removed from a lot of completed splices (i.e., whenever they require replacement).
   • Radiographic testing is required whenever samples are prepared as described in the *Contract Specifications* (i.e., whenever they do not require replacement due to removal from a completed lot).

3. Refer to California Test 670 regarding tensile test (destructive testing) requirements.

**Items to Be Recorded In the Job Files**

During the progress of the work all splice documentation must be filed in Category 37 under the appropriate sub-category headings. Figure No. 5 is an example of summary record of production tests.
<table>
<thead>
<tr>
<th>Type</th>
<th>Size</th>
<th>Date</th>
<th>Description</th>
<th>Location</th>
<th>Number used</th>
<th>Lot No.</th>
<th>QA Test</th>
<th>QC Test</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRC</td>
<td>500/510</td>
<td>10/1/2008</td>
<td>Sleeve forged ends (i.e. threaded sleeves and headed ends)</td>
<td>Bent 19</td>
<td>Column HOV</td>
<td>14</td>
<td>14</td>
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<td>Bent 16</td>
<td>Column HOV</td>
<td>18</td>
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<td>HRC</td>
<td>500/510</td>
<td>10/1/2008</td>
<td>Sleeve forged ends (i.e. threaded sleeves and headed ends)</td>
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<td>92</td>
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<td></td>
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<td>HRC</td>
<td>420/410</td>
<td>1/7/2009</td>
<td>Sleeve tapered three</td>
<td>Bent 17 CIDH</td>
<td>HOV</td>
<td>108</td>
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<td>Bar Grip</td>
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Figure 5. Summary of Record Production Tests.
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Shotcrete – General

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Background

This process establishes Structure Construction (S.C.) responsibilities and procedures for authorization of submittals, quality assurance, materials, construction, and payment for shotcrete.

This process applies generally to all applications of shotcrete. Specific requirements for structural and sculpted shotcrete are included in B.C.M. 53-2, Structural Shotcrete, and B.C.M. 53-3, Sculpted Shotcrete.

Prior to reviewing this B.C.M., it is essential to review Contract Specifications, Section 53-1, Shotcrete – General, applicable to your specific contract, that this B.C.M. is based on, as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this B.C.M.

Process Inputs

1. Form CEM-3101, Notice of Materials to be Used.
2. Concrete Mix Design and other submittals.
3. Structure Resident Engineer (R.E.) Pending File (verification of quantities for payment)

Procedure

1. All work associated with this process is charged as Project-Direct – Construction.
2. Inspection of field work for this process is:
   a. Benchmark inspection earthwork
   b. Intermittent inspection of rebar placement and form construction
   c. Continuous inspection for shotcrete application

3. References:

4. Before construction begins:
   a. Review process criteria:
      i. Contract Documents.
      ii. Structure RE Pending File for verification of quantities.
   b. Review and authorize or reject submittals. Notify the Contractor in writing.
      i. Review the Stormwater Pollution Prevention Plan/Water Pollution Control Plan for compliance with shotcrete work.
   c. Review guidelines on sampling, testing, and release of material:
      i. Construction Manual, Chapter 6-2, Sampling and Testing.
      ii. B.C.M. 6-2.03, Control of Materials – Quality Assurance – Department Acceptance.
   d. Verify all structural materials are included in Form CEM-3101, Notice of Materials to be Used.
   e. For colored shotcrete, coordinate with designer and architect for color approval.
      i. If colored shotcrete, propose test panel to verify color.

5. During construction:
   a. Follow steps of Construction Manual, Section 4-5303, Construction Details – Shotcrete – During the Course of Work:
      i. Submit survey request if needed.
   b. Confirm that all field personnel have copies of authorized submittals.
   c. Perform additional required sampling and testing per B.C.M. 53-2, Shotcrete – Structural Shotcrete and 53-3, Shotcrete – Sculpted Shotcrete.
   d. Monitor vertical surfaces and verify no slough-off occurs especially during the wet-mix process. Notify the S.R. if sloughing occurs.
e. Verify field measurements for payment. See B.C.M. 9-1.16, Payment – Progress Payments, for additional information.

f. Record as-built changes on designated as-built plans per B.C.M. C-5.04, Project Completion Records – As-Built Plans.

g. Document all inspection, construction, and quality assurance activities in the Daily Reports per B.C.M. C-4.04, Daily and Weekly Reports.

h. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual 5-102, Organization of Project Documents.

6. Following Construction:
   a. Submit Final Completion Records to S.C. headquarters:
      i. Report of Completion per B.C.M. C-5.06, Project Completion Records – Report of Completion
      ii. As-Builts per B.C.M. C-5.04, Project Completion Records – As-Built Plans

**Process Outputs**

1. Authorized materials and submittals (as required):
2. Concrete testing results
3. Daily Reports
4. As-Builts

**Attachments**
Structural Shotcrete

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Background

This process establishes Structure Construction (S.C.) responsibilities and procedures for authorization of submittals, quality assurance, materials, construction, and payment for structural shotcrete.

This process applies specifically to the application of structural shotcrete. General requirements for shotcrete are included in Bridge Construction Memo (B.C.M.) 53-1, Shotcrete - General.

Prior to reviewing this B.C.M., it is essential to review the Contract Specifications, Section 53-2, Shotcrete – Structural Shotcrete, applicable to your specific project, that this B.C.M. is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this B.C.M.

Process Inputs

Contractor submittals for structural shotcrete.

Procedure

1. All work associated with this process is charged as Project-Direct – Construction.
2. Inspection of field work for this process is:
   a. Intermittent inspection of earth work and form construction.
   b. Continuous inspection for structural shotcrete application, and coring test samples.
3. Review B.C.M. 53-1, Shotcrete – General, for general shotcrete process tasks for all construction phases.


5. Before construction begins:
   a. Review and authorize submittals:
      i. Notify the Contractor in writing.
      ii. Contractor's quality control plan.
      iii. Concrete mix designs.
      iv. Preconstruction test panel and test core results.
   b. Verify that the test panel is constructed in accordance with the contract and authorized submittals.

6. During construction:
   a. Verify production shotcrete operations comply with the contract and authorized submittals.
   b. Determine locations for required sampling and testing.
   c. Accept or reject shotcrete placement per the requirements of the contract documents based on:
      i. Visual inspection of production test cores.
      ii. Production core compressive strength test results:
         1. Accept or reject work accordingly (e.g., 95% minimum, below 95%, below 85%).
   d. Document all inspection, construction, and quality assurance activities in the Daily Reports per B.C.M. C-4.04, Daily and Weekly Reports.

7. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized Structural Shotcrete submittals
2. Production test core compressive strength results
3. Completed structural shotcrete elements
Attachments

None
Shotcrete – Sculpted Shotcrete

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Click here to request previous versions  
Contact SC Technical Team F for questions

Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, materials, construction, and payment for sculpted shotcrete.

Additional unique requirements that supplement this process are detailed in:

- Section 52, Reinforcement
- BCM 53-1, Shotcrete – General
- BCM 53-2, Shotcrete – Structural Shotcrete

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 53-3, Shotcrete – Sculpted Shotcrete, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Form CEM-3101, Notice of Materials to be Used
2. Contractor’s Quality Control (QC) Plan
3. Sculpted shotcrete mix design (must be compliant with Contract Specifications, Section 53-2.02, Shotcrete – Structural Shotcrete – Materials)
4. Strata lines layout
5. Test Panels.
Procedure

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:
   a. Benchmark for:
      i. Completed form inspection including grades, prior to sculpted shotcrete application.
      ii. Completed strata line inspection and authorization.
   b. Intermittent for inspection of forms, rebar, and strata lines.
   c. Continuous for inspection of sculpted shotcrete delivery and application.

3. Before construction begins the Structure Representative (SR) or delegate must:
   a. Review the Construction Manual, Chapter 4, Construction Details, Section 53, Shotcrete.
   b. Verify information is correct on Form CEM-3101, Notice of Materials to be Used, and includes cement and aggregate.
   c. Review American Association of State Highway and Transportation Officials (AASHTO) publication, Inspector’s Guide for Shotcrete Repair of Bridges, for guidance and information such as shotcrete basics, corrosion protection considerations, construction monitoring, etc.
   d. Review guidance found in Shotcrete – A Field Guide for SC Employees, available on the SC Technical Team F page under the Resources section.
   e. Review and authorize or reject for resubmittal in writing the following required submittals per the contract requirements:
      i. Contractor’s QC plan
      ii. Preconstruction test panels
      iii. Production test scores and test results
      iv. Sculpted shotcrete mix design:
   v. Sculpted shotcrete test panel:
      1. Verify it is safely accessible for inspection and coordinate a visit with the Landscape Architect.
4. During construction the Structure Representative (SR) or delegate must:

   a. Perform the following field inspection tasks:

      i. Verify line and grade of forms.

      ii. Verify that the strata lines match authorized strata line layout before placing reinforcing steel. Remember to invite the Landscape Architect as this will allow them an opportunity to provide input, and will minimize rework.

      iii. Verify all placement of reinforcement bars before placing shotcrete.

      iv. Discuss safe inspection access with the Contractor. Fall protection must be used when riding in a manlift (with a certified operator) to perform inspection.

      v. Understand Cal/OSHA safety requirements such as fall protection, reinforcement impalement protection, and abrasive blast protection; the latter is found in CCR Title 8, §5151, *Ventilation and Personal Protective Equipment Requirements for Abrasive Blasting Operations*.

   b. Perform the following shotcrete application inspection activities:

      i. Verify delivery of the authorized shotcrete mix.

      ii. Verify that the lead sculptor and nozzlemen listed on the authorized plan are being used to perform the work.

      iii. Verify bottom-up application of shotcrete by the wet-mix process unless otherwise authorized.

               1. Verify that the various elements of the shotcrete operation are in conformance with the authorized submittals.

      iv. Do not allow the Contractor to use rebound in sculpted shotcrete.

      v. After the first day of shotcrete application, verify that the surface matches the authorized test panel and continue to monitor for consistency.

   c. Perform sampling and testing of shotcrete materials.

   d. Perform final sculpted shotcrete surface finish inspection prior to curing application.

   e. Verify that sculpted shotcrete is cured as specified in the *Contract Specifications*, Section 51-1.03H, *Concrete Structures – General – Construction – Curing Concrete Structures*.

   f. Request and authorize a repair plan for the replacement of any damaged sculpted shotcrete surfaces.
5. Following construction, the SR or delegate must:
   a. Discuss lessons learned with the Contractor and staff.
   b. Document all inspection, construction, and quality assurance activities pertinent to this BCM in the Daily Reports per BCM C-7, Daily and Weekly Reports.
   c. Complete as-built plans. Refer to the discussion regarding as-buils in BCM C-6, Required Documents to be Submitted During Construction.

6. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized sculpted shotcrete submittals (Subcontractor’s experience, installation plan, test panel)
2. Completed sculpted shotcrete wall conforming to project requirements
3. Sculpted shotcrete test results (core compressive breaks)
4. Daily Reports (include lessons learned)
5. As-built plans.

**Attachments**

None
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55-1.01C     | xx/xx/20xx    | Steel Structures – Submittals |
55-1.03      | xx/xx/20xx    | Steel Structures – Construction |

BCMs for Section 55, *Steel Structures*, have not been posted. Until they are posted refer to Section 170-0.0, *Structural Steel.*
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Steel Structures – Submittals

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BCM 55-1.01C, Steel Structures – Submittals, has not been posted yet.

Until it is posted refer to BCM 170-4.0, Structural Steel Working Drawings.
Steel Structures – Materials

BCM 55-1.02 A-D, *Steel Structures – Materials*, has not been posted yet.
Steel Structures – Construction

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Overhead Sign Structures, Standards, and Poles – Submittals

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Background

This process establishes Structure Construction (SC) roles and responsibilities for review and authorization of overhead sign structure shop drawings and the Contractor’s Quality Control Program prior to fabrication and erection of sign structures.

Process Inputs

1. Sign Structure Shop Drawings.
2. Quality Control (QC) program from each sign structure fabricator including the Welding Quality Control Plan (WQCP).
3. Quality Control program for the installation of the sign structure.

Procedure

1. All work associated with this process is charged to Project-Direct – Construction.
2. Inspection of field work for this process is:
   a. Benchmark for review of submittals and shop drawings.
3. Coordinate with the RE on any changes to electrical work, sign panel sizes or placement, and survey requests as it affects the sign structure.
4. Coordinate with the MR on the review and authorization of the shop drawings and QC program.
5. Consult with the Structure Design and/or SP&I Signs Specialist for unusual details or circumstances.
6. Develop a submittal log:
   a. Document submittal review milestones.
   b. Document conversations, review notes, and reasons for review delays.
   c. Monitor the review time.

7. Perform an initial review of submittals for completeness and return any incomplete document immediately. The submittals need to contain the basic information needed to successfully perform a review.

8. Review the Contractor’s CPM with the RE to verify that specified review times are accounted for in the baseline schedule.

9. Receive overhead sign shop drawings and QC Program for each proposed fabricator in accordance with Standard Specifications (SS)\(^1\).

10. Receive QC program for the installation of the sign structure in accordance with Standard Specifications\(^1\).

11. Verify that the fabrication shop is on the Authorized Facility Audit List

12. Review Shop drawings and QC Program in conjunction with:
   a. Applicable Plans and Specifications:
      i. Note orientation of steel members: major/minor axes, compression/tension members. Make sure shop drawings match what is shown on the contract plans, including direction of truss braces.
   b. *Overhead Sign Structures Guide*:
      i. Section 5, *Shop Drawings* (including erection and QC program).
   c. BCM 56-2.01C, Attachment 1, *Additional Information for Shop Drawing Reviews*.
   d. BCM 11-2, *Welding Quality Control*.
   e. Consult with MR on materials issues, including proposed substitutions, Buy America requirements, and QC Program.
   f. Consider lane closure and night work safety requirements, e.g. work lights. Consult with the Resident Engineer for duration and work space limitations.

13. Verify that the Contractor is not introducing changes to the basic design of overhead sign structure specified in the contract documents. Changes can only be allowed with the Department’s authorization and through a Change Order.

\(^1\) 2018 SS, Section 56-2.01C(3), *Overhead Sign Structures, Standards, and Poles – Overhead Sign Structures – Submittals – Shop Drawings*
14. Document the authorization or rejection of the submittals. The SR provides all final submittal authorization. Stamp each authorized page with the authorizations stamp.

15. Provide copy of authorized submittal to the Contractor along with a reminder regarding the timely notification on the start of fabrication.

16. Provide copy of authorized submittal to METS.

17. Document all submittal activities in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

**Process Outputs**

1. Authorized or Rejected submittals.

**Attachments**

*Attachment 1, Additional Information for Shop Drawing Review.*
Additional Information for Shop Drawing Reviews

Review Sign Structure, Standards, and Pole shop drawings in accordance with contract documents, Overhead Sign Structures Guide, and the information in this Attachment.

Perform an initial review to determine if the shop drawing submittal is complete. Return the document if it is determined to be incomplete. A complete shop drawing submittal will contain the following as a minimum:

1. All items listed under 2018 Standard Specifications (SS), Section 56-2.01C(2), Overhead Sign Structures, Standards, and Poles – Overhead Sign Structures – Shop Drawings.
2. Identification of the project number.
3. Identification of the sign or pole and their location relative to the contract plans.
4. Identification of individual components including their dimensions and material type.
5. Details showing the orientation of the sign or pole structure.
6. Details showing the orientation of member sections.
7. Welding and other connection.
8. Any proposed changes to the contract documents.

Review the drawings based upon the contract plan sheets, Standard Plan sheets, including any addenda issued prior to the bid opening date, and any revised plan sheets included with the contract plans.

Sign Structure Shop Drawing Review

General

1. Verify that the location of the sign structure is correct. Refer to the sign plan sheets. Bridge mounted signs will also be shown on the bridge plan sheets.
2. Verify that the direction and orientation of the truss is in the correct plane.
3. Check the electrical plan sheets for any power and communication connections to the structure.

Post

1. Verify that the top of foundation elevation is not below finished grade. Coordinate with the roadway grading plan sheets. A field survey may be necessary for further confirmation.
2. Verify that the height of the foundation above finished grade is acceptable to the District. There may be aesthetic or safety issues with exposed foundations.
3. Verify the horizontal offset of the pole from the Edge of Travel Way (ETW) is correct. If it is less than 12’-0”, additional safety features will be required such as metal beam guard railing. Work with the Resident Engineer to mitigate these situations.

4. Verify that the orientation of hand holes at the bottom of the pole faces away from the traveled way. If the pole is located in the median, consult with the Resident Engineer.

5. Verify the orientation of the base plate bolt pattern matches and supports the correct orientation of the truss or connecting mast arm. This is especially important for non-circular poles or custom poles and arms.

6. Verify the orientation of the post is correct. This is especially critical for non-circular poles or custom poles and arms.

7. Verify the length of pole is sufficient to achieve the required vertical clearance.

8. If there are electrical/communication connections to the structure, verify that appropriate openings are provided in the baseplate and wire supports are provided in the pole. Be sure to check the number and diameters of conduits to verify that they will fit into the baseplate. Consult with the Sign Specialist if the number of conduits or sizes cannot be reduced, requiring an increase to the base plate cutout.

**Truss and Structural Frame**

1. Verify that beveled washers are specified when fasteners are utilized on sloped steel flange surfaces.

2. Verify that the orientation of the individual truss members is correct.

3. Verify that connection details are specified for all locations.

4. Keep in mind that fillet welds between sections, like the safety railing base plates and support beams, can only be performed when one plate overhangs the other. If both plates are of the same width, a partial penetration weld will be required for this connection.

**Standards and Pole Shop Drawing Review**

**General**

1. Verify that the location of the Standard or Pole is correct. Refer to the sign (S) plan sheets or electrical (E) plan sheets.

2. Confirm that the fabricator is on the Materials Engineering and Testing Services (METS) Authorized Facility Audit List.

3. Verify that the height of the foundation above finished grade is acceptable to the District. There may be aesthetic or safety issues with the exposed foundation.

4. Verify the horizontal offset of the pole from the ETW is correct. If it is less than 12’-0”, additional safety features will be required such as metal beam guard railing.
5. Verify that the orientation of hand holes at the bottom of the pole is correct for its position adjacent to traffic.

**Pole**

1. Verify that the top of the foundation elevation is not below nor too high above the finished grade.

2. Verify that the direction of hand holes at the bottom of the pole face away from the traveled way. If the pole is located in the median, consult with the Resident Engineer.

3. If there are electrical/communication connections to the structure, verify that appropriate openings are provided in the baseplate and wire supports are provided in the pole. Be sure to check the number and diameters of conduits to verify that they will fit into the baseplate. Consult with the Sign Specialist if the number of conduits or sizes cannot be reduced, requiring an increase to the base plate cutout.

4. Verify the orientation of the base plate bolt pattern matches and supports the correct orientation of the pole. This is especially important for non-circular poles.

5. Verify that an installation procedure and/or verification windows are provided for poles and standards that are spliced with slip fit joints. Verification windows provide visual indicators that the upper half of a pole is sufficiently seated into the lower section.

**Quality Control Plan for Field Installation**

Upon receipt of the field installation plan, perform a cursory review to determine if the document is complete. At a minimum the plan is to address:

1. Personnel: including the identification of the person in charge of the operation.

2. Size, number, and type of equipment being utilized.

3. Method of handling the sign or pole structure component during installation in a safe manner.

4. Make reference to the shop drawings or provide the method of tightening anchor bolts and high strength fastener assemblies.

Return the submittal if this is incomplete. The submittal needs to present a clear plan of how the Contractor will erect the sign or pole structure in a safe and controlled manner.

Some items to consider are:

1. A field check to be performed prior to installation by the Contractor that the foundations are correctly spaced for a two-pole sign structure.

2. The use of tag lines to control the truss or pole during lifting to prevent any unplanned incursions into traffic.
3. The use of a secondary pick line to control the base plate during the erection of the pole or support posts to prevent damage. On larger poles, the baseplate may sustain damage if the pole is tipped up on the edge of the baseplate.

4. Does the plan provide for additional safety measures if the operation occurs at night under lane closure?
   a. Sufficient lighting?
   b. Sufficient workspace behind the cones inside the lane closure? Consult with the Resident Engineer if additional space is required or the Contractor proposes to work closer than 6’ from the cones.

5. Will the amount of work planned be completed within the allocated work window?
Overhead Sign Structures – General – Construction

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<td>Steve Altman</td>
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Background

This process also establishes Structure Construction (SC) roles and responsibilities for
construction inspection of overhead sign and bridge mounted sign structures, including
inspection for existing sign structures.

In addition, SC also assists Materials Engineering and Testing Services (METS) with
quality assurance of overhead sign and bridge mounted sign structures, including
quality control for non-destructive testing, walkway safety railing, and Department
acceptance of structural materials. Quality assurance requirements are described in
Contract Specifications, Section 56-2.03, Overhead Sign Structures – General –
Quality Assurance.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the
Contract Specifications, Section 56-2.03, Overhead Sign Structures – General –
Construction that this BCM is based on as identified in the title block above. The
information in the contract specifications typically will not be repeated in the text of this
BCM.

Process Inputs

1. Fabricated and METS released overhead sign structure
2. Overhead sign support structure in place:
   a. Overhead sign structure pile foundation in place per BCM 49-3, *Cast-In-Place Concrete Piling*
   b. Overhead sign structure spread or driven pile footing sign foundation in place
   c. Bridge or other structure ready to receive bridge mounted sign structure

3. Form *CEM-3101, Notice of Materials to be Used*

4. METS inspection and release documentation

**Procedure**

1. All work associated with this process is charged as [Project-Direct – Construction](#).

2. Inspection of field work for this process is:
   a. [Continuous](#) for erection and installation of overhead sign structures.
   b. [Benchmark](#) for review of Quality Control Program.

3. Before construction begins:
   a. Review and perform work in accordance with:
      i. Authorized overhead sign structure submittals, per *BCM 56-2.01C, Overhead Sign Structures, Standards, and Poles – Submittals.*
      ii. *BCM 56-2.03 Attachment 1, Sign Structure Installation Guide.*
      iii. *BCM 56-2.03 Attachment 2, Sign Structure Fastener Installation Guide.*
   b. Coordinate with District construction for:
      i. Traffic work window for overhead sign structure installation.
      ii. Traffic control.
      iii. All work to be performed during overhead sign structure installation.
      iv. Agency/utility impacts.
      v. Coordination for Department-furnished sign materials.
      vi. Covering sign panels if not for immediate use.
   c. Discuss the following protocol for overhead sign structure fabrication with the contractor during the preconstruction conference:
i. Verification that the fabricator is on the METS Authorized Facility Audit List.

ii. Use of the CEM-3101, Notice of Materials to be Used, and Form TL-38, Inspection Request.

iii. Request the contractor to notify the Structure Representative of delivery to the fabrication site.

iv. Discussion of any potential issues identified during shop drawing review regarding the authorized shop drawings.

d. Review the contractor’s CPM schedule for the fabrication, delivery, and installation of the overhead sign structure.

e. Request a copy of CEM-3101 from the Resident Engineer.

f. Contact the METS Representative (METS Rep) regarding inspection of materials, fabrication, and welding non-destructive testing of overhead sign structure fabrication to:

   i. Forward the authorized overhead sign shop drawings and welding quality control plan.

   ii. Verify and obtain a copy of METS inspection forms TL-28, Notice of Materials to be Inspected at Jobsite, or TL-608, Notice of Materials to be Furnished.

g. Contact the Structure Policy and Innovation (SP&I) Overhead Sign Structure Specialist for technical expertise to resolve irregular construction issues.

h. Review the authorized quality control (QC) program submitted with the shop drawings. See BCM 56-2.01 C, Overhead Sign Structures, Standards, and Poles – Submittals.

i. Verify the overhead sign structure location has specified horizontal and vertical clearances.

j. Prepare Form TR-0020, Notice of Change in Horizontal or Vertical Clearance, and submit to the Construction/Maintenance Liaison (Permits) with horizontal and vertical clearances. Report the impaired clearance 15 days prior to erecting the overhead sign structure over traffic.

k. Verify that the concrete elements supporting the overhead sign structure have attained the required time and compressive strength.

l. Verify the height and elevation of anchor bolt assembly (when applicable).

m. Verify the inspection and release of the overhead sign structure with the METS Rep.

n. Upon delivery of the overhead sign structure:

ii. Check for Certificates of Compliance and Buy America Certification.

iii. Review the *Construction Manual*:
   1. Table 6-2.1, *Inspection of Fabricated and Manufactured Materials*.
   2. Table 6-2.2, *Materials Acceptance Based on Authorized Material List*.
   3. Table 6-2.3, *Materials Accepted by Certificate of Compliance*.

iv. Check the overhead sign structure for damage incurred during the delivery:
   1. If any damage is discovered, request a repair plan from the contractor.

v. Check the walkway safety railing wobble per the requirements of the contract documents.

vi. Verify the overhead sign structure delivered is the correct one authorized for the specified location, has the correct spelling, and orientation with the roadway.

vii. Verify that all connection hardware complies with the contract requirements, have been authorized, and/or are listed on Authorized Material Lists (AML), etc.

viii. Contact the METS Rep if no Form TL-0029 was received or there are no inspection release tags.

ix. Check the overall condition of the overhead sign structure to verify compliance with the contract requirements.

x. Authorize installation of the overhead sign structure if it conforms to the requirements of the authorized shop drawings.

o. Department-furnished material:
   i. Review the contract for any requirements for Department-furnished material.

   ii. Resident Engineers will coordinate for Department-furnished sign materials to be ordered and ready for timely delivery.

   iii. Make a physical inspection and inventory to confirm that all Department-furnished sign materials are delivered in good condition.

   iv. Verify correct spelling of messages on sign panels.

   v. After delivery, the contractor is responsible for any damage to Department-furnished materials.

4. During construction:
a. Review the lane closure request to verify that the duration and closure limits are sufficient to support the operation and provide feedback to the Resident Engineer.

b. Conduct a pre-erection meeting with the contractor to discuss:
   i. The Installation Quality Control Program
   ii. Safety (work lights, COZEEP, contingency plan, etc.)
   iii. Splices
   iv. Inspection hold points (if necessary)
   v. Fastener installation and timing of verification
   vi. Verification of staging area (and closure limits) for equipment and installation

c. For field procedures for installation of new or relocated overhead sign structures and bridge mounted signs:
   i. The Structure Representative (SR) disseminates the latest authorized QC program and shop drawings to all SC field staff:
      1. Verify that the contractor is using the same copy.
   ii. Coordinate inspection with the METS Rep for any field welding. Review the Welding Quality Control Plan and check the Certified Welding Inspector requirements.
   iii. Coordinate installation of conduits, boxes, and other electrical appurtenances with the District. For relocated structures, verify openings are sized to support new conduit installation.
   iv. For overhead sign structures:
      1. Verify that installation of the overhead sign structure complies with the project requirements and conforms to the authorized Quality Control Plan.
      2. Deviations to the QC program require discussion with the SR prior to the change.
      3. Verify installation of the fasteners through Direct Tension Indicators or torque, are verified by an approved method. See Attachment 2, Sign Structure Fastener Installation Verification Guide.
      4. Verify that the tightening of anchor bolt nuts for poles is performed incrementally and in an alternating pattern to evenly apply force to the connection. Anchor bolts are tensioned to a snug tight condition unless otherwise specified.
5. Verify rake (lean) of the posts, such that the truss, will be level relative to the traveled way.

6. Verify that the measured clearances are greater than or equal to the clearance previously reported to Construction/Maintenance Liaison (Refer to Step 3j). Do not allow sign structure to be installed if the measured clearance is less than the previously reported. Discuss with the SR for corrective action. Report final values to the Construction/Maintenance Liaison.


v. For bridge mounted sign structures:

1. Verify that anchors have been or will be installed in accordance with the manufacturer’s recommendations to the correct position and dimension.

2. Verify that anchorages will not penetrate prestressing ducts in post-tensioned box girder bridges.

3. Resin capsule anchorages (RCAs) are restricted to certain conditions:
   a. Do not allow RCAs usage in positions where the anchorage is subject to direct, sustained tension.
   b. Usage of RCAs is allowed when attachments are made in specific locations. Refer to *Attachment 2, Sign Structure Fastener Installation Guide* and the *Overhead Sign Structures Guide* for additional guidance on the use of RCAs and locations where RCA usage is allowed.

vi. Upon completion of installation, verify that all temporary shipping, and lifting attachments are removed from the overhead sign structure. Have the contractor repair any damage to the overhead sign structure resulting from the removal of these attachments, including galvanization or painting systems per the *Contract Specifications*, Section 75-1.02B, *Miscellaneous Metal – General – Materials - Galvanizing*.

vii. Measure the horizontal and vertical clearances, and report if less than those provided from previous notice per *BCM C-4.14, Notice of Change of Structure Clearance or Permit Rating*:

1. Record as-built elevations (and vertical clearance) on sign detail plan sheets.

   d. For existing overhead sign structures:
i. When removing or salvaging the overhead sign structure:
   1. Confirm removal depths of foundation with the contractor.
   2. Request, review, and authorize the removal plan.
   3. Coordinate with the receiving site on the timing of a salvage operation (when applicable).

ii. When modifying the overhead sign structure:
   1. Review the condition of the structure.
   2. Verify that existing structures to be modified agree with the as-built drawings.
   3. Initiate a Change Order to replace any portion of the structure that cannot be reused.

5. Refer to Attachment 1, Sign Structure Installation Guide, for complete instructions.

6. Authorize installation of the overhead sign structure if it conforms to the requirements of the authorized shop drawings.

7. Document all field revisions to the contract documents in as-builts. Provide a copy to the pertinent party.

8. Document all inspection, construction, and quality assurance activities in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

**Process Outputs**

1. Inspection release tags (Form TL-0624, Inspection Release Tag, matching Form TL-0029, Report of Inspection of Material)
2. Form TR-0020, Notice of Change in Vertical or Horizontal Clearance
3. Field welding QA forms (if field welding is performed)
4. Welding Inspection Reports
5. Buy America Certification from the manufacturer for Federal Aid projects
6. Certificates of compliance
7. Daily Reports
8. As-builts
9. Installed overhead sign structure
Attachments

**Attachment 1**, *Sign Structure Installation Guide*

**Attachment 2**, *Sign Structure Fastener Installation Guide*
The following is information to assist SC staff with inspecting the installation of overhead sign structures.

1. The Structure Representative (SR) will disseminate the latest authorized plans and shop drawings to all SC field staff:
   a. The Assistant Structure Representative (ASR) will verify that the contractor is using the same copy.


3. Review the *Overhead Sign Structures Guide* (e.g., Section 7, *Installation*).

4. Check that the SR authorized the shop drawings and the Welding Quality Control Plan (WQCP). Verify that the method of sign or pole erection utilizes measures to control lateral movement to prevent incursion into traffic.

5. When applicable, review welding requirements in the *Contract Specifications* and the authorized WQCP. Refer to the *Overhead Sign Structures Guide*, Section 3, *Welding*.

6. Check the station, offset, and elevation of the overhead sign structure relative to the contract plans. Check that the overhead sign structure has vertical clearance necessary, or specified, based upon baseplate elevation.

7. Check the foundation and bolt template for proper orientation. Generally, with the long axis of the foundation parallel to the traveled way.

8. Review the Log of Test Borings to determine the potential groundwater elevations and possible effects on foundation work.

9. Verify that spread footing foundations are against competent undisturbed soil. Refer to the *Foundation Manual*, Chapter 4, *Footing Foundations*.


11. Review the authorized mix design prior to placement of concrete and field verify that all concrete loads delivered comply with contract requirements.

12. Check the electrical contract plan sheets for lighting requirements of the overhead sign structure to allow for conduit installation in the sign foundation. Verify that the
Sign Structure Installation Guide

post base plate opening can accommodate the conduits. Consult with Electrical Design to reduce the number of conduits or size if there are space issues.

13. Verify the contractor’s method for maintaining anchor bolt spacing, orientation, and alignment during concrete placement.

14. Check the spacing, orientation, and elevation of the finished anchor bolts. Note any differences (or settlement):
   a. Always make sure the anchor bolt assembly is set to err on the conservative side to exceed (rather than reduce) vertical clearance requirement.

15. Verify that the concrete has been in place seven full days prior to erection of the overhead sign structure.

16. Prior to drilling anchors into the side of a precast/prestressed (PC/PS) girder, verify that the prestressing steel is not in conflict.

17. Anchor bridge mounted sign structures as detailed on the contract plans and shop drawings. Verify that authorized anchorages and bonding agents are used. Do not allow the use of chemical anchors in a tension or withdrawal condition.

18. Check the sign structure for damage in transit after delivery to the project site. Collect the Materials Engineering and Testing Services (METS) Material Release Tags.

19. Verify that all components of the overhead sign structures are manufactured according to the authorized shop drawings. Refer to the Overhead Sign Structures Guide, Section 7, Installation.

20. For single post signs with cantilevered truss, verify post is shown on the correct side of the truss.

21. Review connection details in authorized shop drawings and applicable contract requirements. Refer to the Overhead Sign Structures Guide for detailed information. Also see Bridge Construction Records and Procedures Manual, Section 55, Steel Structures.

22. Conduct a pre-erection safety meeting with the contractor and ASRs prior to erection of the sign to discuss the requirements of the authorized Quality Control Plan, including but not limited to the following:
   a. Sign handling is safe and appropriate, for example:
      1) Verification of staging area (and closure limits) for equipment and installation.
   b. Splices of sign are correctly assembled.
c. Direct tension indicators (DTI) installation or torque verified by an approved method.

d. Discuss fastener tension verification to coordinate inspection times and access (for QA acceptance).

23. Verify the rake (lean) of the post, of a post-type overhead sign structure, such that the truss will be level relative to the traveled way.

24. Verify that the contractor adheres to the erection plan and discuss changes to the plan with the SR prior to the actual change.

25. Measure the vertical clearance of the completed overhead sign structure and complete the Vertical Clearance Diagram for Sign Structures contained in the Construction Manual, Form TR-0020, Notice of Change in Vertical or Horizontal Clearance. Take measurements at the point of minimum vertical clearance. Re-measure the vertical clearance if the surfacing below is altered during the life of the contract.

26. If the measured vertical clearance is less than the minimum values shown on the contract plans:

   a. Remove the truss and do not reset pending corrective plan.

   b. Consideration of removal of the truss is dependent upon the vertical clearance of the upstream and downstream structures.

27. Document as-built changes on the as-built plans.
Sign Structure Fastener Installation Guide

The following is information to assist SC staff with inspecting bolted connections for overhead sign structures.

Unless otherwise specified, all bolts and nuts must conform to the specifications of ASTM Designation A307. Also, unless otherwise specified, A-307 bolts should be furnished with commercial quality washers, have hex heads and nuts, and should be “snug tight”. A-307 bolts should be of such length that they extend entirely through the nut (or nuts), but not more than 1/4 inch beyond. A-307 bolts in shear must have not more than one thread within the grip.

Anchor bolts for sign foundations must conform to the specifications of ASTM Designation F1554 Grade 55, weldable steel. These bolts, washers, and nuts are to be galvanized as specified. Tighten anchor bolts to prevent removal by hand (snug-tight).

Where high-strength bolts are specified for overhead sign structures, the bolts, nuts, and washers must conform to the specifications of ASTM Designation A-325. ASTM A-325 requires that the bolt head be marked “A-325”. In addition, the bolt head may be marked with 3 radial lines spaced 120 degrees apart. High-strength nuts will be marked with the number “2” or “2H”, by three equally spaced circumferential lines, or by the letters “D” or “DH”. These fastener assemblies are zinc coated by the mechanical deposition processes.

High-strength bolts used in overhead sign structures are tightened by any method using an alternating snugging and tensioning pattern to obtain the required tension. Do not allow the reuse of tensioned bolts.

As indicated in the Contract Specifications, Section 55-1.02E(6)(c), Steel Structures – General – Materials -Fabrication – Bolted Connections – Installation, a (flat) hardened washer must be installed under the high-strength nut or bolt head, whichever will be turned to tension the bolt, regardless of the method used to tension the bolt, or the type of connection design. Lock washers are not an allowable substitute.

For overhead sign structures, measurement of the bolt tension of field connections must be by approved direct tension indicators (DTI) furnished by the contractor. Assembly of high strength bolted connections for sign structures may be performed with galvanizing or paint on the contact surfaces.

If raised-lug washer-type direct tension indicators are used, one indicator must be furnished and installed with each bolt in accordance with the following:
• Washer-type tension indicators must be installed so that the lugs bear against the head of the fastener, which is not turned during tightening. After snugging up all bolts of the joint, tightening must progress from the most rigid part of the joint to the free edges. Bolts are tightened until at least 50% of the gaps on each indicator are between 0.000 and 0.005 inch. Reject assemblies where all the protrusions are completely crushed. The perimeter of DTI gaps needs to be sealed with caulking.

The threads of nuts and bolts are to be properly prepared to prevent "galling" and excessive friction losses. A-307 and high strength nuts and bolts are to have their threads properly tapped to accommodate for galvanization. These fastener assemblies are mechanically galvanized and do not require that the nut threads be “chased.” The nuts are to receive a lubricant that is clean and dry to the touch. No attempt should be made to tension a high-strength fastener assembly that is not properly lubricated. The bolt threads will usually gall and strip before the required bolt tension is reached. Nuts for HS bolts that are specified to be snug-tight must not be lubricated.

**Bridge Mounted Signs**

Design will primarily specify the use of resin capsule anchorages (RCA) to support bridge mounted sign structures. Resin capsule anchorages will not be placed where the RCA is subjected to direct, sustained tension applications due to the susceptibility of the RCA to creep.

Prior to installation, verify that the resin capsule anchors are on the METS Authorized Materials Lists.

Installation of the RCAs must follow the manufacturer’s recommendations including the use of recommended drilling equipment. Do not allow installation in cored holes.

Verify that the installations are in holes that are clean and dry.

Do not allow the loading of the RCAs until the adhesive cure time has elapsed (shown in the Authorized Material List).

If mechanical anchorages are specified on the plans, check the Special Provisions for specific requirements. Do not allow the use of headed bolts inserted into wedge anchors. The use of drop-in (expansion) anchors and headed bolts may give questionable results. There is no way of confirming whether the drop-in anchor assembly has seated firmly in the concrete or if the headed bolt is cinched up against the mounting bracket.
For additional information relative to expansion anchors refer to BCM 135-5.0, *Mechanical Anchorage Devices*. A complete list of expansion anchors that have been approved by the Transportation Laboratory is available on the METS Authorized Material Lists.
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Revision Date: 05-31-2022
Nature of Changes: Original issue. Published BCM 57-3.
Approved By: Richard Foley
Wood and Plastic Lumber Structures – Plastic Lumber Structures

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, materials, and construction of plastic lumber structures.

Plastic lumber is typically used as secondary members in structures and is generally installed in accordance with manufacturer’s instructions.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 57-3, Wood and Plastic Lumber Structures – Plastic Lumber Structures, which this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. [Form CEM-3101], Notice of Materials to be Used
2. [Form TL-0029], Report of Inspection of Materials
3. Per contract specifications, submittals include:
   a. Product Data
   b. Certificates of Compliance accompanied by a laboratory test report
   c. Test samples for void testing
d. Results of stiffness tests  
e. Plastic lumber shop drawings

**Procedure**

1. All work associated with this process is charged as [Project Direct – Construction](#).

2. Inspection of field work for this process is:
   a. **Benchmark** for inspection of plastic lumber delivered to the job site.
   b. **Intermittent** for inspection of construction of plastic lumber structures.

3. Before construction begins:
   a. Review the following:
      i. **Contract documents**
      ii. *Construction Manual, Chapter 4, Construction Details, Section 57, Wood and Plastic Lumber Structures.*
   b. Discuss the following with Materials Engineering and Testing Services (METS) Representative Form CEM-3101, *Notice of Materials to be Used,* and Form TL-0029, *Report of Inspection of Material,* regarding any plastic lumber materials to be inspected and released.
      i. Review requirements of stiffness test (prior to shipment) to job site and void testing (after delivery) and agree on release process of material. Note that:
         1. METS will witness the stiffness testing at an authorized laboratory prior to job site delivery.
         2. If void testing is satisfactory, SC field staff will field release material using **Form CEM-4102, Materials Inspected and Released on Job.**
   c. Discuss testing requirements with the contractor and METS Representative.
   d. Review and authorize (or reject for resubmittal) the following submittals:
      i. Product data
      ii. Certificates of Compliance accompanied by a laboratory test report
      iii. Test samples for void testing
      iv. Results of stiffness tests
      v. Plastic lumber shop drawings

4. During construction:
a. Inspect and field-release plastic lumber materials conforming to the contract documents utilizing Form CEM-4102, *Materials Inspected and Released on Job*, as follows:
   i. Verify that stiffness testing of material delivered has been completed and obtain documentation of the same.
   ii. Select samples and perform void testing per contract specifications.

b. Collect Form TL-0624, *Inspection Release Tag*, commonly referred to as orange tags, and attach to the associated with Form TL-0029 for any plastic lumber materials released by METS.

c. Follow safety requirements in the Safety Data Sheets and Code of Safe Practices when working with plastic lumber materials.

d. Verify installation procedures for plastic lumber elements are in accordance with the requirements of the contract documents, authorized shop drawings, and manufacturer’s instructions.

e. Maintain summaries of construction materials incorporated into the project.

f. Document all inspection, construction, and quality assurance activities in the Daily Reports per BCM C-7, *Daily and Weekly Reports*.

5. Following construction:
   a. File all project documentation (correspondence, materials acceptance documentation, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.
   b. Submit final Shop Drawing as-builts to SC-HQ office, per BCM C-6, *Required Documents to be Submitted During Construction*.

**Process Outputs**

1. Authorized plastic lumber submittals
3. Form CEM-4102, *Material Inspected and Released on Job*
4. Daily Reports

**Attachments**

None
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<td>10-28-2022</td>
<td>Original issue. Added BCM 59-1</td>
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Structural Steel Coatings – General

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for coating structural steel that apply generally to all types of structural steel coatings, including:

1. Review and authorization of submittals for blast cleaning material.
2. Quality assurance, including measurement of coating thickness, coating adhesion strength, and sealing compounds.
3. Review and authorization of general materials, including water, sealing compounds, abrasives, and coatings.
4. Construction, including protective devices, weather conditions, cleaning, and painting. Painting quality assurance, including measurement of coating thickness, coating adhesion strength, and sealing compounds.
5. Documentation of cleaning and painting activities.

Specific contract requirements for painting structural steel, galvanized surfaces, and sign structures are included in the Contract Specifications:

- Section 59-2, Structural Steel Coatings – Painting Structural Steel,
- Section 59-3, Structural Steel Coatings – Painting Galvanized Surfaces
- Section 59-4, Structural Steel Coatings – Painting Sign Structures.

Prior to reviewing this BCM, it is essential to review Contract Specifications, Section 59-1, Structural Steel Coatings – General, that this BCM is based on, as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.
Process Inputs

2. Form CEM-3101, Notice of Materials to Be Used, to include the paint materials.

Procedure

1. All work associated with this process is charged to the project as Project Direct - Construction.
2. Field work for this process is:
   a. Intermittent inspection for surface cleaning.
   b. Benchmark inspection for surface preparation and painting.
3. Before construction begins the Structure Representative (SR) or delegate must:
   a. Consult with the Resident Engineer (RE) and/or the District Environmental Branch regarding any issues with environmental requirements, workspace, lead compliance, hazardous materials (including lead coatings), and traffic control requirements.
   b. Review the project water pollution control program and the requirements as they pertain to the cleaning and application processes.
   c. Review BCM B-2, SC Lead Compliance Plan, for information on SC responsibilities in administering the Caltrans Injury and Illness Prevention Program (CT IIPP) in the Caltrans Safety and Health Manual, and any project specific lead compliance plans if the potential for lead exposure is present on the contract.
   d. Discuss any questions regarding the coating systems, manufacturer’s recommendations, and application methods with the:
      i. Structures Maintenance & Investigations (SM&I) Bridge Paint Program Advisor or Materials Engineering and Testing Services Representative (METS Reps) for technical assistance with regards to the Society for Protective Coatings (SSPC) Qualification Procedure (QP) Certifications, surface preparation, painting and coating systems, etc.
      ii. SC Technical Team G, Structural Steel.
   e. Procure necessary:
      i. Personal protective equipment (PPE) which may include respirators and fall protection:
1. Refer to the Caltrans Safety and Health Manual, Chapter 15, Respiratory Protection Program and coordinate with the Bridge Construction Engineer, to comply with respirator safety protocols.

ii. Paint inspection tools contained in the SC Paint Kit including dry film thickness gauges, hygrometer, or sling psychrometer, chalk or other marking media, and magnetic surface temperature gauge:

   1. Calibrate equipment including hygrometers, and DFT gauges.

f. Arrange with the Bridge Construction Engineer to complete SC’s training course # 101059, Contract Administration of Field Clean & Paint Steel, which is provided on demand.

i. If the training is not available, review the course material on the SC Intranet under the Training tab.

h. As required by the project, verify that the painting contractor and/or fabrication shops have obtained and maintain specific credentials including American Institute of Steel Construction (AISC) Certification Endorsement and SSPC QP certificates.

i. Verify that the Contractor has submitted form CEM-3101, Notice of Materials to Be Used, for the paint materials.

j. Discuss the following requirements for structural steel coatings with the Contractor:

   i. Protective devices

   ii. What environmental controls will be implemented during the course of work.

   iii. Cleaning and painting

   iv. Placement of paint orders with sufficient time to allow for testing and authorization of material lots.

   v. Local requirements, including local Air Quality Board requirements.

k. In addition to verifying contract compliance for informational submittals (certificate of compliance, safety data sheet (SDS), etc.), refer to BCM 59-2, Structural Steel Coatings – Painting Structural Steel, BCM 59-3, Structural Steel Coatings – Painting Galvanized Surfaces, and the Contract Specifications listed in the Background section for authorizing action submittals for specific coatings.
l. Review and verify requirements for water used for cleaning, sealing compounds, and abrasives are being met as they are delivered to the work site.

m. Coordinate the inspection and release of materials with the METS Rep.

n. Coordinate with the SC Falsework Engineer for temporary structure submittals (i.e., scaffolding, containment structures, etc.) for work involving the railroad. Verify the requirements for agreements with the railroad company and preservation of property are met per the Contract Specifications, Section 5-1.20C, Control of Work – Coordination with Other Entities – Railroad Relations, and Section 5-1.36, Control of Work – Property and Facility Preservation.

4. During construction the SR or delegate must:

a. Verify materials comply with authorized work plans and submittals. Reject any unauthorized material and provide written notification to the Contractor.

b. Verify environmental conditions are within the limits specified in the contract documents and any Contractor environmental controls are maintained if utilized.

c. Verify that protective devices are operating as intended. Notify the Contractor immediately if corrective action or adjustments are required for containment.

d. Review water sample test results for compliance.

e. Verify contractor compliance with requirements for cleaning using pressure rinsing, pressure washing, steam cleaning, or blast cleaning methods as applicable or specified for the work:

i. Document cleaning daily on Form SC-4601, Daily Clean and Paint Record.


f. When independent adhesion testing is requested by the Engineer or required following ASTM D4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers, coordinate inspection with the METS Rep.

i. The ASTMs can be accessed using the “Engineering Workbench” section of the Caltrans Transportation Library (Note – registration required).

g. Provide written notification to the Contractor for non-compliant work and request mitigation plan.

h. Verify “Date Painted” is stenciled on the bridge at two locations, as required by the Contract Specifications.
i. Document all inspection, construction, and quality assurance activities pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports. In addition to documenting daily cleaning and painting activities on Form SC-4601, include the following on the daily report:

   i. Limits of activities
   ii. Environmental conditions
   iii. Painting system utilized

5. After construction the SR or delegate must:

   a. Document cleaning and painting costs for each structure using Form SC-6302, Clean and Paint Cost Summary, using data from Form SC-4601, Daily Clean and Paint Record.

   b. Document cleaning and painting work for each structure using Form SC-6305, Paint Record, using data from Form SC-4807, Spot-Sandblasting Report, and submit to Structure Construction Headquarters by email per guidance in BCM C-6, Documents to be Submitted During Construction.

6. File all project documentation (correspondence, materials acceptance documentation, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Chapter 5, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Submittals
2. Completed cleaning and painting forms
3. Certificates of Compliance and SDS
4. Daily Reports

**Attachments**

None
Structural Steel Coatings – Painting Structural Steel

Revision and Approval

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Click here to request previous versions   Contact SC Technical Team G for questions

Background

This process establishes Structure Construction (SC) roles and responsibilities for painting structural steel including:

1. The review and authorization of submittals specifically for painting structural steel and steel soldier piles, including certification for the maximum allowable dry film thickness for inorganic zinc-rich coatings to be used on faying surfaces of High Strength (HS) bolted connections, mandatory Society of Protective Coatings-Qualification Procedures (SSPC-QP) certifications, and the Painting Quality Work Plan (PQWP).

2. Administration of Contractor’s quality assurance efforts including the prepainting meeting and quality control testing. The prepainting meeting is used to discuss the requirements of the PQWP and takes place before the PQWP is submitted. Testing of paint application is extensive and requires a thorough understanding of the contract requirements.

3. Construction activities including:
   a. Construction of authorized containment systems
   b. Surface preparation and cleaning
   c. Painting
   d. Work area monitoring.

4. Preparing and painting sign structures.
Additional unique requirements that supplement this process are detailed in the Contract Specifications (CS):

- Section 59-1, Structural Steel Coatings – General
- Section 59-4, Structural Steel Coatings – Painting Sign Structures.

Prior to reviewing this Bridge Construction Memorandum (BCM), it is essential to review the CS, Section 59-2, Structural Steel Coatings – Painting Structural Steel, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Painting Quality Work Plan
2. Society for Protective Coatings (SSPC)-Qualification Procedures (QP) Certifications
3. American Institute for Steel Construction (AISC) Certifications
4. Maximum Dry Film Thickness Certification for faying surfaces of high strength (HS) bolted connections
5. Debris containment and collection plan, if field painting
6. Authorized scaffolding plan, if applicable
7. Quality Control (QC) test reports performed during the paint work
8. Fabricated sign structure

**Procedure**

1. All work associated with this process is charged as Project Direct – Construction.
2. Inspection of field work for this process is:
   a. Intermittent for containment system construction and work area monitoring.
   b. Benchmark for surface preparation and painting.
3. Before construction begins the Structure Representative (SR) or delegate must:
   a. Meet with the Materials Engineering and Testing Services Representative (METS Rep) to go over the project and painting requirements ahead of the prepainting meeting.
   b. Attend the prepainting meeting with METS Rep, the Contractor, and all painting sub-contractors to:
      i. Discuss the paint quality work plan requirements.
ii. Discuss the hold points required for inspections.

c. Review and authorize or return for resubmittal the following submittals:

i. The coating material certification indicating maximum allowable dry film thickness (DFT) on HS bolted connections.

ii. The Mandatory SSPC-QP and/or AISC Certification. Verify:

   1. The certification dates are current through the life of the project.
   
   2. Questions regarding Caltrans SSPC QP Requirement Notice can be referred to Structure Maintenance & Investigations (SM&I) Bridge Paint Program Advisor.

iii. The PQWP. Verify:

   1. The submittal is complete and:

      a. Includes the required SSPC, AISC, and American Society for Testing and Materials specifications.

      b. Includes the Maximum DFT Certification for faying surfaces of high strength bolted connections.

      c. If the submittal is incomplete, the Contractor received the written notification that the submittal was returned and understands the review clock stopped.

   2. Copies are distributed for review to the METS Representative.

   3. The PQWP is consistent with minutes of the prepainting meeting.

   4. The Contractor personnel meet the certification and qualification requirements of the project through the life of the project. Communicate the need to resubmit certifications that will expire during the life of the project.

   5. Proposed materials are listed on the Department’s Authorized Material List (AML):

      a. Review manufacturer’s guidelines for compatibility with proposed PQWP.

      b. Collect complete records prior to construction including paint batch Quality Assurance (QA) results from METS Chemical Testing Branch.

      c. Verify that finish coats for sign structures match color requirements specified in the CS, Section 59-4.03D, Structural Steel Coatings – Painting Sign Structures – Construction – Finish Coats.

   6. The PQWP is compliant with environmental requirements, including material storage and handling, surface preparation, painting, providing
adequate containment, etc. Coordinate review and verification with the Resident Engineer.

7. The water supply meets requirements and:
   a. Review source and quality of Contractor developed water supplies.
   b. The development of water supply is compatible with the project schedule.

8. The containment and scaffolding systems are in conformity with:
   a. The design criteria in the contract documents.
   b. The requirements of BCM 7-1.02K(6)(e), Legal Relations and Responsibility to the Public – Laws – Labor Code – Occupational Safety and Health Standards – Scaffolding.
   c. The requirements of the PQWP.

9. The PQWP is reviewed with the Resident Engineer for conformance with:
   a. Environmental requirements (e.g., noise, water pollution control)
   b. Traffic control requirements (e.g., lane closures)
   c. Staging area (e.g., footprint, site access, sufficiently sized)
   d. Safety (e.g., containment system, access points)
   e. Temporary traffic control requirements of the contract documents:
      i. Maintain pedestrian access (if applicable) per BCM 16-2.02, Temporary Facilities – Temporary Pedestrian Facilities, and in accordance with Temporary Pedestrian Access Routes Handbook.
   f. Items related to the railroad.

10. The SC Falsework Engineer is consulted for submittals that affect the railroad.
   iv. Paint color samples for match to project referee samples. Consult with the project architect if required.

1. Note that the project architect may be the Landscape Architect from the District, and on other projects the project architect may be the Architect from the Division of Engineering Services, Office of Transportation Architecture.
   d. Notify the Contractor in writing of rejection or authorization of all submittals.
   e. Provide copies of authorized submittals to field staff, METS Representative, project files, architect, and designer (as requested).
f. Coordinate review of the lead compliance plan with the Resident Engineer (RE) per Contract Specifications, Section 7-1.02K(6)(j)(ii), Legal Relations and Responsibility to the Public – Laws – Labor Code – Occupational Safety and Health Standards – Lead Safety – Lead Compliance Plan, if a lead compliance plan item is identified by the contract.

g. Review the CS, Section 59-4, Structural Steel Coatings – Painting Sign Structures, for contract requirements for preparing and painting sign structures.

h. Consult with the Bridge Construction Engineer (BCE) to obtain medical clearance and initiate medical surveillance process for field personnel when disturbing lead-based paint systems:

i. Respirators and other appropriate PPE must be utilized when working around lead-based paint systems. Refer to Chapter 12, Personal Protective Equipment, and Chapter 15, Respiratory Protection Program, of the Caltrans Safety and Health Manual for guidelines, along with BCM B-2, SC Lead Compliance Plan.

ii. Use Form SC-0602, SC Medical Testing Authorization Form.

i. Arrange with the BCE to complete SC’s training course # 101059, Contract Administration and Inspection of Field Clean and Paint Steel Training, which is provided on demand.

i. If the paint training is not available, review the course material on the SC Intranet under the Training tab.

j. Acquire suggested Personal Protective Equipment (PPE), inspection tools, and supplies as listed in Attachment 1, Cleaning and Painting of Structural Steel. Review the project specific Code of Safe Practices (COSP) for PPE requirements and safety hazards associated with the painting operations.

k. Obtain and review the schedule of values (SOV) from the Contractor, as mentioned in Attachment 1, Cleaning and Painting of Structural Steel.

l. Direct any paint related questions to the appropriate resources as follows:

i. Coating Specialists at the METS Chemical Testing Lab, who:

1. Provide testing and problem-solving services related to the chemical content of materials and products (e.g., coating systems, sealing compounds).

ii. Structure Maintenance and Investigations (SM&I) Bridge Paint Program Advisor who:

1. Responds to subject area inquiries.

2. Responds to questions regarding SSPC Qualifications.
iii. SC Technical Team G, *Structural Steel Team*, that:

1. Responds to subject area inquiries.

m. Review the authorized project Water Pollution Control Plan (WPCP) or Storm Water Pollution Prevention Plan (SWPPP).


o. Discuss with the Contractor and evaluate the quantity of spot sandblasting specified in the contract. Discuss locations and quantities with the designer:

i. Write a Change Order (CO) to increase bid item quantity if needed.

p. Discuss safe access with the Contractor and verify adequacy during the work. Request corrections as needed in writing.

q. Arrange for a test section on the bridge to ensure that the Contractor’s means and methods for degree of cleaning, surface preparation, and paint application yield acceptable results.

r. Review coating manufacturers and Department’s guidelines and recommendation for surface preparation, painting, drying, and curing.

s. Coordinate with the Contractor to implement protective measures that prevent overspray and accidental paint to adjacent non painted or concrete surfaces or properties (e.g., drop cloths, screen/barriers, overhead tarps, etc.).

4. During Construction the SR or delegate must:

a. Continue to monitor Contractor SSPC or AISC paint certification expiration dates and remind the Contractor of keeping the certifications up to date as needed.

b. Sample paint in the field and send to the METS Chemical Testing Branch to test paint in compliance with *BCM 91-1, Paint – General*.

c. Consult with the RE to verify compliance with the authorized SWPPP/WQCP and PQWP for:

i. Material storage and handling

ii. Containment

d. Verify removal of paint with lead content complies with the:

i. Project Lead Compliance Plan

ii. SC Lead Compliance Program per *BCM B-2, SC Lead Compliance Plan*. 
e. Monitor weather forecasts and maintain communication with the Contractor to:

i. Verify that the temperature and humidity at intervals are being checked for compliance. Check inside the containment system if being utilized on the project.

ii. Stage activities accordingly and optimize time for working windows.

iii. Address and request for repair if containment system is compromised during heavy winds.

iv. Look for and repair or replace uncured paint compromised by weather.

f. Perform timely field inspections including safe operations, obtaining and verifying the Contractor QC test results, performing QA testing, and accepting or rejecting work.

g. Perform additional timely field inspections including:

i. Verifying that safe access to the work is being provided by the Contractor to be assured of specification compliance.

ii. Verifying that the solvent (pressure washing or steam) cleaning operation is satisfactorily removing all dirt, grease, loose chalky paint, or other foreign materials.

iii. Verifying that the specified biodegradable detergent is being used.

iv. On repainting projects, taking initial DFT readings on the existing paint system to obtain average baseline values at various locations on the structure.

v. Identifying, measuring, and agreeing with the Contractor on the square footage of spot blast clean areas.

vi. Reviewing spot blasted and 100% blasted areas to verify that all rust and old coatings systems have been removed.

vii. Measuring and recording spot blast areas daily.

viii. Verifying that specification requirements are being complied to with regards to the disposal of used abrasive material.

ix. Negotiating a day labor CO for power tool cleaning if the contract spot blast quantity is projected to be less than required in the field.

x. Verifying that structural steel is dry prior to application of coating.

xi. Verifying that the air pressure and nozzle size meet the specifications.

xii. Verifying that the first undercoat is being applied shortly after blasting. If not, be sure that areas are re-blasted before the coating is applied.
xiii. Visually inspecting the backsides of rivets, top of diaphragms, tops of bottom flanges, and other hard to reach areas to verify that they are properly cleaned and have the required coating coverage.

xiv. Observing the mixing of coating materials to verify that the mixing is being properly performed.

xv. Randomly checking the wet film thickness for each coat after the coating is applied.

h. Select locations for the various specified quality control (QC) tests:
   i. Verify that the dry film thickness of the undercoats is sufficient before allowing top coat application to proceed.
   ii. Verify final dry film thickness for as-built purposes.

i. Issue formal notification of rejection for failed tests and request a remediation plan for review and authorization.

j. Obtain and evaluate METS QA paint test results.

k. Review the Contractor’s reports for QC tests. Verify the results and frequency with the requirements of the contract documents, and notify the Contractor in writing of deficiencies for:
   i. Blast-cleaned steel for soluble salts
   ii. Inorganic zinc undercoat before applying final or finish coats
   iii. Adhesion and hardness testing
   iv. Soluble salts where final coats are required
   v. For AASHTO M300 Type II and Type I inorganic zinc primers, dry to solvent insolubility.
   vi. Surface pH.

l. Coordinate with the District for temporary traffic control, if applicable.

m. Coordinate with the District for handling and disposal of hazardous waste usually generated when lead based paint systems are disturbed by the removal or cleaning process.

n. When shop coated materials arrive at the jobsite:
   i. Verify that shop coated materials arriving at the jobsite have been inspected and released by METS per Form TL-6042, Coating Inspection Report.
   ii. Inspect for coating damage that may have occurred due to handling or shipping and notify the Contractor for required repairs.
iii. Verify repairs to galvanized surfaces are performed per CS, Section 75-1.02B, *Miscellaneous Metal – General – Materials – Galvanizing*. Refer to BCM 75, *Miscellaneous Metal*, for guidance.

iv. If satisfactory field repair is difficult or cannot be achieved, consult with the METS Rep to determine the desired course of action.

o. For sign and pole structures painted at the jobsite:

   i. Inspect galvanized surfaces for defects or damage and verify repairs are performed per CS, Section 75, *Miscellaneous Metal*. Refer to BCM 75, *Miscellaneous Metal*, for guidance.

p. For paint work on column casings, verify application of zinc rich primer utilizing the conventional spray method. Minor repairs can be made using a brush or roller.

q. Keep test equipment calibrated (e.g., film thickness gauge) by:

   i. Monitoring the equipment calibration tag on the instruments, and
   
   ii. Sending devices to SC Headquarters for servicing ahead of expected work or expiration.

   iii. Some instruments can be calibrated in the field. See Attachment 1, *Cleaning and Painting of Structural Steel*.

r. Comply with safety precautions required for the paint systems in use or being disturbed by:

   i. Following medical surveillance procedures:

      1. All staff shall observe medical surveillance procedures required for the hazards presented by the affected paint systems and procedures.
      
     2. The BCE monitors employee compliance.

   ii. Verifying that PPE for lead based paint removal is:

      1. Supplied by the Contractor which includes supplying personal protective equipment, training, and washing facilities for five State employees per the Lead Compliance Plan. Refer to the *Contract Specifications*, Section 7-1.02K(6)(j)(ii), *Legal Relations and Responsibility to the Public – Laws – Labor Code – Occupational Safety and Health Standards – Lead Safety – Lead Compliance Plan*.

s. Verify that the Contractor is taking necessary measures to prevent overspray of paint onto adjacent non painted or concrete surfaces or properties, such as bridge soffits, concrete caps and piers, and other bridge elements. Areas not protected must be cleaned before the project is accepted.
Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports. Additionally, maintain records of paint work by:

i. Tracking daily atmospheric measurements, surface roughness measurements, quantities of paint and abrasives used, labor and equipment hours, and locations of applied paint.

ii. Recording information daily as work proceeds onto forms:
   1. Form SC-4807, Spot-Sandblasting Report
   2. Form SC-4601, Daily Clean & Paint Record.

iii. Recording information upon completion of work onto forms:
   1. Form SC-6305, Paint Record
   2. Form SC-6302, Clean and Paint Cost Summary.

5. Following construction, the SR or delegate must:
   a. For bridge painting lump sum pay items, prepare a summary sheet reflecting the percent of work each activity represents. Use summary sheet for tracking payment. Utilize the schedule of values previously obtained from the Contractor.
   b. Submit the Form SC-6305, Paint Record, immediately after the structure is painted per guidance in Section 8, Paint Records and Reports, of Attachment 1, Cleaning and Painting of Structural Steel.

File all project documentation (correspondence, test results, daily reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized submittals
2. Prepainting meeting records and minutes
3. Hazard waste disposal manifests
4. Medical Authorization Forms
5. Notification of QC Test results
6. QC Test reports
7. Daily reports
Attachments

Attachment 1, Cleaning and Painting of Structural Steel
Cleaning and painting of structural steel bridges is a vital, specialized phase of bridge construction and maintenance.

Structure Representatives are responsible for verifying the satisfactory completion of cleaning and painting work in accordance with the Contract Specifications.

The following information on cleaning and painting methods, procedures and precautions, paint material, inspection techniques and record keeping, is intended to provide Structure Representatives and their assistants with a rudimentary knowledge of paint inspection, and cleaning and painting of structural steel bridges. Any specific instructions in the Contract Specifications will supersede or modify these instructions.

1 – Purpose of Painting

The paint on structural steel may be described as a relatively impervious barrier imposed between the steel surface and its environment. Paint retards the corrosion of the steel. Corrosion may manifest itself in many forms, and it may have many causes, but the effect is always the same: metal is consumed or deteriorated.

Paint or the coating system, then, may be considered a low-cost renewable or repairable shield or membrane which acts as a moisture barrier to the environment to protect the metal. The service life expectancy of the coating system in California as
affected by climatic conditions, is illustrated by Figure 3, *Paint Service Life on Structural Steel Bridges*.

The service life of the coating system is also a function of the surface preparation, degree or levels of cleanliness, and application of the coating. The coating must be properly formulated and prepared from components having certain necessary properties. It must be properly applied to clean steel surfaces, and the completed dry film must have adequate thickness. Shortcomings in any of these requirements result in a decreased service life of coatings. In California, atmospheric conditions affecting the service life of coatings vary between two extremes: the saline humidity of the seacoast and the hot aridity of the desert. Between these two extremes are regions where milder weather conditions prevail. The need for protection is considerably less under mild exposure than it is under severe exposure. The coating system specified is therefore designed to meet the needs of the area and conform to the latest air quality regulations imposed on the solvent content of paint materials.

Current Department specified coating systems are either a water-borne, moisture cure, or inorganic zinc.

Due to air quality regulations in certain regions of the state, a coating system consisting of water-borne primers and topcoats has been developed by the Department’s chemistry lab at Materials Engineering and Testing Services (METS). This system consists of two undercoats and two finish coats, applied in two or more applications. Water-borne coatings generally require higher temperatures and lower relative humidity than some other coatings to cure properly. Check the historical data available for the region where the paint system is to be applied. Consider the coating system initially selected during the constructability review stage for compatibility with the regional weather conditions and the intended construction schedule.

The specification of multiple coating applications and the minimum dry film thicknesses of the coating system has evolved. Most coatings used on structural steel contain varying amounts of volatile solvents which, when they evaporate during the curing process, leave minute holes in the paint film. The application of multiple coatings, not too thin or too thick, tends to overcome the adverse pin-hole pattern in each coat and assures a truly impervious membrane.

Most coatings will not tolerate extra thick applications or puddles. If too much coating is applied, or puddles of the material are left on the surface, the coating will crack and lose bond with the steel or underlying coat. Each application should be held to near the amount specified.
2 – Surface Preparation

The most important factor affecting the protective service life of a coating is the surface preparation prior to application of the coating. The best coating available will not give optimum service when applied over improperly cleaned surfaces. It is essential, therefore, that the coating is applied only to clean, sound, dry, and properly prepared surfaces.

Although several methods of surface preparation are employed in the painting industry, it has been found that solvent cleaning (SP-1) and blast cleaning (SP-6) are the most effective and least expensive methods. These two methods are specified almost exclusively. Occasionally, in mild exposure areas or where the type and amount of rust does not warrant the expense of blast-cleaning, power tool cleaning methods may be allowed by the specification. The Society for Protective Coatings (SSPC) has specifications that address the different levels of surface preparation including the following:

- SP-1 Solvent Cleaning
- SP-2 Hand Tool Cleaning
- SP-3 Power Tool Cleaning
- SP-6 Commercial Blast Cleaning
- SP-10 Near-White Metal Blast Cleaning

Blast-cleaning is simply the propulsion of an abrasive against an object, and the cleaning is accomplished by the abrasive action. Wet blast-cleaning methods may be specified for personal protection measures due to high concentrations of heavy metals in the existing coating system.

Abrasives obtained from commercial sources generally meets Department requirements. Use of unwashed beach or river sand is not permitted because contaminants or too many fines are often present. It also does not meet Air Resource Board requirements and newer silica dust requirements.

Most often the abrasives used are steel shot, steel grit and slag from copper, nickel, and silver smelting processes. The use of steel shot or steel grit is usually limited to shop blasting where recovery for reuse is possible. High initial cost and lack of a practical recovery method prohibit the use of these abrasives in the field. Mineral and slag abrasives must comply with SSPC-AB 1 Class A, Grade 2 to 3. Steel abrasives must comply with SSPC-AB 3. Recycled steel abrasives must comply with SSPC-AB 2. In the field, the use of metal abrasives requires additional care after blasting for removal from crevices in the steel connections and to prevent loose particles from falling and coming to rest onto the surfaces below and causing corrosion stains.
Solvent cleaning can be performed by methods including but not limited to pressure washing, or steam cleaning. Pressure washing consists of washing the surface to be coated with a pressure wash system consisting of pressures ranging from 2,500 to 5,000 psi at the nozzle applied directly to the surface to be cleaned. The pressure can be derived from the pressure wash system’s gallons per minute (gpm) ratings. Some machines have adjustable pressures with gauges attached. The water is directed against the surface, and the contaminants are loosened and carried away by the water. Any residue remaining on pressure washed surfaces should be rinsed before painting. Steam cleaning uses high temperature steam to remove contaminants from the surface.

Pressure washing is almost always used in lieu of steam cleaning. The primary purpose of steam cleaning or pressure washing is to remove surface contaminants which would hinder the bonding of the new to existing coating system. Steam cleaning is often specified on overhead painting projects to remove railroad soot from the existing structure. Pressure washing will remove some loose rust from the surface. Any remaining rust that will hinder bonding of the new coating system after steam cleaning or pressure washing will generally be followed by spot abrasive blast-cleaning.

An interval of at least 24 hours should elapse after pressure washing or steam cleaning, before the coating is applied.

3 – Caulking

Caulk is applied to all joints, seams, built-up sections, or open seams greater than 6 mils using an authorized sealing material after application of the undercoat. Verify that the application of this material does not create a condition where water can pond. The caulk needs to be cured prior to application of the finish coats.

4 – Mill Scale

Mill scale is a thin, hard, brittle layer of iron oxides that forms on the outer surface of hot rolled steel. It is more cathodic than the base steel to which it adheres. Mill scale expands and contracts at a different rate than base steel causing it to de-bond, resulting in cracking and flaking off the surface. Mill scale is cathodic (-0.2) to steel (-0.5 to -0.8) so in the presence of moisture, corrosion will form in the underlying steel. See Figure 1, *Galvanic Series of Selected Metals*, for the galvanic series of selected metals.
Mill scale has been found on older structures. During cleaning, any loose mill scale that is encountered needs to be removed to prevent further corrosion. This may involve chasing the loose mill scale. Consult with the Bridge Construction Engineer and Structure Maintenance and Investigation (SM&I) Bridge Paint Program Advisor if large areas of mill scale are encountered.

SSPC Surface Preparation standards SP-6 and SP-10 both address mill scale. SP-6 specifies the removal of all visible mill scale whereas SP-10 specifies the removal of all mill scale. One of the main differences is in the amount of staining that is allowed to remain: SP-6 allows 33% versus 5% with SP-10.

5 – Coating System Application

The coatings specified generally consist of one or more undercoats. The various coats or layers are planned and specified:

1. To achieve an impervious membrane which inhibits corrosion.
2. To protect the steel against impact or abrasion.
3. To give the structure a pleasing appearance.

The normal functions of undercoats are to inhibit corrosion, to provide a suitable base for the finish coats, and to present a secondary barrier to any moisture penetrating the finish coats. A stripe coat is applied to all edges, corners, and other irregular surfaces such as bolts, prior to application of the undercoat. This is to ensure full coverage by the undercoat.
Finish coats comprise the tough outer layer of the paint film which is directly exposed to the weather. They are the weathering or wearing coats of a coating system and must, therefore, have a harder, more impervious surface than the undercoats. The finish coat must be compatible with the prime coat. Two applications of finish coat are normally specified.

The coating may be applied to structural steel by brush, roller, or spray, following the manufacturer’s recommendations. Regardless of the method used, care must be exercised in the application to achieve the maximum service-life of the coating system. It is the responsibility of the Structure Representative to verify that the Contractor applies the coating properly. The coating should be well mixed and uniformly applied, and any skips or holidays should be picked up before subsequent applications are allowed, since the smallest break or thin spot in the paint film is a potential trouble spot.

The conventional method uses air to atomize the paint at the nozzle. Jets of air break the paint at the nozzle into tiny droplets and carry it to the surface. Because the atomization of the paint can be adjusted at the nozzle, paint can be applied in varying pattern shapes. The paint can be controlled for spraying irregular shapes and corners. A typical conventional spray method setup includes an appropriately sized air compressor, air hose, fluid hose, moisture/oil extractor, pressure pot, and spray nozzle. Adjustments to the air and fluid lines are made at the pot and nozzle. These will regulate the flow of air and material to affect the amount and pattern of paint dispensed from the system.

The airless spray method atomizes paint through hydraulic pressure as it exits the spray nozzle. It does not utilize air like the conventional method and therefore uses only one hose to the nozzle. As the paint leaves the spray tip under high pressure, it atomizes into a fine spray. Airless spray units can be self-contained units relying on an internal pump or an external air compressor to develop the necessary fluid pressure. This method uses high pressures up to 4500 psi. Adjustments are limited to the tips used on the spray nozzle.

All specified coatings now in use, except the inorganic zins, can be applied by any of the previously mentioned methods. The conventional method is preferred over the airless method. Spraying by conventional methods is the only satisfactory method for application of inorganic zinc. Zinc will mud crack if sprayed too thick. The airless method is best suited for large flat areas like girder webs. The airless method should be avoided when applying PWB 161/162 Aluminum Leafing due to undesirable finish results. Aluminum Leafing will be blotchy with non-uniform finish and color. Use of an agitating mixing pot is a must for the zinc and PWB 161/162 paint systems. Small holidays or skips which sometimes occur around rivets or bolts can be picked up with a brush, and areas inaccessible with a spray gun should be swabbed or brushed. Application of a stripe coat on steel edges, corners, seams, crevices and around rivets and bolts is
critical and is a requirement noted in the specifications. These are the first areas to have corrosion issues if there is not adequate coating system thickness.

Coatings for use on structural steel, except inorganic zinc primer and moisture cure urethane, are manufactured ready for application and thinning is not necessary, nor should it be tolerated. Inorganic zinc primer and moisture cure urethane, may be thinned as recommended by the manufacturer.

Coatings applied to column casings follow the requirements of normal coatings systems application using the spray method. Except for limited areas inaccessible to spray application, the application of zinc rich primer using brush, dauber, or roller methods do not meet contract requirements.

Painting for appearance may be considered of secondary importance to painting for protection, but it is evident that the public is aware of bridge appearance. Both maximum protection and pleasing appearance can be achieved by a paint job properly done. The most common causes of poor appearance are runs or sags in the paint film and paint spray or splatters on the concrete portion of the structure. By using care and caution, it is far easier to prevent these defects than it is to correct them.

**6 – Thickness of Paint Film**

Each coating has a designed thickness that is listed in the *Contract Specifications* and it is paramount that verification of these values be performed.

Since wet coatings shrink when they dry, there are two basic methods to measure a coating application:

- Wet Film Thickness (WFT) is measured with a step gauge (non-electronic device) used by the painters during coating application to achieve a desired dry thickness.
- Dry Film Thickness (DFT) is measured when the coating is dry (electronic device) to verify that the specified thickness was achieved.

While there is an emphasis on the DFT test, as it is ultimately the acceptance test, it is the WFT test that will control the success of the application. The WFT of undercoats and finish coats will vary depending on the type of coating system applied. The estimated wet thickness is derived from a shrinkage factor (% volume solids) found within the Product Datasheet developed by the manufacturer. The wet film thickness can be easily checked using a pocket-sized wet film thickness gauge. Verify the WFT sporadically as the coating is being applied to determine if too much or too little coating is being applied. Consult with the SM&I Paint Coordinator or METS Chemistry Lab to obtain the WFT range for the coating system specified. The WFT is generally twice the DFT value but can vary slightly from this value.
The DFT of the coating system is generally specified by Contract Specifications. The frequency and location of DFT testing is determined by the Contract Specifications and is often but not always referred to the SSPC-PA-2 Standards. Appendix 1 of SSPC-PA-2 provides guidance on the testing of complex shapes but is not considered a mandatory part of the standard. The Contract Specifications allow for testing locations as selected by the Engineer.

Paint dry film thickness is measured by a type 2 magnetic dry film thickness gauge. Gauges are supplied by Structure Construction with instructions for their use. They use a measuring probe and the magnetic induction, hall-effect, and/or eddy current measurement principles in conjunction with an electronic microprocessor to produce a coating measurement. Type 2 gauges use both an integrated probe or a cable attached probe. These devices are delicate and expensive instruments and should, therefore, be handled with care. Gauges should not be stored near active electrical circuits, and they should not remain near welding equipment longer than absolutely necessary. Periodic checks to determine the accuracy of the gauge is necessary. These checks may be made by using the shims provided. All measurements should be taken with the gauge placed firmly at right angles to the area being measured; even a slight slanting of the device gives a high reading, as will lack of solid contact. Recalibrate gauges on different types and sizes of steel. Reading differences have been noted between webs, stiffeners and braces. Practice using the gauge to get familiar with the device. Periodically have the gauges calibrated by an authorized vendor through Structure Construction.

Each DFT Type 2 gauge must have the calibration verified and recorded prior to, and after, each shift of use. Steps to verify a DFT Type 2 gauge involve measuring a shim of a known thickness similar to your application. Measurements from the gauge are received from the highest peaks found within the blasting profile (See Figure 2, Typical Gauge Position); therefore, the verification of calibration should be performed on a similar substrate, with a similar blast profile. The gauge readings represent all the coatings that are currently applied to the base metal. Thus, reading the intermediate coat will include the thickness of the prime coat, plus the thickness of the intermediate coat. Methods of verifications are as follows:

Figure 2. Typical Gauge Position
1. Make sure the DFT gauge probe is clean.

2. Review the manufacturer’s method for verifying the calibration as there can be variations between makes and models.

3. Agree with the Contractor on a representative substrate to measure verification shims.

4. Use two shims to measure atop the representative substrate, one slightly less than the “combined” target thickness and one slightly greater than the “combined” target thickness. Take the average of 10 readings on each of the shims and adjust gauge as described by the manufacturer.

5. Retake readings on shims for verification. Readings should be +/- 3% of shim thickness.

On repainting projects take DFT readings on the existing paint system to obtain average baseline values for various points on the structure. Upon completion, take similar readings at or close to the initial locations. Obtaining accurate intermediate readings on these projects may be difficult as the exact same points may not be duplicated. Wet thickness gauges can be utilized with the DFT being roughly 50% of the wet film thickness.

On blast and paint or spot blast and paint contracts, take DFT readings at each stage of the operation. When painting over an existing coating system, take DFT readings on the existing coating to establish a DFT baseline.

The measuring of DFT's isn't always an exact science. Taking measurements over the course of multiple applications of coatings, on top of an existing coating system, can be challenging even if you are careful to measure at the same locations. Do not hesitate to take several measurements around the local area of interest to verify that the readings are accurate.

The importance of adequate paint film thickness cannot be overstressed. All other things being equal, it is one of the factors that determine the service life of a paint job. It follows, therefore, that sufficient measurements should be taken to assure specified thicknesses in all places.

7 – Protective Measures

Inherent in a bridge painting operation is the possibility of the creation of a nuisance, or of physical damage to adjacent property or to the traveling public. This is particularly true on contracts involving the repainting of structures over traffic. A containment system will most often be required on all projects to prevent the discharge of wash
water and any blasting or paint debris. Check the contract Special Provisions for additional details.

Although the responsibility for the prevention of damage rests with the Contractor, the Structure Representative must constantly be aware of the job situation and should not hesitate to call the existence of hazards or potential sources of damage to the Contractor's attention.

In the event passing automobiles are spattered with paint, little damage will occur if the paint is immediately removed with a compatible solvent or with water for water-borne paints. However, this should not be a common occurrence. A prudent contractor will use protective devices such as drop cloths, screens, overhead tarps, and the like to adequately protect passing traffic or adjacent property.

Particular emphasis should be placed on the protection of concrete surfaces which are a part of the structure. The Contractor should not be allowed to mix paint or charge paint pots on bridge decks without adequate drop cloths. It is next to impossible to remove paint from concrete, and particular care should be exercised to prevent spattering such surfaces. After the paint is dry, the area should be rubbed with a stone and wire brushed, or lightly blast-cleaned.

The coating being sprayed can drift as much as a quarter mile or more, and contractors should be reminded of this possibility, particularly if automobiles are being parked nearby.

Ventilated containment systems may be necessary for the project and must comply with scaffolding specifications. A table summarizing the available bridge load capacity is usually provided in the Contract Specifications. Contact the designer if this is not provided. The containment system plans are submitted as action type submittals and reviewed by the Structure Representative. The specified concentrated loads in the Contract Specifications originate from the SM&I Paint Coordinator and account for typical equipment used in the cleaning and painting process.

When working with existing paint systems containing lead or other hazardous materials, a negative pressure containment system is utilized to control airborne lead particles and prevent their migration outside of the containment. In this setup, air flows into the containment and is filtered before being allowed to exit. This way no particles can exit the containment structure.

In general, the best protective measure is the anticipation of possible damage and prevention of its occurrence.
8 – Paint Records and Reports

The following forms must be completed and are used to keep paint records for each phase of cleaning and painting operations:

Form SC-4601, Daily Clean and Paint Record
Form SC-4807, Spot-Sandblasting Report
Form SC-6302, Clean and Paint Cost Summary
Form SC-6305, Paint Record

Per BCM C-6, Required Documents to be Submitted During Construction, Form SC-6305, Paint Record, must be submitted to SC HQ by email to sc.office.associates@dot.ca.gov, immediately after the structure is painted. Paint forms were developed to simplify the reporting of statistical data as well as to ensure uniformity in record keeping. Structure Representatives should be familiar with the use of these forms and should enter the required information on them.

In addition to the paint records, the Resident Engineer's and/or Assistant Resident Engineer's Daily Reports are required for the painting operation.

The blast-cleaning and paint record Form SC-4601, Daily Clean and Paint Record, is a diary form used by the Structure Representative for the various phases of the cleaning and painting work. These diaries have the same significance as a daily diary and therefore should receive the same degree of care in their preparation and distribution.

Form SC-4807, Spot-Sandblasting Report, is a record of spot blast cleaning performed. The purpose of this form is to have the Structure Representative and the Contractor's representative agree, on a daily basis, on the amount of spot blast cleaning that was performed.

On repainting projects, the Structure Representative will prepare, from the information gathered in the daily diaries, cost data for the various phases of blast-cleaning and painting. This data will be entered on the paint data sheets, Form SC-6302, Clean and Paint Cost Summary. Use of this form aids the Structure Representative in making a systematic and uniform record of cost data.

Following completion of the painting operation, statistical information included on the paint record sheets is summarized on Form SC-6305, Paint Record. The primary purpose of the information summarized on this form is to provide a sound basis for estimating the cost of future painting projects. This also provides information regarding the type and quantities of paint used, which may be used for future paint projects.

The forms in this section must be completed as the work progresses. Delays will result in the loss of information and a potentially large backlog of documents.
9 – Surface Area Computations

The area to be cleaned and coated is an important part of the paint inspection procedure. The surface area must be known to enable the Structure Representative to determine the true rate of progress and to calculate coverage rates. Surface area calculations are also of great value in the planning of future painting contracts. Surface areas of most structures are available in the Sacramento Structures Maintenance and Investigations (SM&I), which is within the Division of Maintenance. These records may also be available from the Designer or may be included in the Structure Resident Engineer’s Pending File. If they are not available, it will be the responsibility of the Structure Representative assigned to the project to calculate them. All calculations should be clearly shown so they may be easily checked by another person. Include subtotals for each span and a separate summary sheet for each structure in the project.

Submit surface area computations with Form SC-6305, Paint Record, as an attachment to the Paint Record for future reference.

These surface area computations will assist the Structure Representative in completing the required as-built plan sheets at the completion of the project.

On request, charts to assist in the calculation of surface areas will be furnished to the project by SM&I.

10 – Payment

Before the painting operations begins, request a schedule of values for payment purposes on Lump Sum items from the Contractor.

Discuss with the designer how the spot blast and paint quantities were developed. It is good practice to track this quantity to monitor cumulative usage through the project to prevent overruns.

11 – As-Built Plan Sheets

The information that should be included on the as-built plan sheets includes:

1. The method of paint application: clean and paint, blast and paint, spot blast and paint or other combinations
2. The coating system utilized
3. The spot blast clean square feet area total
4. The average dry film thickness of the existing coating system after initial cleaning
5. The average dry film thickness of all coatings
6. The average of the applied paint thickness (total – initial)

The averages should represent large areas throughout the structure; for example if the structure is a simple four span bridge, it could be divided up into 4 locations. See Figure 4, As-Built Plan Example, for a sample of an as-built plan sheet.

12 – Coatings Used by the Department

The different types of coatings currently being used by the Department are identified and listed on the Approved Materials List (AML) which can be found at the following links:

https://dot.ca.gov/programs/engineering-services/bridge-paint-pavement-striping-paints - is a list of the standard bridge paint coatings used by Structure Construction, as well as pavement striping paints used by the Department.

https://dot.ca.gov/-/media/dot-media/programs/engineering/documents/mets/inorganic-zinc-primer-a11y.pdf - is a list of approved inorganic zinc-rich primers, and


No coating is to be used unless it is on the Departments AML or meets the specifications of the Department's standard coatings.

13 – Environmental Protection

Structure Construction must comply with regulations imposed by various public environmental protection agencies which operate statewide. The primary concerns of these agencies are air and water pollution as well as noise abatement.

Curtailment methods for dust and waste products include confinement within the immediate work area and use of abrasives which create less dust. Wet-blast cleaning may be another alternative, subject to authorization of the Engineer, and in conformance with the specifications.

Confinement of waste products and dust is accomplished by using an engineered containment system. The confined waste materials are then collected, tested, and hauled to an authorized waste handling facility by an authorized transporter.

Copper, silver, and nickel slags are sources of abrasives commonly used. These abrasives are more expensive than sand. All abrasives for dry, unconfined blasting including sand, must be approved by the Air Resources Board.
Lead pigmented paints are no longer being specified for use on structural steel because of their toxicity. However, lead pigmented paints may still be present on existing structures and proper precautions need to be taken when working around lead and other hazardous materials such as chromium. A site-specific safety plan is required when working around these systems. Refer to BCM B-2, SC Lead Compliance Plan, for additional information.

The appropriate Personal Protective Equipment (PPE) should be used, and respirators must be utilized, when working in an area where hazardous paints are being disturbed. See Chapter 12, Personal Protective Equipment, and Chapter 15, Respiratory Protection Program, of the Caltrans Safety Manual. Note that a physician’s examination and fit testing is required for the use of half-face and full-face respirators. Lead Compliance Training must be completed prior to working on a bridge painting project where hazardous paints are present.

14 – How to Operate a Sling Psychrometer

There are different manually operated sling psychrometers available. They all operate under the same principle of determining wet and dry bulb temperatures as follows:

1. Inspect the instrument to verify:
   a. The cotton wick on the wet bulb is in good condition, in contact with the end of the bulb and not yellow or frayed.
   b. If the instrument utilizes a reservoir, that the reservoir holds water and the cap is in place.
   c. The thermometer body rotates freely around the handle.

2. Thoroughly saturate the wick with distilled water. Replace the wick if water beads up and does not soak in. For reservoir type units, fill the reservoir with distilled water.

3. Facing the wind, rotate the thermometer body around the handle at a steady rate.

4. At the one-minute mark, record both the wet and dry bulb temperatures.

5. Rotate the instrument for another minute and record both the wet and dry bulb temperatures.

6. If the temperatures have not changed, proceed to the next step. Otherwise continue until there are no changes. The goal is to take the readings once the thermometers have stabilized.

7. Determine Relative Humidity using the following method depending upon the psychrometer type:
a. Open Thermometer Type:
   i. Calculate the difference between the wet and dry bulb temperatures.
   ii. Use the Relative Humidity Table to interpolate the relative humidity value based upon the dry bulb temperature and calculated value.

b. Reservoir Type:
   i. Reset the temperature body back into the handle.
   ii. Slide the body until the wet temperature and dry temperature scales coincide.
   iii. Read the relative humidity value as indicated by the arrow on the lower scale.

15 – Typical Paint Kit Contents

SC assembles and issues paint kits to Structure Representatives for use in administering painting contracts. This kit typically includes the following, and may change due to supply:

1. Magnetic surface thermometer
2. Digital Thermometer
3. Hygrometer / Digital Psychrometer
4. Sling Psychrometer
5. Coating Thickness Gauge
6. Dial Thickness Gauge
7. Inspection Mirror
8. Surface Profile Tape
9. Soluble Salt Test Kit
10. Chloride Test Kit
11. Feeler Gauge

The contents of the kit include instruments that will need periodic calibration and consumables that need to be replaced as needed. Please contact SC Headquarters to coordinate calibration and for restocking of consumables.

Additionally, the following tools are recommended:

1. Dull putty knife for scraping loose paint.
2. Chalk or soapstone to mark structural steel.

3. Painter's tape for marking surfaces.
Information shown is approximate only and not to scale. Compiled from records of existing bridges on the State Highway System.

Figure 3. Paint Service Life on Structural Steel Bridges
Figure 4. As-Built Plan Example
Structural Steel Coatings – Painting Galvanized Surfaces

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for preparation and painting of galvanized metal surfaces.

This process is in addition to general activities for structural steel coatings and galvanizing described in:

1. BCM 59-1, Structural Steel Coatings – General
2. Contract Specifications:
   a. Section 59-4, Structural Steel Coatings – Painting Sign Structures
   b. Section 75-1.02B, Miscellaneous Metal – General – Materials – Galvanizing
   c. Section 91-2.02, Paint – Paint for Metal – Materials, for potential coating standards.

Prior to reviewing this Bridge Construction Memorandum (BCM), it is essential to review the Contract Specifications, Section 59-3, Structural Steel Coatings – Painting Galvanized Surfaces, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.

Process Inputs

Authorized submittals per Contract Specifications, Section 59-1.01C, Structural Steel Coatings – General – Submittals.
Procedure

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:
   a. Intermittent for preparation and painting of galvanized steel surfaces.

3. Before construction begins the Structure Representative (SR) or delegate must:
   a. Review the contract documents for requirements pertaining to:
      i. Painting structural steel
      ii. Painting galvanized surfaces
      iii. Specified paint system including paint color
      iv. Painting sign structures
   b. Review Construction Manual, Chapter 4-59, Structural Steel Coatings.
   c. Consult with the Materials Engineering & Testing Services Representative (METS Rep) for questions related to surface preparation and coatings application requirements.
   d. Attend a prepainting meeting with the METS Rep, the Contractor, and all painting sub-contractors as necessary.
   e. Arrange with the Bridge Construction Engineer (BCE) to complete:
      i. SC’s training course # 101059, Contract Administration of Field Clean & Paint Steel, which is provided on demand.
         1. If the training is not available, review the course material on the SC Intranet under the Training tab.
      ii. Mandated safety training as applicable, which may include: respirator, confined space, and fall protection training.
   f. Obtain testing equipment from the SC Paint Kit which includes dry film thickness (DFT) gauge, surface temperature gauge, hygrometer or sling psychrometer.
   g. Consult with the Resident Engineer (RE) regarding issues related to the control of wash or steam cleaning water, and other environmental requirements.
   h. Review applicable authorized submittals per:
      i. BCM 59-1, Structural Steel Coatings – General.
      ii. BCM 56-2.01C, Overhead Sign Structures, Standards, and Poles – Overhead Sign Structures – General – Submittals
i. For the State Specification PWB-174A paint system, review the specifications provided on the METS Bridge Paint and Pavement Striping Paints link.

j. Review coating manufacturer’s guidelines and recommendations for surface preparation, painting, drying, and curing and compare to the requirements in the Contract Specifications.

k. Review Society for Protective Coatings (SSPC as referenced in the product guidelines, and as applicable for surface preparation and coatings application).

l. Coordinate with the Contractor to implement protective measures that minimize damage (accidental paint) to adjacent concrete surfaces or other surfaces and properties not designated for painting (e.g., drop cloths, screens/barriers, overhead tarps, etc.).

m. Review personal protective equipment (PPE) requirements and safety hazards associated with the painting operation. Inspection may require:
   i. Fall protection when working on elevated surfaces or manlifts.
   ii. Dust masks/ respirators for incidental exposure to airborne hazards resulting from the operations.

4. During construction the SR or delegate must:

   a. Verify that shop coated materials arriving at the jobsite have been inspected by METS per Form TL-6042, Coating Inspection Report. If the painted or galvanized surface is damaged (flaking, peeling, rusting, pitting, etc.):
      i. Notify the Contractor in writing that the damaged surfaces are rejected and request a repair plan adhering to Contract Specifications, Section 75-1.02B, Miscellaneous Metal – General – Materials – Galvanizing.
      ii. Verify the damaged galvanized surface is repaired per authorized repair plan.
      iii. If satisfactory field repair is difficult or cannot be achieved, consult with the METS Rep.

   b. For materials painted at the job site:
      i. Review the project Storm Water Pollution Prevention Plan or Water Pollution Control Plan and verify that it includes measures to address the cleaning and painting process.
      ii. Verify if containment systems or ventilated work areas are required.
      iii. Verify if scaffolding or other work platforms will be utilized. Review safety precautions for use, including daily inspections.
iv. Inspect galvanized surfaces for defects or damage and verify repairs are performed per the *Contract Specifications*, Section 75-1.02B, *Miscellaneous Metal – General – Materials – Galvanizing*.

v. Verify procedures for surface preparation, paint application, drying, and curing are performed in accordance with the requirements of the contract documents, *State Specification*, authorized submittals, and manufacturer’s recommendations.


2. Verify that the 2nd finish coat color matches the required color in the *Contract Specifications*.

vi. Perform timely inspections including verification of safely executed operations, obtaining and verifying contractor quality control test results, performing Quality Assurance (QA) testing, and accepting or rejecting work.

vii. Obtain and evaluate METS and Assistant Structure Representative’s QA test results.

viii. Issue formal notification of rejection for failed tests and request a remediation plan for review and authorization.

c. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, *Daily and Weekly Reports*.

5. Following construction, the SR or delegate must:

a. Complete required documents and forward to SC Headquarters as applicable:

   i. *Form SC-6305*, *Paint Record*

   ii. *Form SC-6302*, *Clean and Paint Cost Summary*

b. Document paint information on the as-built project plans; reference BCM 59-2, *Attachment 1*, *Cleaning and Painting of Structural Steel*.

6. File all test results and Daily Reports in the appropriate category in the project records as specified in the *Construction Manual*, *Section 5-102*, *Organization of Project Documents* and BCM Section 4, *Control of Materials*.

**Process Outputs**

1. Daily Reports
2. Completed Form SC-6302, *Clean and Paint Cost Summary* and Form SC-6305, *Paint Record*

3. Properly painted galvanized surfaces

**Attachments**

None
Structural Steel Coatings – Painting Sign Structures

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BCM 59-4, *Structural Steel Coatings – Painting Sign Structures*, has not been posted yet.
BCM 59-5, *Structural Steel Coatings – Thermal Spray Coat Structural Steel*, has not been posted yet.

Until it is posted refer to the *Contract Specifications*, Section 59-5, *Structural Steel Coatings – Thermal Spray Coat Structural Steel*. 
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<td>12-22-2022</td>
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Memo No  Issue Date  Title
60-2.02A(3&4)  12/31/2021  EXISTING STRUCTURES – STRUCTURE REMOVAL – BRIDGE REMOVAL – GENERAL – SUBMITTALS AND QUALITY ASSURANCE
60-2.02C  08/31/2020  EXISTING STRUCTURES – STRUCTURE REMOVAL – CONSTRUCTION
60-3.02  07/15/2021  EXISTING STRUCTURES – STRUCTURE REHABILITATION – BRIDGE DECK REPAIR & PREPARATION
60-3.03B  07/15/2021  EXISTING STRUCTURES – STRUCTURE REHABILITATION – METHACRYLATE RESIN BRIDGE DECK TREATMENT
60-3.04B&C  04/29/2022  EXISTING STRUCTURES – STRUCTURE REHABILITATION – DECK OVERLAYS – POLYESTER CONCRETE OVERLAYS & EXPANSION DAMS
60-3.04D  01/05/2023  EXISTING STRUCTURES – STRUCTURE REHABILITATION – DECK OVERLAYS – CONCRETE OVERLAYS
60-3.05B  07/15/2021  EXISTING STRUCTURES – STRUCTURE REHABILITATION – REPAIRING SPALLED SURFACE AREA
60-3.05C  06/30/2022  EXISTING STRUCTURES – STRUCTURE REHABILITATION – EPOXY CRACK INJECTION
60-3.05D  11/23/2022  EXISTING STRUCTURES – STRUCTURE REHABILITATION – HEAT STRAIGHTEN STEEL GIRDER
60-4.04  12/22/2022  EXISTING STRUCTURES – MODIFYING STRUCTURES – CORING CONCRETE
60-4.06  05/31/2022  EXISTING STRUCTURES – MODIFYING STRUCTURES – STEEL COLUMN CASINGS
60-4.09  10/28/2022  EXISTING STRUCTURES – MODIFYING STRUCTURES – BRIDGE JOINT RESTRainers
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Existing Structures – Structure Removal – Bridge Removal – Construction

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for inspection of bridge removal activities, including determining the need for additional exploratory work for unforeseen damage prior to bridge removal, protective covers, and assessing whether aspects of bridge removal work can be classified as preliminary work.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review Contract Specifications, Section 60-2.02C, Existing Structures – Structure Removal – Construction, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Authorized Bridge Removal Work Plan
2. Authorized Debris Containment and Collection Plan
3. As-Built Drawings for existing structures
4. Authorized Lead Compliance Plan
5. Authorized Water Pollution Control Plan and other environmental requirements/submittals
Procedure

All work associated with this process is charged as Project-Direct – Construction.

1. Inspection of field work for this process is:
   a. Continuous for bridge removal and installation, jacking, and removal of temporary supports.

2. Before construction begins:
   a. Review:
      i. Contract documents, permits, licenses, and agreements.
      ii. Construction site.
      iii. Railroad demolition guidelines (if applicable).
      iv. As-built plans.
      v. Authorized submittals (see Input section of this BCM).
      vi. Construction Manual, Chapter 4, Section 60, Existing Structures.
   b. Document condition of existing structures to remain.
   c. Determine whether additional exploratory work of existing bridge members for unforeseen damage is needed.
   d. Conduct a pre-bridge removal meeting:
      i. The following responsible parties should attend:
         1. Contractor
         2. Engineer of Record for bridge removal work plan.
         3. Demolition subcontractor (if applicable).
         4. District (Resident Engineer, and others as required; for example, Public Information Officer, Traffic Operations).
         5. Railroad representative (if applicable).
         6. Assistant Structure Representatives assigned to the work.
      ii. Discuss and coordinate among the responsible parties, including but not limited to:
         1. Authorized bridge removal work plan.
         2. Key contact persons and phone numbers.
5. Removal of any items to be salvaged and stored.
7. Personnel Protective Equipment including fall protection, respirators, etc.
8. Hazardous material handling, storage, and removal.
10. Protecting adjacent facilities and utilities.
11. Lane closure schedule (if applicable).
12. Contingency plan (if applicable).

e. If the contractor wants to perform preliminary bridge removal work, determine allowable activities that can be performed. Consider the following:
   i. Structural stability during and after each partial demolition segment.
   ii. The partial removal component is no longer in use by the public or Caltrans.
   iii. The necessary protective measures are in place.

f. If railroad is involved, schedule railroad flagman and observer (if required), at least two weeks in advance of removal operation.

3. During construction:
   a. Verify that the engineer of record for the bridge removal work plan is present during removal operations.
   b. If railroad is involved, verify flagman and railroad observer (if required) are present.
   c. Coordinate traffic control and local agency requirements with resident engineer and contractor.
   d. Verify conformance with the authorized bridge removal work plan and contract documents.
   e. Verify required work area monitoring is being performed in accordance with contract documents.
   f. Verify hazardous materials are stored and removed in accordance with:
      i. Authorized Debris Containment and Collection Plan.
      ii. Authorized Lead Compliance Plan.
      iii. Authorized Water Pollution Control and other Environmental Requirements/Submittals.
g. Verify work practices and worker health and safety conform to California Code of Regulations, Title 8, *Construction Safety Orders*.

h. Review daily inspection reports prepared by engineer signing the bridge removal work plan

i. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-4.04, *Daily and Weekly Reports*.

4. Following construction:

   
   b. File all correspondence and daily reports in the appropriate category in the project records as specified in the CM 5-1.02, *Organization of Project Documents*.

**Process Outputs**

1. Daily Reports
2. Disposal Documentation
3. As-Builts

**Attachments**

None
Existing Structures – Structure Rehabilitation – Bridge Deck Repair and Preparation

Revision and Approval

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<td>Original Issue</td>
<td>Michael Francis</td>
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Background

This process establishes Structure Construction (SC) roles and responsibilities for bridge deck repair and preparation of the bridge deck for sealing or an overlay. Structure Construction acts to preserve and extend the life of the State’s infrastructure by the most economical and efficient means.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 60-3.02, Existing Structures – Structure Rehabilitation – Bridge Deck Repair and Preparation, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Submittals required by the Contract Specifications for work that requires bridge deck repair

Procedure

1. All work associated with this process is charged as: Project-Direct – Construction.
2. Inspection of field work for this process is:
a. **Benchmark** for removal of bridge deck surfacing, seals, and unsound concrete; and preparing the bridge deck surface for sealing or overlays.

b. **Continuous** for installing rapid setting concrete patches, sealing and/or overlays.

3. Before construction begins:
   
a. Review the following:
      
i. Contract plans for bridge deck preparation limits.


      iii. Documents from the Structures Maintenance and Investigations BIRIS website for each site planned for repair:
         1. The as-built plans.
         2. Latest bridge inspection reports.
         3. Previous test results conducted by bridge maintenance staff for each site.

      iv. For methacrylate application, review the *Contract Specifications*, Section 41-3, *Existing Concrete Pavement – Crack Treatment*, and applicable sections of the Special Provisions for contractor's Public Safety and Application Plan.


b. Review and authorize contractor's work plan chip seal removal submittal.

c. Verify the concrete repair material the contractor plans to use is on the Authorized Materials List (AML), *Precast Concrete Cementitious Based Repair Materials* (These products are also used on non-precast concrete).

d. Take photos to document the existing condition of all sites that will be repaired.

e. Review freeway lane closure charts with the Resident Engineer, and discuss any issues (discrepancies, omissions, etc.) that could affect deck repair and preparation work.

f. Suggest scheduling a preconstruction meeting to discuss submittals, quantities, correspondence, communication, request for information (RFI's), material release or any issues that may need stakeholder's input.

4. During construction:
a. Determine the limits of unsound concrete by chaining the deck.

b. Mark the areas that require repair and discuss with the contractor.

c. Store and/or dispose of materials removed per the authorized submittal for chip seal removal.

d. After unsound concrete is repaired, calculate payment quantities per Contract Specifications, 60-3.02D, Existing Structures – Structure Rehabilitation – Payment, and document in the daily diaries.

e. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the daily reports per BCM C-4.04, Daily and Weekly Reports.

f. Transfer all field changed details and dimensions from the original plans to the new as-built plans. Document as-built changes on the as-built plans.

5. Following construction:

a. Enter material information on the Report of Completion.

6. File all materials acceptance documentation and daily reports in the appropriate category in the project records as specified in the Construction Manual, 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized submittals

2. Information on Required Document including Report of Completion and as-builts

3. Daily reports and quantities

**Attachments**

None
Existing Structures – Structure Rehabilitation – Methacrylate Resin Bridge Deck Treatment

Revision and Approval

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for submittal review, quality assurance, materials inspection, construction of, and payment for methacrylate resin bridge deck treatment.

Requirements for deck surface preparation are detailed in:
- **BCM 60-3.02**, Existing Structures – Bridge Deck Repair and Preparation

Requirements for friction testing are detailed in:
- **BCM 51-1.01**, Concrete Structures – General

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 60-3.03B, Existing Structures – Structure Rehabilitation – Methacrylate Resin Bridge Deck Treatment, that this BCM is based on as identified in the title block above. The information in the contract specification(s) typically will not be repeated in the text of this BCM.

Process Inputs

1. Submittals required by the Contract Specifications for work that requires methacrylate
**Procedure**

1. All work associated with this process is charged as [Project-Direct – Construction](#).

2. Inspection of field work for this process is:
   a. [Continuous](#) during methacrylate placement.

3. Before construction begins:
   a. Review the following:
      i. Contract documents
      ii. *Concrete Technology Manual, Chapter 6, Structure Concrete Repair and Rehabilitation*
      iii. [Attachment 1, Methacrylate Deck Treatment Inspection Guidelines](#)
   b. Review and authorize the following:
      i. Work plan for applying the methacrylate resin treatment
      ii. Manufacturer’s product data and material Safety Data Sheets
      iii. Contingency Plan
   c. Review the Resident Engineer authorized:
      i. Traffic Management Plan
      ii. Lead Compliance Plan
      iii. Public Safety Plan.
   d. Verify the methacrylate was tested and released by Materials Engineering and Testing Services (METS):
      i. Call METS Translab to verify the lot number on the Certification of Compliance.
      ii. If necessary (when material storage condition is of concern), collect a sample for additional testing and send to Translab with Form TL-0101, [Sample Identification Card](#).
   e. Verify SC staff have trained and fit tested to use respirators per the [SC Code of Safe Practice](#).
   f. Verify the location to be treated meets contract requirements, BCM 60-3.02, [Bridge Deck Repair and Preparation](#).
   g. Hold preconstruction meeting with the contractor to discuss the required test area, skid testing, pretreatment deck repair (if needed), application equipment, safety, abrasive cleaning methods, and contingency plan if the resin does not cure in time.
h. The Structure Representative should ensure that Assistant Structure Representatives are made aware of the applicable submittals for performing work.

i. Review the contractor's look ahead schedule and discuss with the METS representative for upcoming test for the surface skid resistance.

j. Verify and authorize the location of test area:
   i. Perform steps 4.a. thru 4.h.
   ii. Verify the completed test area demonstrates compliance with the contract requirements, applicable authorized submittals and the manufacturer's recommendations (i.e., application rate, initiator/promotor amount, set time, coefficient of friction, mixing guidance/sequence, equipment, tools, etc.).
   iii. Review and authorize airborne emissions monitoring of the test area. Refer to the Cal/OSHA title 8, Section 5155, Airborne Contaminants, for information regarding Permissible Exposure Limit (PEL).
   iv. Arrange for coefficient of friction test, California Test 342, Method of Test for Surface Skid Resistance with the California Portable Skid Test, BCM 51-1.01, Concrete Structures – General.
   v. Authorize or reject the treated surface at the test area.

4. During construction:
   a. Verify that material arrived at the site has been tested by METS.
   b. Verify the concrete surface is cleaned prior to methacrylate application per Contract Specifications 60-3.02C(7), Existing Structure – Bridge Deck Repair and Preparation – Prepare Concrete Deck Surface.
   c. Prior to application of methacrylate, check if conditions, relative humidity, and deck surface temperature are within the requirements of contract documents.
   d. Coordinate lane closures with the District.
   e. Track the amount of methacrylate resin, sand, and diatomaceous material that is placed and produce pay quantities.
   f. Verify manufacturer mixing guidance/sequence in the field to avoid accidents resulting in fire or explosion.
   g. Review the production airborne emissions monitoring after completing treatment activities.
   h. Monitor the production applications and finished deck texture for similarity with the test area.
i. If production application and texture differ from test area, arrange for Coefficient of Friction test, CTM 342, *Method of Test for Surface Skid Resistance with the California Portable Skid Test*; and BCM 51-1.01, *Concrete Structures, General*.

j. Document all inspection, construction, and quality assurance activities, pertinent to the BCM in the Daily Reports per BCM C-4.04, *Daily and Weekly Reports*.

5. Prior to opening the treated area to traffic verify Standard Specifications Section 60-3.03(B)(3), *Existing Structures – Bridge Deck Treatment – Methacrylate Resin Bridge Deck Treatment – Construction*, conditions are met.

6. After construction:
   a. Record any changes to the as-built plans.

7. File all materials acceptance documentation and Daily Reports in the appropriate category in the project records as specified in the *Construction Manual*, 5-102, *Organization of Project Documents*.

### Process Outputs

1. Authorized submittals
2. Materials certification documentation
3. Lane Closure coordination
4. Methacrylate placement quantities
5. Rehabilitated bridge deck
6. Skid test results
7. Daily Reports for the work performed
8. As-built plans

### Attachments

*Attachment 1*, *Methacrylate Deck Treatment Inspection Guidelines*
Methacrylate Deck Treatment Inspection Guidelines

Methacrylate deck crack treatment uses methacrylate resin to seal cracks in concrete bridge decks and is designed to be a crack sealer only. It is not a surface overlay. Methacrylate resin is used to repair newly placed decks that exceed the crack intensity limits and to rehabilitate existing bridge decks that have deteriorated over time.

Typically, the resin is applied to the deck surface by hand or mechanically sprayed and spread with a broom or squeegee. In general, the application of methacrylate on a bridge deck is a simple process. However, careful inspection is needed to assure the treatment is effective and that the treated surface maintains a desirable roadway surface condition.

This attachment contains inspection guidelines to assist Structure Construction staff when inspecting a methacrylate application.

Additional information regarding methacrylate is available in the Concrete Technology Manual.

During Construction Operations

1. As a rule of thumb, 100 ft²/gal (2.45 m²/liter) is a good starting point for the spread rate of resin on normal concrete. Lightweight concrete will require more resin and may reduce the spread rate to about 65 ft²/gal (1.6 m²/liter). For very dense concrete, less resin is required, and the spread rate can increase to about 175 ft²/gal (4.29 m²/liter). As a rule of thumb, the surface above cracks should be slightly wet with resin, 20 minutes after application. This is an indicator that the cracks are completely filled. If dry after 20 minutes, increase the amount of resin being applied. If ponding is evident, reduce the amount of resin. It is essential that the resin remains fluid long enough (40 to 90 minutes) for the cracks to be filled. If rapid gelling occurs the material should be rejected.

2. Methacrylate resin must only be applied to the deck area. The contractor is required to protect or avoid placing resin on other parts of the structure (e.g., barrier rails, joints, drainage facilities, etc.). It is important to ensure resin does not leak or drip into waterways, roadways, or parking areas below the bridge. Sealing of joints and scupper drains is one method to prevent this.

3. Sand is applied to increase skid resistance. Careful inspection of the deck surface after the sand application is needed to ensure that the sand adheres to the deck. Any areas found absent of sand adhesion must be abrasively blasted. Vacuum attachments must be used during abrasive blasting operations.
4. Apply absorbent material. The absorbent material removes oily residue that can form and prevents tracking of residue onto the adjacent pavement.

5. The Contract Specifications include deck surface condition, temperature range and ambient relative humidity limits for application of high-molecular-weight methacrylate (resin). The deck must be dry, between 50-100 degrees Fahrenheit, and the relative humidity must not exceed 85% during application. Suggest utilizing an “Hourly Weather Forecast” tool such as one found in NOAA (National Oceanic and Atmospheric Administration), to view the forecast a few days in advance of upcoming work shifts, and share any concerns with the contractor prior to actual start of shift. In coastal areas, the relative humidity may often exceed the acceptable threshold during the night in late spring and early summer.

6. Verify manufacturer mixing guidance/sequence in the field to avoid accidents resulting in fire or explosion. Flash fire will occur if promoter (typically purple color) comes in direct contact with initiator (typically clear color). Check manufacturer’s website for most current mixing guidance.

**Typical Problems Associated with Bridge Deck Methacrylate Resin Treatment Operations**

1. **Oiliness**: The tack, or the oiliness, of methacrylate resin can create serious problems, especially in cold night closures. Opening traffic lanes prior to the complete cure of the resin can cause the tracking of residue, oiling of cars, and/or reduced skid resistance. This issue is due to oxygen inhibition of the top surface. Methacrylate resin cures from the lack of oxygen; thus, the exposed surface tends to cure last. Even if the bulk of the resin sets up and can resist penetration with a screwdriver, the surface can still be covered with an oily sheen. Modern methacrylate resins contain additives to prevent this phenomenon.

2. **Inability to spread material**: Heat and sunlight can cause methacrylate to set faster. Occasionally, the resin will set before the material is spread. This causes the worst case for crack sealing as it prevents the resin from properly flowing into the cracks.

3. **Sand does not adhere**: Resin that sets prior to applying sand will result in the creation of glassy spots. The glassy areas may have reduced skid resistance and remedial work to repair these areas would be required. Methods that have been proven effective are to abradively blast the glassy areas. For larger areas where the sand was not promptly applied and didn’t adhere, resin and sand can be reapplied (time permitting).
Existing Structures – Structure Rehabilitation – Deck Overlays – Polyester Concrete Overlays and Expansion Dams

**Revision and Approval**

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**Background**

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, materials, construction, and payment of polyester concrete overlays and expansion dams.

Polyester concrete is used by Caltrans to provide a wearing surface and prevent intrusion of salts and other chemicals into concrete bridge decks, thus extending the service life of bridge decks. Also, polyester concrete can be used to repair concrete decks by removing unsound concrete and replace it with polyester concrete. Additionally, polyester concrete may be used to correct surface profile or cross section of structures to provide improved drivability, drainage and/or bridge deck configuration.

Additional unique requirements for Polyester Concrete Overlays and Expansion Dams are detailed in BCM 60-3.03B, *Existing Structures – Methacrylate Resin Bridge Deck Treatment*.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, 60-3.04B-C, Existing Structures – Structure Rehabilitation – Deck Overlays – Polyester Concrete Overlays and Expansion Dams, that this BCM is
based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Submittals per contract documents

**Procedure**

1. All work associated with this process is charged as [Project Direct – Construction](#).
2. Inspection of field work for this process is:
   a. [Continuous](#) during placement of polyester concrete overlay.
3. Before construction begins:
   a. Review the following:
      i. [Contract documents](#)
      ii. [Attachment 1, Polyester Concrete Overlay & Expansion Dams](#)
      iii. [Concrete Technology Manual (CTM), Chapter 6, Structure Concrete Repair and Rehabilitation – Bridge Deck Rehabilitation – Methacrylate Overlays](#)
      iv. Authorized Traffic Management Plan
      v. Authorized Lead Compliance Plan
   b. Review and authorize the following:
      i. Work plan for placement of polyester concrete overlay
      ii. Public Safety Plan
   c. Forward [Form CEM 3101, Notice of Materials to be Used](#), to Materials Engineering and Testing Services (METS).
   d. Verify the material was tested and released by METS:
      i. Call METS Translab to verify the lot number on the COC.
      ii. If necessary (when material storage condition is of concern), collect a sample for additional testing and send to Translab with Form TL-0101, [Sample Identification Card](#).
   e. Verify that SC staff have been medically cleared, trained, and fit tested to use respirators.
f. Verify that the location to be overlaid meets contract requirements, and **BCM 60-3.02, Existing Structures – Structure Rehabilitation – Bridge Deck Repair and Preparation**.

g. Hold a preconstruction meeting with the contractor to discuss the required deck repair area, test area, skid testing, application equipment, safety, abrasive cleaning methods, and the contingency plan if the resin does not cure in time.

h. Communicate all authorized submittals with Assistant Structure Representative and Resident Engineer.

i. Review the contractor’s three week look ahead and discuss with the **METS Representative** for upcoming friction tests.

j. Review and authorize contingency plan for polyester concrete overlay.

4. During construction:

a. For the test area, perform the following:

i. Verify that the material that arrived at site has been tested by METS.

ii. Verify that the **CTM 109, Method of Testing of Material Production Plants**, certification is current.

iii. Verify that the concrete surface is cleaned prior to placement of polyester concrete overlay per the contract documents.

iv. Prior to placement of the polyester concrete overlay, check that the weather conditions, relative humidity, and deck surface temperature are within the requirements of the contract documents.

v. Coordinate lane closures with the Resident Engineer.

vi. Track the amount of methacrylate/polyester resin material placed and produce pay quantities.

vii. Complete Daily Reports for the work performed.

viii. Review production airborne emissions monitoring after completing polyester concrete overlay placement activities.

ix. Verify that the completed test area demonstrates compliance with contract requirements, applicable authorized submittals, and the manufacturer’s recommendations (i.e., application rate, initiator/promotor amount, set time, coefficient of friction, mixing guidance/sequence, equipment, tools, etc.).

x. Review and authorize airborne emissions monitoring of the test area (Cal/OSHA GISO § 5155, **Airborne Contaminants**, regarding Permissible Exposure Limit for Hazardous Substances.)
xi. Arrange for coefficient of friction test, **CTM 342, Method of Test for Surface Skid Resistance with the California Portable Skid Test**, **BCM 51-1.01**, **Concrete Structures – General**.

xii. Review and authorize the treated surface at the test area.

b. For production work, repeat steps 4.a.i. thru 4.a.xi.

c. Prior to opening the overlaid area to traffic verify the following **Contract Specifications**, Section 60-3.04B(3)(c), **Existing Structures – Structure Rehabilitation – Deck Overlays – Polyester Concrete Overlays – Construction – Placing Polyester Concrete**, requirements are met:

i. The completed concrete deck surface has a uniform surface texture with a coefficient of friction of at least 0.35 when tested under CTM 342 and the surface smoothness is complying with the **Contract Specifications**, Section 51-1.01D(3)(b)(ii), **Concrete Structures – General – Quality Assurance – Department Acceptance – Test Concrete Surfaces – Surface Smoothness**.

ii. The polyester concrete overlay edges are tapered if the overlay is not completed within the allowable lane closure time, or the overlay is more than 1/2-inch higher in elevation than the adjacent pavement.

iii. The edges transverse to the direction of traffic are tapered at a 20:1 (horizontal: vertical) slope. Taper the edges that are longitudinal to the direction of traffic at a 4:1 (horizontal: vertical) slope.

5. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per **BCM C-7, Daily and Weekly Reports**.

6. Following construction:

a. Record any changes to the as-built plans. Refer to **BCM C-6, Required Documents to be Submitted During Construction**, for guidance.

7. File all project documentation (correspondence, materials acceptance documentation, Daily Reports, etc.) in the appropriate category in the project records as specified in the **Construction Manual, Section 5-102, Organization of Project Documents**.

**Process Outputs**

1. Authorized submittals
2. Materials certification documentation
3. Lane Closure coordination
4. Methacrylate/Polyester placement quantities
5. Rehabilitated bridge deck
6. Skid test results
7. Daily Reports
8. As-built plans

Attachments

Attachment 1: Polyester Concrete Overlay & Expansion Dams
Polyester Concrete Overlay & Expansion Dams

This attachment includes information to assist SC Staff when verifying the contract requirements are met during the placement of polyester concrete overlays and expansion dams.

1 - What is Polyester Concrete?

A very durable composite material made of hardened polyester resin and aggregate. The polymerized resin serves as the binding agent – similar to hydrated Portland Cement in Portland Cement Concrete (PCC).

2 - What are the Differences Between PCC and Polyester Concrete?

a. Polyester Concrete aggregates must have a moisture content less than 0.5% of the absorption capacity of the aggregates.
b. Polyester Concrete cannot tolerate moisture in the concrete matrix.
c. Polyester Concrete hardens much more quickly than PCC
d. Some materials used in Polyester Concrete are volatile and must be handled properly and safely.

3 - What are Typical uses of Polyester Concrete?

a. Bridge deck overlay
b. Expansion dam headers
c. PCC Repair

4 - What are Placement Methods of Polyester Concrete?

a. Drop-In or Brookhaven Method- This was a very old method that was used in 1950 to place Polyester concrete. It was also known as broom-and-seed method where the resin was broomed to the bridge deck first and afterwards the bridge deck was seeded with aggregate. This method exhibited poor performance and the overlay would fail early than expected by delamination.
b. Pre-mix or Oregon Method- In this method the resin and aggregate is premixed prior to the placement on bridge deck. This is the method that was initially developed by Oregon DOT in 1970s, later modified by Caltrans and currently being used on Caltrans projects.
5 - What are Advantages of Polyester Concrete?

a. Superior mechanical properties - Durable: 10 times abrasion resistance of PCC.
b. Impermeable to chloride penetration.
c. Best alternative for repair and rehabilitation of structures. Can be placed in thin sections, i.e., reduced dead load, and under a wide range of conditions.
d. Rapid return to service, 3 hours. Minimal delay to traffic.
e. Non-skid wearing surface.
f. Longevity, replaceable, not soluble in fuel, will not sustain fire.

6 - What are Mechanical Properties of Polyester Concrete?

Table 1 shows mechanical properties of polyester concrete.

Table 1. Mechanical Properties of Polyester Concrete

<table>
<thead>
<tr>
<th></th>
<th>Polyester Concrete</th>
<th>Portland Cement Concrete (8 sack)</th>
<th>Latex-modified Concrete</th>
<th>Silica-fumed Concrete</th>
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<tr>
<td>Compressive strength, psi</td>
<td>8,000</td>
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<td>Flexural strength, psi</td>
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<td>Abrasion (weight loss, grams)</td>
<td>1-2</td>
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<tr>
<td>Return to service</td>
<td>3 hours</td>
<td>5 days</td>
<td>4-5 days</td>
<td>2-4 days</td>
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<tr>
<td>Chloride permeability, coulombs</td>
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<td>1,000</td>
<td>500</td>
<td>500</td>
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7 - Unique Specification Requirements

a. Mix the resin and catalysts thoroughly before adding the aggregates.
b. Specified resin content is 12%, low resin= too many voids, too high = thermal incompatibility with the PCC substrate.

c. Compaction
d. Immediately after placement and before gelation of the resin:
   i. Finishing should be done
   ii. Apply sand on exposed polyester concrete
e. Curing polyester concrete is not necessary.

8 - Unique Aggregate Specification Requirements

a. Aggregate quality same as PCC aggregate
b. Crushed particle counts less than 45% (based on retained #8 fraction
c. Gradation requirement on “combined” aggregate
d. Must be Very Dry: Absorption less than 1%
e. Moisture content is less than half the absorption
f. Sand must be natural

9 - What is the definition of Polymers?

Polymers are hard glassy solids made up of long-chain molecules formed by joining together of simple monomer molecules. Nearly all polymers are organic (carbon-based molecules). Synthetic polymers are more commonly known as “Plastic”.

10 - What is Polymerization?

b. Chemical reaction - typically using catalyst - in which a large number of relatively simple molecules combine to form a chain-like macro-molecule (polymer).
c. Long-chain polymer molecules are formed by repeated linking of monomer molecules typically using the process shown in Figure 1.
Alternatively, the component may be mixed as shown in Figure 2.

The free-radical process of polymerization (using initiators/promoter systems) is an independent reaction (that is, independent of the resin) where the peroxide is catalyzed by the cobalt. Consider the independent reaction between cobalts and peroxides - if they are combined directly, they decompose very rapidly, resulting in fire or explosion as depicted in Figure 3. The resin is used to insulate or dilute this effect.
11 - Resin Delivery, Storage, Measurement and Payment

Resin is delivered in tank trucks in drums and is tagged at the source. Resin can be off-loaded from the tank truck into 500-gallon poly tanks for storage in the yard as shown in Figure 4. The resin amount is tracked for measurement and payment.

12 - Polyester Resin Additives

a. Silane Coupling Agent used to improve bond between polymer and mineral surfaces. Organosilane ester gammamethacyloxypropyltrimethoxsilane

b. Wax specified to lower emission levels. Specification limit emission to static Volatile Emission of 60 gr/sq mtr max. Rule 1162 SCAQMD. Paraffin wax BYK-S740

c. Accelerator is an additive used to accelerate polymerization. Must be compatible with initiators.

d. Antioxidants used to stop or slow oxidation and its degrading effect

e. Other additives such as Antistatic Agents, Colorants, etc.
**12.1 - Promoter**

- a. Chemicals that accelerate the chemical reaction.
- b. These chemical compounds reduce the critical temperatures of peroxide initiators, thus forming free radicals at ambient temperatures.
- c. Not consumed by the reaction. Also known as Catalysts.
- d. Metallic soaps are generally used as promoter such as Cobalt Napthenate (CoN) or Cobalt Octoate (CoO).

**12.2 - Initiators**

- a. Chemicals that start the polymerization process
- b. These compounds initiate the polymerization by decomposing into free radicals, which actually starts the polymer chain growth
- c. Normally consumed in the reaction
- d. Also known as “Hardeners”
- e. Generally used initiators are: Cumene Hydroperoxide (CHP) or Methyl Ethyl Ketone Peroxide

**13 - Construction Sequence**

- a. Set up Lane Control
- b. Deck Preparation
- c. Identify & remove unsound concrete
- d. Shot blast deck
- e. Block out joints
- f. Clean deck - Air Sweep
- g. Set Grade Control
- h. Apply methacrylate primer
- i. Mix and place polymer concrete
- j. Saw cut overlay over joints
- k. Sweep deck
- l. Pick up grade control
- m. Open to public
14 - Trial Slabs

Trial slabs are required in contract so that the contractor can demonstrate that his overlay operation would be completed with the time allowed given the temperature and other environmental conditions specific to the time and place of operation. Figure 5 is a photo of a trial slab construction.

![Figure 5: Trial Slab Construction](image)

15 - Quality Assurance

Schmidt hammer shown in Figure 6 can be used as an NDT for concrete strength, but it is for reference only since it is not accurate. As such the contract specification does not reference using this tool. Additional testing will be needed to verify the actual strength of concrete when result from Schmidt hammer testing might suggest insufficient concrete test strength. In placing polyester concrete, the Standard Special Provisions (referred to as the SSPs) requires that PCC to have reached specific strength before it can be overlayed. This tool can used to make a preliminary assessment of the concrete strength.
16 - Compaction Test

a. Specification: 97%

b. Taken while overlay is wet - immediately behind paving machine

c. Might get inconsistent compaction test results, from low 90’s to above 100%

d. Function of density

e. This test should be used as a guide

f. If low compaction results are obtained, examine the area of low compaction result with other areas with good test results for difference in appearance. Test other areas looking similar to the low compaction result area.

g. Resin flushed to the surface is usually a good indication of adequate compaction

17 - Material Testing

If corrective actions do not result in higher compaction numbers and overlay appears to be compacted, coring or pull-out test as shown in Figure 7 may be necessary.
Pull-out Test Cores as shown in Figure 8 should be examined for uniformity from top to bottom. Unit weight should be investigated.
Existing Structures – Structure Rehabilitation – Deck Overlays – Concrete Overlays

Revision and Approval

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<td>0</td>
<td>01-05-2023</td>
<td>Original Issue</td>
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Background

This process establishes Structure Construction (SC) responsibilities for review and authorization of operations for concrete overlays, including submittals, materials, and construction.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 60-3.04D, Existing Structures – Structure Rehabilitation – Deck Overlays – Concrete Overlays, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Contractor’s submittals per the contract documents

Procedure

1. All work associated with this process is charged as Project Direct – Construction.
2. Inspection of field work for this process is:
   a. Intermittent for installation of forms and reinforcement.
b. **Benchmark** for:
   i. Inspection of deck preparation
   ii. Final inspection of the finishing equipment prior to concrete placement.

c. **Full-time** for:
   i. Removal and repair of existing bridge deck
   ii. Concrete placement of concrete overlay
   iii. Installation of any drill and bond dowels.

3. Before construction begins, the Structure Representative (SR) or delegate must:
   a. Review the following:
      i. **Contract documents**
      ii. *Concrete Technology Manual (CTM)*, Chapter 6, *Structure Concrete Repair and Rehabilitation*, the section titled *Conventional Portland Cement Concrete Overlays*
      iii. **BCM 51-1.01**, *Concrete Structures – General*
      iv. **BCM 51-1.03C-D**, *Concrete Structures – General – Construction – Preparation and Placing Concrete*
      v. **BCM 51-1.03F(5-6)**, *Concrete Structures – General – Construction – Finishing Concrete – Finishing Roadway Surfaces and Finishing Pedestrian Overcrossing Surfaces*
      vi. **BCM 60-3.02**, *Existing Structures – Structure Rehabilitation – Bridge Deck Repair and Preparation*
      vii. **Contract Specifications**:
         1. Section 51-1.01C, *Concrete Structures – General – Submittals*
         2. Section 51-1.03I, *Concrete Structures – General – Construction – Protecting Concrete Structures*
      ix. Resident Engineer (RE) Pending File for any pertinent information about overlay
      x. Authorized lead compliance plan.
   b. Review and authorize the following submittals:
      i. Concrete mix designs
      ii. Deck placement work plan
c. Hold preconstruction meeting with the Contractor to discuss the required deck repair area, skid testing, safety, and authorized deck placement work plan.

d. Communicate all authorized submittals with Assistant Structure Representative and Resident Engineer.

e. Review the Contractor’s three week look-ahead and discuss upcoming friction tests with the Materials Engineering and Testing Services (METS) Representative.

4. During construction, the SR or delegate must:

a. Inspect the bridge deck for existing spalls/unsound concrete and repair as needed. Refer to BCM 60-3.02, Existing Structures – Structure Rehabilitation – Bridge Deck Repair and Preparation, and the Concrete Technology Manual, Chapter 6, Structure Concrete Repair and Rehabilitation.

b. If the contract documents require trial overlay, perform the following:

i. Verify the concrete surface is cleaned prior to placement of concrete overlay.

ii. Coordinate lane closures with the District.

iii. Verify that the overlay location and limits comply with contract requirements.

iv. Track the amount of material placed and produce pay quantities.

v. Verify that the concrete surface is finished and cured per contract requirements. Arrange for coefficient of friction test, CTM 342, Method of Test for Surface Skid Resistance with the California Portable Skid Test.

vi. Verify concrete compressive strength is in compliance with contract requirements.

vii. Verify that concrete is protected after placement.

c. For production work, repeat steps 4.b.i thru 4.b.vii.

d. Document all inspection, construction, and quality assurance activities pertinent to this BCM in the daily reports per BCM C-7, Daily and Weekly Reports.

5. Following construction, the SR or delegate must:

a. Verify the completed concrete deck surface has:

i. A uniform surface texture with a coefficient of friction of at least 0.35 when tested under CTM 342.

b. File all project documentation (correspondence, materials acceptance documentation, daily reports, etc.) in the appropriate category in the project records as specified in the *Construction Manual, Section 5-102, Organization of Project Documents.*

c. Record any changes to the as-built project plans.

**Process Outputs**

1. Authorized submittals
2. Weekly and daily reports
3. Materials certifications
4. Rehabilitated bridge deck
5. Lane Closure coordination
6. Overlay placement quantities
7. Skid test results
8. As-built project plans

**Attachments**

None
Existing Structures – Structure Rehabilitation – Repairing Spalled Surface Areas (Except Bridge Decks)

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<td>07-15-2021</td>
<td>Original Issue</td>
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Background

This process establishes Structure Construction (SC) roles and responsibilities for submittal review and authorization, quality assurance, materials, construction inspection, and payment for repair of spalled concrete surfaces.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 60-3.05B, Existing Structures – Structure Rehabilitation – Repairing Structures – Repairing Spalled Surface Areas, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Submittals required by the Contract Specifications for work that requires spall repair

Procedure

1. All work associated with this process is charged as: Project-Direct – Construction.

2. Inspection of field work for this process is:
a. **Benchmark** to:
   
   i. Verify workmanship of chipping. Sound the concrete after chipping is complete. (Remove additional damaged material as necessary).
   
   ii. Verify surface prep (cleanliness before placement of patching material).

b. **Intermittent** for all other activities.

c. **Continuous** during patching.

3. Before construction begins:

   a. Structure Representative (SR)/Assistant Structure Representative (ASR) reviews the contract documents and the RE pending file; inspects the spalled and unsound areas of concrete and determines a root cause. See *Concrete Technology Manual (CTM), Chapter 6. Structure Concrete Repair and Rehabilitation*.

   b. The SR/ASR measures amount and extent of damage using appropriate tools (i.e. pick hammer, marking paint, measuring instrument):
      
      i. If damaged areas are larger than what is shown in the contract plans, consult with Design and or Structures Maintenance & Investigations (SM&I).

   c. If not shown on the contract documents, determine a repair method:
      
      i. Refer to *CTM, Chapter 6*.
      
      ii. Consult with SM&I.

   d. Review and authorize the contractor’s submittals for filler material and repair method. See *CTM, Chapter 6*.
      
      i. Consult with Materials Engineering and Testing Services (METS) on proposed replacement/repair product.
      
      ii. Consult the METS **Authorized Materials List** for precast repair materials.
      
      iii. If the contractor proposes a new repair material, consult with METS for testing and review of the contractor’s proposal.

4. During construction:

   a. Inspect repair work according to *CTM Chapter 6*. SR/ASR to ensure that ambient temperatures and weather are suitable for undertaking repair work:
      
      i. Use a temperature gun to determine if the surface temperature of the area to accept the repair material is within manufacturer’s recommended temperature range.

   b. Measure repair work performed on a daily basis and discuss quantities with the contractor. Track quantities on the daily inspection reports.
c. Verify soundness of the patched concrete 14 days after placement.
d. Contact the designer for assistance to address any unusual conditions that are discovered during the investigative and/or repair work that should be addressed by a change order or in a future contract.
e. Document all inspection, construction, and quality assurance activities pertinent to this BCM, in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

5. Following construction:
a. Review quantities and authorize payment for completed repair work.

6. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized submittals for filler material and repair method
2. Daily reports

**Attachments**

None
Existing Structures – Structure Rehabilitation – Repairing Structures – Epoxy Crack Injection

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<td>06-30-2022</td>
<td>Original Issue</td>
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Background

This process establishes Structure Construction (SC) responsibilities and procedures for filling cracks in concrete structures using epoxy resin injection, including the selection of cracks to be filled.

Additional unique requirements for Epoxy Crack Injection are detailed in:

- BCM 95-1, Epoxy-General

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications (CS), Section 60-3.05C, Existing Structures – Epoxy Crack Injection, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Contract work requiring the use of epoxy crack injection.
2. Epoxy submittals as required by the Contract Special Provisions.
Procedure

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:
   a. Continuous for selection of cracks to be filled, the cleaning of cracks and inspection of all aspects of epoxy injection work being performed.

3. Before construction begins:
   a. Verify the epoxy material is in conformance with the specification values listed in CS, 95-1.02H, Epoxy – General – Materials – Epoxy Resin Adhesive for Pressure Injection Grouting of Concrete Pavement. Obtain and verify proof of contractual compliance for the epoxy material prior to incorporation into the work.
   b. Verify Form CEM-3101, Notice of Materials to Be Used, includes epoxy material:
      i. On an as needed basis, contact the Material Engineering and Testing Services (METS) Chemistry Lab to arrange for QA testing.
      ii. Verify the proposed epoxy material is compatible with the project parameters and field conditions. The associated concrete temperature and ambient temperature expected at the project should fall in line with the manufacturer’s requirements and instructions for mixing and application of epoxy material.
   c. Review the following documents:
      i. Attachment 1, Epoxy Crack Injection Inspection Guidelines
      ii. Structure Maintenance and Investigations (SM&I) training materials for Epoxy Crack Injection
   d. Discuss operations, including unique safety concerns, with all personnel that will be involved. Review the Material Safety Data Sheet (MSDS) for materials to be used. Review project specific Code of Safe Practices.

4. During construction:
   a. Verify the contractor follows manufacturer’s instructions and contract requirements for epoxy packaging, labeling, and storage requirements.
   b. Verify the contractor cleans the concrete surface to allow for location and limits of the cracks to be repaired. See the Concrete Technology Manual, Chapter 6, Structure Concrete Repair and Rehabilitation, (Page 6-22 to 6-23) for additional details on epoxy injection.
c. Select cracks to be repaired in accordance with the requirements of the contract documents. If the crack sizes exceed the specified limits of 8 mils to 250 mils (where 1 mil = 1/1000th inch) consult Bridge Design.

d. Verify the contractor cleans and prepares cracks in accordance with the specification and the requirements of the other contract documents.

e. Verify the temperature of concrete to be injected is within allowable limits.

f. Verify the contractor places injection ports into cracks for epoxy injection and places epoxy in accordance with the requirements of the contract documents and the manufacturer’s instructions. See the Concrete Technology Manual, Chapter 6, (Page 6-22 to 6-23) for additional details on epoxy injection.

g. Verify epoxy is being sampled prior to and during operation when requested.

h. After epoxy cures, verify the contractor removes epoxy ports and cleans the concrete surface in accordance with the contract documents.

i. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Following construction:

a. Measure sealed cracks per the contract documents for payment.

6. File all project documentation (correspondence, materials acceptance documentation, Daily Reports, etc.) in the appropriate category in the project records as specified in Construction Manual, Section 5-102, Organization of Project Documents.

Process Outputs

1. Completed repair work requiring epoxy crack injection, which complies with the contract requirements

2. Daily Reports

Attachments

Attachment 1, Epoxy Crack Injection Inspection Guidance
Epoxy Crack Injection Inspection
Guidance

Epoxy crack injection uses epoxy material to seal cracks in concrete structures (bridges, walls, etc.) and is designed to be a crack sealer and structural repair for concrete elements. The repair methodology outlined below is a step-by-step process similar to the work the contractor will perform in conjunction with the project contract plans to complete the structural repairs.

Locating Cracks and Cleaning Cracks in Preparation for Epoxy Injection

Review the contract plans and locate the cracks in the structural element that require repair. If necessary, remove any obstructions that impair the field engineer’s ability to locate the limits of the cracks. For example, if the cracks extend below grade, then the contractor would need to excavate around the abutment, footing or other structure element to be repaired by epoxy injection. The contractor should use compressed air to blow off cracks to expose the visible limits of the cracks. Sand blasting may also be necessary in some cases to open up or expose more of the crack (or cracks) in the damaged area. Follow the specifications for cleaning of the cracks prior to the contractor moving on the epoxy injection work. Removing all dirt, dust, and other unsound concrete material from the cracks is an important step in preparation for the epoxy injection procedure. The specification calls for flushing the crack with water under pressure and drying the crack with oil-free compressed air to complete the preparation of the cracks. Thorough surface and crack preparation will allow for the proper bonding and flow of the epoxy material into the cracks in the concrete.

Preparation for Epoxy Injection – Installation of Injection Ports

The next step the contractor must perform is to set the spacing and attach the injection ports into the cracks to receive the epoxy injection (See Figure 1). The spacing and number of injection ports installed will depend upon the thickness of the element being repaired and the size of the crack. The specification calls for a maximum injection port spacing along the crack of not more than the thickness of the element being repaired. At the ends of the crack the specifications call for a maximum injection port spacing of half of the thickness of the element being repaired. The specifications also allow for a closer port spacing if needed to ensure the epoxy fills the cracks. The contractor can install and secure the injection ports over the crack in a variety of different ways. For instance,
the contractor can use hot glue, from a hot glue gun, or a rapid setting epoxy to stick the injection ports directly into the crack. The contractor should be cautious when applying rapid setting epoxy or hot glue to the injection ports so as not to get any in the injection port or cover the opening at the end of the injection port. Once the ports are properly spaced and set the remaining length of the crack will need to be sealed.

![Figure 1. Installing Injection Ports](image)

**Preparation for Epoxy Injection – Sealing Cracks Between Injection Ports**

The next preparatory step for the epoxy injection process involves sealing the remaining length of the crack. The specification calls for the use of tape or other temporary sealant “capable of retaining epoxy in cracks during pressure injection” to seal the crack. The contractor can use a quick setting epoxy (or even Bondo), or tape to cover the cracks (See Figure 2). Any deficiencies in sealing the cracks may only become evident when pumping epoxy under pressure into an adjacent port. The pressurized epoxy injection may cause a leak to appear along the length of the crack (See Figure 3). If this happens stop the pressurized injection work and have the contractor repair the leak. As a matter
of tribal knowledge in some cases, rubbing bees wax or paraffin over a leak may be sufficient to seal the leak. If this method does not work, place more rapid setting epoxy over the leak before continuing.

Figure 2. Sealing a Crack Between Injection Ports
Pressurized Epoxy Injection

With the completion of the preparatory work the contractor can commence the pressurized epoxy injection work. Verify that the concrete temperature is within the allowable temperature range per the contract specifications (50-90 degrees F) and the manufacturer’s recommendations. The idea of epoxy injection is to start injecting epoxy at the low end of the crack and keep the epoxy moving from port to port. The contractor will insert the injection gun (See Figure 4 and Figure 5) on to the first port and will keep pressure injecting the epoxy until the epoxy runs out of the next port in line (i.e. return). When the epoxy returns from the adjacent port the crack between the ports is now filled with epoxy. The contractor’s field crews will then disconnect the injection gun from the first injection port, cap it off and reconnect to the next port. The epoxy injection work will continue in this fashion, moving from port to port to keep the epoxy flowing, until the entire crack is filled with epoxy. Sometimes the epoxy will follow a subsurface crack that was previously unseen and will come out (return) somewhere else. For example, the epoxy return could occur at another port on another crack, or even start oozing out of an unseen crack. When this happens, the contractor will need to either cap off the port with
the epoxy return, or if it is a new crack, stop and seal the crack. The idea is to fill all the cracks with epoxy. The operation will continue by pumping and capping off the ports. Eventually the epoxy will eventually fill all the cracks and return from all the ports. If there is a problem with a crack that keeps leaking, stop pumping on that crack and go on to another crack. This will give the epoxy time to gel in the crack and the contractor can come back to it later. The epoxy will have to set overnight to cure, or for a duration recommended by the manufacturer. After the epoxy has hardened the contractor will seal the ports by removing the port fittings and filling the voids with epoxy and covering the voids with tape or sealant. Leave the tape or sealant in place until the epoxy has hardened. The contractor may use a chipping hammer to chip off the ports and most of the epoxy. The contractor can use a grinder or an air powered sanding disk tool to grind down the remaining epoxy smooth. If questions from the contractor or the field Engineer’s arise on the type of epoxy to use, coordinate with Structure Design or Structure Maintenance Design on which low viscosity epoxy to select. Selection of an epoxy that meets the standard specifications and the project objectives will ensure the epoxy will flow through even the smallest cracks allowing for a quality repair of the damaged member.

Note: Epoxy injection can be a very slow process. The key to the success of the process is to go at slow rate when injecting the epoxy into the ports. The pump and mixing machine will continue to inject epoxy if the button is held down. The pressure will build up in the crack and may lead to blowing holes in the epoxy cover over the cracks. To avoid this, the contractor should inject a little at a time and allow the pressure to dissipate in the crack. Most machines have a pressure gauge on the injection line that the field Engineer and the contractor’s personnel can watch. When the pressure goes up, the contractor should exercise caution and even stop until the pressure goes back down. Once the pressure spike subsides, to low or zero pressure, the contractor can continue to inject epoxy. The contractor may elect to have a tripod that will hold the epoxy gun during the injection process. On some large cracks, epoxy injection can take place for several minutes non-stop before there is any return. Very small cracks may take a long time to fill, so the contractor should go slowly.
Figure 4. Epoxy Injection Pump and Injection Gun
Figure 5. Epoxy Injection Pump, Injection Gun, and Two-Part Epoxy
Existing Structures – Structure Rehabilitation – Repairing Structures – Heat-Straighten Steel Girders

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<td>11-23-2022</td>
<td>Original Issue</td>
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Background

This process establishes Structure Construction (SC) responsibilities, and procedures for authorization of submittals and construction of heat-straightening damaged steel girders.

Administration of construction work performed for heat-straightening existing steel girders requires careful attention as this work is often performed on existing structures over traffic that have been damaged by high load hits.

Heat-straightening of existing girders is typically an emergency response to damage such as a high load hit. Because any damage sustained could compromise the capacity of the structure, close coordination with Structures Maintenance & Investigations (SM&I) is necessary.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications (CS), Section 60-3.05D, Existing Structures – Structure Rehabilitation – Repairing Structures – Heat-Straighten Steel Girders, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.
Process Inputs

1. Submittals

Procedure

1. All work associated with this process is charged as Project Direct – Construction.
2. Inspection of field work for this process is Continuous.
3. Before construction begins the Structure Representative (SR) or delegate must:
   a. Verify Structure Maintenance & Investigations (SM&I) Bridge Maintenance Design Engineer (BMDE) identified the bridge closure limits near the damaged structure members. These bridge closure limits will be in place prior to starting the heat-straightening contract work. SM&I BMDE may impose additional live load and traffic restrictions. The live load and traffic restrictions may require additional closure limits on the structure during the heat-straightening process (see step 4.h. below).
   b. Secure tools (temperature indicating crayon and temperature gun, etc.) to measure the temperature of the steel.
   c. Review the contract documents and the following BCMs for submittal reviews and construction requirements. The SR should also review applicable field procedures with SC staff:
      i. BCM 48-3, Temporary Structures – Temporary Supports
      ii. BCM 48-5, Temporary Structures – Jacking (If required to access damaged members or complete repair of the superstructure)
      iii. BCM 55-1.01C, Steel Structures – Submittals
      iv. BCM 55-1.03, Steel Structures – Construction
      v. BCM 59-2, Structural Steel Coatings – Painting Structural Steel
      vi. BCM 11, Welding, for guidance on reviewing the quality control plan for welding.
   d. Review and authorize or reject for resubmittal the following submittals:
      i. The shop drawings for heat-straightening steel girders per the CS, Section 60-3.05D(1)(c), Existing Structures – Structure Rehabilitation – Repairing Structures – Heat-Straighten Steel Girders – General – Submittals. The SR performs a concurrent review with the Materials Engineering and Testing Services Representative (METS Rep) and SM&I BMDE. Note that SM&I would provide goals (targets) for the repair work that must be achieved prior to returning the bridge to service.
ii. If temporary supports are required for the girder or the structure during the heat-straightening procedure, review the submittals for temporary supports for the structure including shop drawings for temporary supports, per the contract requirements in the CS, Section 48-5, *Temporary Structures – Jacking*, and guidance in BCM 48-5.


v. The welding quality control plan, which requires a concurrent review with the METS Rep, per the contract requirements in the CS, Section 11-2.03B, *Welding – Welding Quality Control – Submittals – Welding Quality Control Plan*.

vi. The painting quality work plan, per the contract requirements in the CS, Section 59-2.01A(3)(c), *Painting Structural Steel – General – Submittals – Painting Quality Work Plan*.


i. Identify the designated work area(s) that will be used to monitor the containment system, for which the Contractor will collect and analyze ambient soil samples and provide a report with soil test results that includes a recommendation for corrective action of the containment system if the specified exposure levels of the contaminant are exceeded.

ii. Inform the Contractor where the designated work area(s) is/are, that the Contractor will monitor for contaminant exposure.

iii. Verify the required soil samples from the designated areas are collected prior to the start of work as specified in the *Contract Specifications*.

f. Notify the Contractor when the submittals are authorized per *Contract Specifications*, Section 5-1.23, *Control of Work — Submittals*, and guidance in *BCM C-11, Shop Drawing Review of Temporary Structures*.

g. Review the project specific *Code of Safe Practices* (COSP). Coordinate with the Bridge Construction Engineer to obtain fitted respirators when applicable.
(for example, for removal of lead-based paint from existing steel) and medical clearance for those using respirators.

i. Refer to the Respirator Q&A in the Safety tab of the SC Intranet, for additional guidance on respirators.

h. At least one week before work begins, inform the SM&I BMDE and the METS Rep when the work to heat-straighten the steel girder will begin. The designer and METS Rep need to be available to consult if additional damage is discovered, the damage is not as anticipated, or the heat-straightening is unsuccessful and/or not progressing as anticipated, etc. If any of this occurs, the Contractor may need to submit a revised submittal that must be reviewed and authorized.

4. During construction the SR or delegate must:
   a. Verify the heat-straightening work is performed in accordance with the authorized submittals (including any restraints or jacks used in the straightening work). Restraints and jacks are used to keep the heat-straightened member from moving in an unintended manner or unintended direction. The heating and cooling cycles described in the authorized submittals is the primary mechanism of the repair process.
   b. For contracts with a pay item, Work Area Monitoring:
      i. Verify the Contractor collects and tests the required number of ambient soil samples before starting work, as well as within 36 hours of any cleaning operations of the existing steel at the designated work area(s) for monitoring.
      ii. Review the report(s) with the soil test results.
      iii. If corrective action of the containment system is needed, verify the corrective action is taken as specified in the Contract Specifications.
   c. When air monitoring is performed:
      i. Collect and review the Air Monitoring Report.
      ii. Verify the air monitoring is performed per the:
   d. After the existing paint is removed and the girder is cleaned, verify the extent of damage is similar to what was anticipated. Secure the site and take job photos to document condition of the damaged steel girder. Consult the
designer if the damage is not as anticipated or if additional damage is discovered.

e. Confirm that the Contractor verifies all controlling field dimensions before ordering or fabricating any material.

f. Verify the temporary supports for the structure is constructed per the authorized shop drawings:
   i. Confirm that temporary supports for the structure remain in place until the girder cools.

g. If jacking of the superstructure is required to allow access to damaged members or to complete the superstructure repair, follow the requirements of BCM 48-5, Temporary Structure – Jacking, and Section 48-5, Jacking of the Contract Specifications. Monitor jacking sequences and design values in the authorized submittals.

h. SM&I will set the live load and traffic restrictions on the structure during the heat-straightening work (See step 3.a. above). The SR, in coordination with the District, shall prohibit live traffic in the limits set by design and under any steel girder being heat-straightened. Check the contract documents for additional lane closure requirements, allowable lane closure times, and durations.

i. Verify the girder steel temperature using temperature indicating crayons and/or a temperature gun. Verify that the maximum allowable temperatures for different types of girder heating (preliminary, spot and vee heats) are not exceeded.

j. Verify that the heat-straightening procedures are working as intended. The member undergoing the heat-straightening process should move in the anticipated direction during the cooling cycle. Any warping, distortion, or movement of the member in an unanticipated direction is an indication that the process is not working as intended. If the heat-straightening of the girders is not working as anticipated stop the work and consult the SM&I BMDE and METS Rep. The Contractor may have to revise the previously authorized submittals.

k. In accordance with Deputy Directive 109, Bridge Emergency Response, discuss with the SM&I BMDE to determine who has the authority to reopen a damaged structure to traffic following repair or stabilization.

l. Measure and record the bridge clearance after field work is complete per BCM C-12, Notice of Change of Structure Clearance or Permit Rating.

m. When welding is performed, review the welding report submitted by the Contractor to verify conformance with the authorized Welding Quality Control Plan (WQCP). Refer to BCM 11, Welding, for guidance.
n. When welding is performed at the jobsite, collect certificates of compliance from the welding Quality Control Manager (QCM), for each item of work for which welding is performed.

o. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Following construction, the SR or delegate must:

   a. File all project documentation (correspondence, submittals, certificates of compliance, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

6. Additional resources include:

   a. AASHTO Guide for Heat-Straightening of Damaged Steel Bridge Members
   b. Caltrans project Heat Straightening of Bridge on 101 Freeway (video)
   c. Caltrans Transportation Library Engineering Workbench (requires a one-time account setup with Caltrans email, and subsequent login)

Process Outputs

1. Authorized submittals
2. Daily Reports
3. Straightened Steel Girder(s)

Attachments

None
Existing Structures – Modifying Structures – Coring Concrete

Revision and Approval

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Background

This process establishes Structure Construction (SC) responsibilities for review and authorization of operations for coring concrete, including submittals, materials, construction, and payment.

Cored holes greater than 10 feet in length require submittals for a work plan and the labeled cores. Cored holes that cut reinforcement designated not to be cut in the contract documents require submittals for a work plan to repair reinforcement and prevent additional cutting of reinforcement.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 60-4.04, Existing Structures – Modifying Structures – Coring Concrete, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.

For specific requirements pertaining to coring through a CIDH pile due to a blocked vertical inspection pipe, refer to the Contract Specifications, Section 49-3.02C(5), Piling – Cast-In-Place Concrete Piling – Cast-In-Drilled-Hole Concrete Piling – Construction – Vertical Inspection Pipes.

Process Inputs

1. Contract requiring cored holes in existing structures
2. Concrete coring work plan submittal (when applicable)
3. Work plan for repair of cut reinforcement (when applicable)

**Procedure**

1. All work associated with this process is charged as: [Project Direct – Construction](#).

2. Inspection of field work for this process is:
   a. [Intermittent](#) for inspection of coring operations unless otherwise noted by the Structure Representative.

3. Before construction begins, the Structure Representative or delegate must:
   a. Review the [contract documents](#) and Resident Engineer's Pending File items related to coring concrete in existing structures.
   b. Review as-built drawings to avoid cutting rebar, utilities, etc.
   c. For cored holes greater than 10 feet in length, discuss submittal requirements with the Contractor.
      i. Review and authorize the work plan for coring activities as required by the [Contract Specifications](#).
   d. Ask the Contractor to identify the source of water for coring:
      i. If not a municipal water supply, obtain test results to verify water impurities do not exceed limits specified in the Contract.
   e. Discuss containment of coring water and unique Storm Water Pollution Prevention Plan/Water Pollution Control Program (SWPPP/WPCP) requirements with the Contractor.
   f. Prior to concrete coring:
      i. Discuss planned activities with the Contractor along with SWPPP/WPCP requirements.
      ii. If an authorized coring submittal is in effect, verify equipment and methods conform to the submittal.
      iii. Notify Materials Engineering and Testing Services (METS) if assistance is needed evaluating existing concrete (for investigative coring, METS may have the required tools and expertise to assist SC staff).
   iv. Verify coring location:
      1. Considering access and footprint needed for coring equipment.
      2. Has been laid out (e.g., painted or marked with lumber crayon) per contract requirements.
3. Record selected core location on a layout sketch:
   a. Include sufficient horizontal and/or vertical distances measured from known reference points.
   b. When possible, authorize adjustments to core locations to avoid rebar. Allow for permissible drift.

g. Verify containment system for coring water is in place and functioning.

h. When entry into a confined space is necessary (e.g., bridge cell), review project-specific Code of Safe Practices and the Contractor’s Injury and Illness Prevention Program. Verify the Contractor’s confined space procedure.

4. During construction, the Structure Representative or delegate must:
   a. Verify that the Contractor cores concrete in accordance with the contract documents and any authorized work plans by taking the following steps, as applicable:
      i. Be present when the Contractor extracts concrete core sample from the coring barrel, and:
         1. Have receptacles for collecting concrete core samples available if needed.
      ii. For cored holes greater than 10 feet in length, verify that the Contractor is labelling the cores as required by the Contract Specifications.
      iii. Observe and document the quality of concrete along the core:
         1. Verify each core is labeled with its location and required information with permanent marker.
         2. Keep track of which end of the core is top and bottom, or other reference orientation.
         3. When the cored concrete is part of a long, cored hole, document its position (dimension) along the cored hole.
            a. If anomalous concrete is observed, take care to recover and preserve any loose contents with the core. Note the limits of any anomalous region. Contact Bridge Design and discuss the observations.
      iv. Verify and document the cored hole length as specified in the contract documents by:
         1. Measuring the depth of the hole.
         2. Measuring the length of the core pieces. If there are multiple pieces of coring, lay them out and fit them together, then measure to obtain the entire length of core.
v. If the core barrel drifts beyond the allowable deviation specified in the Contract or authorized work plan, stop the operation. Consult with Bridge Design to select a new representative coring location:

1. To avoid excessive drifting, verify anchor is secured at the base of the coring apparatus. Check plumbness of the steel casing during drilling.
2. Drifting can also be caused by encountering steel or very hard aggregate.

vi. Maintain communication with the operator during coring. Stop the operation if the core bit cuts rebar specified as “not to be cut”, unanticipated utilities, prestress ducts, etc.

1. Perform the following activities before resuming the coring operation:
   a. Request a work plan from the Contractor that includes measures to repair the cut reinforcement, and prevent cutting additional reinforcement.
   b. Review and authorize the work plan.
   c. Verify damaged reinforcement is satisfactorily repaired.

vii. If core barrel breaks and becomes lodged inside cored hole:

1. Extract if feasible.
2. Consider using a larger diameter core barrel.
3. If not feasible, abandon in place and select a new core location.
4. Consult with the designer when necessary.

b. Verify the cored hole is correctly filled if required by the Contract (e.g., high strength grout, dry pack, etc.).
   i. If concrete coring damages an adjacent concrete surface (e.g., bridge deck, face of walls, etc.), sawcut a neat line before patching.

   c. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the daily reports per BCM C-7, Daily and Weekly Reports.

5. Following construction, the Structure Representative or delegate must:

   a. Evaluate the core sample and coring log.
   b. As-built the core locations:
      i. When cores deviate from the locations shown on plans
      ii. For retrofit projects
c. File all test results and Daily Reports in the appropriate category in the project records as specified in the *Construction Manual*, Section 5-102, *Organization of Project Documents*.

**Process Outputs**

1. Authorized submittals (when applicable)
2. Completed concrete cores
3. As-builts (when applicable)
4. Daily Reports

**Attachments**

None
Existing Structures – Modifying Structures – Steel Column Casings

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of operations for steel column casings, including submittals, materials, and construction.

Steel column casings are generally specified for bridges that require a substructure retrofit for seismic safety or other reasons.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 60-4.06, Existing Structures-Modifying Structure-Steel Column Casings. that this BCM is based on as identified in the title block above. The information in the contract specification(s) typically will not be repeated in the text of this BCM.

Process Inputs

1. Submittals per the contract documents

Procedure

1. All work associated with this process is charged as Project Direct – Construction.
2. Inspection of field work for this process is:
a. **Intermittent** for excavation, column cleanup, waterproofing, steel casing placement, backfill, removal of concrete and welding operations.

b. **Continuous** for grouting operations.

3. Before construction begins:
   a. Review the following:
      i. Contract documents
      ii. Project-specific Code of Safe Practice (COSP)
      iii. [Attachment 1, Steel Column Casing Guidance](#)
      iv. Authorized Traffic Management Plan
      v. Environmental compliance (i.e., bats, birds, lead etc.)
      vi. [BCM 11-2, Welding Quality Control](#), for welding submittals
      vii. [BCM 55-1.01C, Steel Structures – Submittals](#), for steel column casing submittals
      viii. [BCM 59-2, Structural Steel Coatings – Painting Structural Steel](#), for paint submittals
      ix. [BCM 59-5, Structural Steel Coatings – Thermal Spray Coat Structural Steel](#), for paint submittals
   b. Confirm that the contractor has verified the controlling field dimensions by taking measurements in the field. Work with the Structure Designer to take corrective action should the actual field dimension differ from those on the contract plans. Write a change order when planned dimensions are changed by the Structure Designer.
   c. Review and authorize (reject as necessary and work with contractor to get them authorized) the following submittals:
      i. Column casing shop drawings
      ii. Painting quality work plan
      iii. Welding quality control plan
      iv. Excavation plan
      v. Concrete/grout mix designs
      vi. Manufacturer’s product data and Safety Data Sheet (SDS)
   d. Coordinate review and authorization of steel column casing shop drawings with the Designer and the METS Representative.
e. Coordinate inspection of steel column casing fabrication, and field welding with the METS Representative. After fabrication, verify materials is released and Form TL-29, Report of Inspection of Material is issued by METS.

f. The Structure Representative (SR) should communicate with ASR, and Resident Engineer to verify that all staff are aware of the applicable submittals for performing work.

4. During construction:

a. Collect orange tags from fabricated steel column casings delivered to the job site and match them with Form TL-29, Report of Inspection of Material. Verify that steel column casing was not damaged during transportation.

b. Verify the column footing area is excavated per the limits shown on the contract plan.

c. For Type P/F casing, verify that polystyrene is placed around the bottom of the column with a waterproof adhesive.

d. Verify the material used for column and footing waterproofing is authorized and adhesive is applied to the entire contact surface.

e. Verify steel column casing placement, and fit-up provides clearances with the column as shown in the contract plan.

f. Coordinate the field welding operation schedule with the METS Representative and verify that welds are per authorized shop drawings.

g. Verify the grouting operation is in accordance with the requirements of the contract documents and there are sufficient and properly spaced grout ports and grout lifts.

h. Work with the contractor to take corrective action should casing shift during grouting.

i. Verify the steel column casing painting operation is in accordance with the authorized painting quality control plan as follows:

   i. Prior to application of paint, verify that weather conditions and relative humidity comply with the contract requirements.

   ii. After the application of the paint, measure and verify paint thickness and adhesion (pull test) for compliance with contract requirements.

j. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. After construction:

a. Document any changes on the as-built plans per BCM C-6, Required Documents to be Submitted During Construction.
6. File all project documentation (correspondence, materials acceptance documentation, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized submittals
2. Form TL-29, Report of Inspection of Material, and orange tags
3. Daily Reports
4. Steel column casings installed in conformance with the contract documents

**Attachments**

[Attachment 1, Steel Column Casing Guidance]
Included in this attachment is guidance to assist SC Staff in understanding features of column casings:

- Backing plates for column casing to have a thickness equal to 3/8".
- When welding column casing sections together in the manufacturer's shop, the backing bars are to have a continuous full-length weld.
  The backing bars used to weld the column casing sections together in the field will only be welded to the column casing on one side by non-continuous welds. These welds will be 2" long and at 8" centers. This backing bar does not need a continuous full-length weld.

- Column casing welds must comply with Section 11, *Welding*, and Section 55, *Steel Structures*, of the *Contract Specifications*. The requirements of the American Welding Society (AWS) D1.5 *Bridge Welding*, do apply to the welding of column casings. A column casing is not considered a *primary member* unless it is designated as such in the contract. Therefore, any column casing not designated as a *primary member* on the contract plans is not subject to Nondestructive Testing (NDT) other than visual inspection, per AWS D1.5 Section 6.7.1. The base metal testing and preparation, weld quality, welder, welding operator, Welding Procedure Specification qualifications, and material requirements established in AWS D1.5 do apply for shop and field welding.

- *Bridge Design Aids, 14-2, Steel Column Casing Design and Details*, includes information regarding design considerations relevant to construction.
Existing Structures – Modifying Structures – Bridge Joint Restrainers

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of bridge joint restrainers, including submittals, quality assurance, materials and fabrication, construction, and payment.

Bridge joint restrainers may consist of cable-type restrainers, bar-type restrainers, or pipe-type restrainers. Additional unique contract requirements for cable, bar and pipe type restrainers are detailed in the following Contract Specifications:

- Section 11, Welding
- Section 51-1.01, Concrete Structures – General
- Section 51-1.03E, Concrete Structures – General – Construction – Miscellaneous Construction
- Section 52-1, Reinforcement - General
- Section 59-1, Structural Steel Coatings – General
- Section 59-2, Structural Steel Coatings – Painting Structural Steel
- Section 60-4.04, Existing Structures – Modifying Structures – Coring Concrete
- Section 75, Miscellaneous Metal

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 60-4.09, Existing Structures – Modifying Structures – Bridge Joint Restrainers that this BCM is based on as identified in the title block above.
The information in the contract specifications typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Submittals
2. Manufacturer's product data

**Procedure**

1. All work associated with this process is charged as [Project Direct – Construction](#).
2. Inspection of field work for this process is:
   a. **Benchmark** for the following activities:
      i. Verifying restrainer length and placement
      ii. Verifying scaffolding/protective covers are constructed per authorized drawings.
      iii. Material inspection
   b. **Continuous** for the following activities:
      i. Rebar detection
      ii. Coring
      iii. Concrete and grout placement (if placed)
      iv. Tensioning restrainer cable (if applicable)
3. Before construction begins the Structure Representative (SR) or delegate must:
   a. Review the [contract documents](#) regarding bridge joint restrainers.
   b. Complete applicable safety training such as:
      i. Confined spaces
      ii. Lead exposure
      iii. Fall protection
   c. Request necessary tools such as:
      i. Harness
      ii. Headlamp
   d. Review the Resident Engineer (RE) Pending File (accessed in either Category 11 or via [VISION](#)) and bridge inspection reports (accessed in either BIRIS or [BView](#)).
e. Document existing conditions with photos or video.

f. Review the following reference documents for information and guidance on joint restrainers:
   i. Memos to Designers (MTD 20-3), Restrainers at Support Joints
   ii. BCM 11, Welding
   iii. BCM 51-1.01, Concrete Structures – General
   iv. BCM 51-1.03E, Concrete Structures – General – Construction – Miscellaneous Construction
   v. BCM 52-1, Reinforcement – General
   vi. BCM 59-1, Structural Steel Coatings – General
   vii. BCM 59-2, Structural Steel Coatings – Painting Structural Steel
   viii. BCM 60-4.04, Existing Structures – Modifying Structures
   ix. BCM 75, Miscellaneous Metal

g. Review and authorize (or reject for resubmittal) the following submittals (if required by contract):
   i. Scaffolding
   ii. Protective Cover

h. Coordinate the review and authorization of the cable-type or pipe-type bridge joint restrainer shop drawings (if required by the contract) with the Designer and the Materials and Engineering Testing Services Representative (METS Rep). For all bridge joint restrainers:
   i. Verify the bridge joint restrainer shop drawings have been received by the SC Office Associates from the contractor per the Contract Specifications, Section 5-1.23(B)(2), Control of Work – Submittals – Action Submittals – Shop Drawings.
   ii. Perform a concurrent review with the Designer and the METS Rep to verify the submittal meets the requirements detailed in the Contract Specifications. Unique considerations that should be addressed in the shop drawings for installing bridge joint restrainers:
      1. On existing concrete structures include:
         1-1. Coring of existing concrete requirements in the CS, Section 60-4.04, and guidance in BCM 60-4.04.
         1-2. Drill and bond dowels requirements in the CS, Section 51-1.03E(3), and guidance in BCM 51-1.03E.
         1-3. Rebar and concrete for a bolster requirements in the CS, Sections 51-1.01 and 52-1, and guidance in BCM 52-1 and BCM 51-1.01.
2. On existing steel structures include:
   2-1. Removal of the existing paint system per guidance in BCM 59-1, Structural Steel Coatings – General.

3. On new structures include:
   3-1. Installation and verification in accordance with contract documents.

   i. Provide all authorized submittals to Assistant Structure Representative (ASR).

   j. Communicate means and methods of construction and inspection of restrainers to ASRs.

   k. Communicate with the METS Rep to review the following control of materials requirements:
      i. If specified, verify restrainer test samples have been received and accepted by METS Rep at the fabrication site.
      ii. Verify materials are released in conformance with Construction Manual, Chapter 6, Table 6-2.3, Materials Accepted by Certificate of Compliance.

   l. Request assistance from the METS Rep with welding quality control plan review (if applicable). For guidance on the welding quality control plan submittal review, refer to BCM 11, Welding.
      i. Welding of the restrainer miscellaneous metals should be in accordance with AWS D1.1.

4. During construction the SR or delegate must:
   a. Verify that any scaffolding or protective covers (if any) is constructed per authorized submittals.
   b. Check for and obtain materials inspection release tags on all restrainer units delivered to the project. The SR must field release items described in Construction Manual, Chapter 6, Sampling and Testing.
   c. Verify lengths of restrainers.
   d. Verify the restrainer and coring (if any) layout does not conflict with the access openings and rebar.
   e. Follow installation procedures outlined in the project plans and authorized submittals. Verify torque on nuts, installation of thread locking compound, installation of cable yield indicator (if required), and that restrainers have sufficient length given the movement rating of the structure shown on the project plans.
f. Keep track of installed quantities for payment purposes.

g. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

h. Maintain as-built project plans per BCM C-6, Required Documents to be Submitted During Construction.

5. File all project documentation (correspondence, material acceptance documentation, daily reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized submittals
2. Daily Reports
3. Completed restrainers and as-built shop drawings

**Attachments**

None
Miscellaneous Drainage Facilities – Casings for Bridges

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BCM 70-7, Existing Structures – Structure Removal – Construction, has not been posted yet.
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Slope Protection – Slope Paving

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, materials, construction, and payment for concrete slope paving, including exposed aggregate slope paving and slope paving with concrete pavers.

Concrete slope paving is generally constructed with minor concrete or shotcrete, so processes for minor concrete or shotcrete also apply to this process.

Additional unique requirements for slope paving are detailed in:

- **BCM 19-3.03E**, *Earthwork – Structure Excavation and Backfill – Construction – Structure Backfill*
- **BCM 51-2**, *Concrete Structures – Joints*, for expanded polystyrene and premolded joint filler requirements
- **BCM 52-1**, *Reinforcement – General*
- **BCM 53-1**, *Shotcrete – General*

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review *Contract Specifications*, Section 72-11, *Slope Protection – Slope Paving*, that this BCM is based on as identified in the title block above, as well as *Contract Specifications*, Section 72-1, *Slope Protection – General*. The information in the *Contract Specifications* typically will not be repeated in the text of this BCM.
Process Inputs

1. Contract work requiring slope paving

Procedure

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:
   a. **Benchmark** for construction of slope paving foundation, construction of forms, and placement of bar reinforcing steel.
   b. **Intermittent** for placement of concrete pavers (including grouting) and/or placement of pipe down drains under concrete slope paving.
   c. **Continuous** during shotcrete application and placement of minor concrete.

3. Before construction begins:
   a. Review the contract documents to determine:
      i. The types of slope paving to be constructed: shotcrete, minor concrete, minor concrete with exposed aggregate, or concrete pavers.
      ii. Whether a slope paving test panel will be required.
      iii. Whether there are color and/or surface texture requirements for slope paving.
   b. Review the *Construction Manual*, Chapter 4-72, Construction Details – Slope Protection.
   c. Verify that Form CEM-3101, Notice of Materials to be Used, has been submitted to the Resident Engineer (RE).
   d. Review and authorize the following contractor submittals:
      i. For shotcrete, review the shotcrete mix design in accordance with BCM 53-1, *Shotcrete – General*.
      ii. For minor concrete, review the minor concrete mix design for compliance with the *Contract Specifications*, Section 90-2, *Concrete – Minor Concrete*. If applicable, review the *Contract Specifications*, Section 72-11.02B, *Slope Protection – Slope Paving – Exposed Aggregate Slope Paving – Materials*.
      iii. For concrete pavers, review the manufacturer’s data to ensure compliance with *Contract Specifications*, Section 72-11.03B, *Slope Protection – Slope Paving – Slope Paving with Concrete Pavers – Materials*. 
e. For concrete pavers, verify the contractor’s means and methods can produce the grout lines required in the contract documents.

f. If a test panel is required per the contract documents, coordinate with the contractor for viewing the Department’s sample panel.

g. Coordinate with the landscape architect regarding any color and/or surface texture requirements for slope paving.

h. Coordinate with the contractor to verify that the application of shotcrete or minor concrete placement (including finishing and curing work) can be completed on the same day that the work is started.

i. Verify with the contractor and RE that an authorized traffic control plan is in place.

j. Verify that concrete curbs and sidewalks have been constructed before constructing slope paving.

4. During construction:

a. For all types of slope paving:

i. If a test panel is required per the contract documents, inspect the contractor’s completed test panel. Invite the landscape architect to this inspection. If the test panel does not meet the contract requirements, reject the test panel. Do not allow production slope paving work to begin until a test panel is authorized.

ii. Verify that foundations are evenly graded and compacted and are free of surface water. Refer to BCM 19-3.03E, Earthwork – Structure Excavation and Backfill – Construction – Structure Backfill.


b. For slope paving constructed with shotcrete or minor concrete:

i. Inspect the placement of bar reinforcing steel in accordance with BCM 52-1, Reinforcement – General.

ii. Be present throughout shotcrete application or minor concrete placement to verify and/or perform the following:

1. Verify materials delivered comply with the authorized shotcrete/minor concrete mix design.

2. Collect shotcrete/minor concrete tickets and corresponding certificates of compliance.

3. Verify all finishing and curing operations meet contract requirements, which includes using curing compound number 6 for slope paving.
iii. For exposed aggregate surfaces, verify that additional finishing and curing procedures are performed in accordance with the contract documents.

c. For slope paving with concrete pavers:
   i. Verify that the bond coat and/or mortar bedding has been placed and cured in accordance with the contract documents.
   ii. Inspect placement of concrete pavers to verify that joints between the paving units are straight and have uniform widths.
   iii. Verify that the specified waiting period (48 hours after installation of concrete pavers) has elapsed before grouting work begins.
   iv. Verify that the concrete pavers are kept continuously damp for 72 hours after grouting work is completed.

d. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

5. Following Construction:
   a. Compute payment quantities for slope paving bid items as described in the contract documents and provide these quantities to the RE.

6. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual, 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized slope paving submittals
2. Authorized slope paving test panel, if required
3. Completed slope paving

**Attachments**

None.
Miscellaneous Metal

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BCM 75, *Miscellaneous Metal*, has not been posted yet.

Until it is posted go to BCM 135-5.0, *Miscellaneous Anchorage Devices*; 168-2.0, *Expansion Anchors for Bridge Mounted Signs*; 168-4.0, *Resin Capsule Anchorage for Bridge Mounted Sign Structures*. 
Wells

BCM 76, Wells, has not been posted yet.

Until it is posted go to BCM 115-1.0, Inspection of Electrical, Mechanical, Water, and Wastewater.
Incidental Construction

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BCM 78-4, *Incidental Construction*, has not been posted yet.
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<td>Added BCM 83-(2.05-2.08) and 83-11.03</td>
<td>Richard Foley</td>
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<td>Original issue. Added BCM 83-3</td>
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Railings and Barriers – Metal Railings and Barriers – California Bridge Rails, Chain Link Railings, Cable Railings, and Tubular Railings

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for:

- Review and authorization of submittals, quality assurance, materials, and construction for California bridge rails and tubular railings, as well as payment for California bridge rails.
- Review and authorization of materials and construction for chain link railings and cable railings. There are no submittal requirements for these sections. However, all materials and construction must comply with the applicable Standard Plans.

Additional unique guidance related to this Bridge Construction Memo (BCM) is detailed in:

- **BCM C-13, Permanent Reference Elevations**
- **BCM 52-1, Reinforcement - General**
- **BCM 52-2, Reinforcement – Epoxy-Coated Reinforcement and Epoxy-Coated Prefabricated Reinforcement**

Additional unique guidance for field repair or shop galvanizing is detailed in:

- **BCM 75, Miscellaneous Metal**
Prior to reviewing this BCM, it is essential to review the following Contract Specifications (CS), Sections:

- 83-1, Railings and Barriers – General
- 83-2.01, Railings and Barriers – Metal Railings and Barriers – General
- 83-2.05, Railings and Barriers – Metal Railings and Barriers – California Bridge Rails
- 83-2.06, Railings and Barriers – Metal Railings and Barriers – Chain Link Railings
- 83-2.07, Railings and Barriers – Metal Railings and Barriers – Cable Railings
- 83-2.08, Railing and Barriers – Metal Railings and Barriers – Tubular Railings,

which includes sections that this BCM is based on as identified in the title block above. Information in the CS typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Contract work that includes California bridge rails, chain link railings, cable railings, or tubular railings

2. Submittals:
   a. Shop drawings for California bridge rails and tubular railings
   b. Concrete mix designs
   c. Form CEM 3101, Notice of Materials to be Used

**Procedure**

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:
   a. Benchmark for verification of layout and completed railings.
   b. Intermittent for placement of bar reinforcing steel, installation of posts and railings, and during concrete curing.
   c. Continuous for concrete placement.

3. Before construction begins, the Structure Representative (SR) or delegate must:
   a. Review the contract documents for material requirements and discuss with the Materials Engineering and Testing Services (METS) Representative (METS Rep) and the Contractor.
   
   b. Review the Construction Manual, Chapter 4, Construction Details, Section 4-83, Railings and Barriers, with an emphasis on Section 4-8303C,
Pipe Handrailing, Steel Bridge Railing, Cable Railing, Metal Railing (Tubular), and Chain Link Railing.

c. Review the applicable **Standard Plans** related to Metal Railings and Barriers, which include sheets B11-7 through B11-52, and B11-65 through B11-78.

d. Review the **Outline of Field Construction Practices**, Section 40, **Barrier Railing**.

e. Review and authorize shop drawing submittals for California bridge rails and/or tubular railings.
   
i. Verify whether the CS requires the tubing for railings to be shop bent or fabricated to fit the horizontal curvature.

f. Review and authorize concrete mix design submittals in accordance with **BCM 90-1**, Concrete – General.

g. Review Form CEM-3101, **Notice of Materials to be Used**, and discuss requirements with the METS Rep; notify the Contractor of any discrepancies.

h. Perform field surveying to obtain as-built bridge deck/top of rail elevations and determine adjustments to obtain smooth railing profile from specific grade points.
   
i. For additional guidance on this process, review **BCM 83-3**, Railings and Barriers – Concrete Barriers.

i. Determine locations of permanent reference elevation points and field mark these locations. Refer to **BCM C-13**, Permanent Reference Elevations, for guidance.

4. During construction, the SR or delegate must:

a. Verify that the Contractor’s railing layout (geometry, expansion joints, auxiliary structures, sidewalks, etc.) conforms to the contract documents.

b. Verify that bar reinforcing steel is placed properly in accordance with contract documents and BCM 52-1, Reinforcement – General.

c. Verify that epoxy-coated reinforcement (in freeze-thaw area) is placed in accordance with BCM 52-2, Reinforcement – Epoxy-Coated Reinforcement and Epoxy-Coated Prefabricated Reinforcement.

d. Verify that anchorage assemblies and post pockets are located and installed in accordance with the contract documents.

e. Verify that electrical conduits and other utilities are placed in accordance with the contract documents.

f. Verify plumbness and alignment of forms and/or railings are within tolerances detailed in the CS.
i. Note that the orientation of posts for California bridge rails and tubular bicycle railings is normal to the profile grade.

ii. Verify whether the CS requires vertical adjustment of the railing to compensate for camber and dead load deflection; if required, provide values to the Contractor before the railing is installed.

g. Verify the concrete is placed in accordance with BCM 51-1.03(C-D), Concrete Structures – General – Construction – Preparation and Placing Concrete; and cured in accordance with BCM 90-1, Concrete – General.

i. Note unique requirements in the CS for curing mortar, and for curing concrete in freeze-thaw areas.

h. Verify that the railings present a smooth and uniform appearance in their final position.

i. Verify that protection systems are provided for public and workers’ safety and for environmental compliance.

j. Mark the permanent reference elevation points at the top of the outside rail anchor bolts in accordance with BCM C-13, Permanent Reference Elevations and the SC Bridge Construction Survey Manual.

k. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the daily reports per BCM C-7, Daily and Weekly Reports.

5. Following construction, the SR or delegate must:

a. Measure along the completed lengths of rail to determine the monthly payment quantities described in the contract documents.

b. Survey elevations of permanent reference points and document the information on the as-built plans per BCM C-13, Permanent Reference Elevations.

c. File all test results and daily reports in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

Process Outputs

1. Authorized shop drawing submittals for California bridge rails and/or tubular rails

2. Authorized concrete mix design submittals

3. Completed bridge railings and barriers meeting contract requirements

4. Permanent reference locations and elevations
Attachments

None
Railings and Barriers – Concrete Barriers

Revision and Approval

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for submittals, quality assurance, materials, construction, and payment for concrete barriers.

This process considers concrete barriers normally administered by SC, which encompass concrete barriers constructed using the cast-in-place-with-fixed-forms method. Concrete barriers constructed using extrusion or slip-form methods are excluded.

This process includes concrete barriers constructed on new or existing structures, but also may apply to concrete barriers constructed on grade or on grade foundations.

Additional unique requirements for concrete barriers are detailed in:

- BCM C-5.01, Permanent Reference Elevations.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review Contract Specifications, Section 83-3, Railings and Barriers – Concrete Barriers, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.
**Process Inputs**

1. Contract work that includes concrete barrier(s) to be constructed using the cast-in-place-with-fixed-forms method.

**Procedure**

1. All work associated with this process is charged as Project-Direct-Construction.
2. Inspection of field work for this process is:
   a. **Benchmark** for verification of layout and during form construction.
   b. **Intermittent** for placement of bar reinforcing steel, and during curing and surface finishing operations.
   c. **Continuous** during concrete placement.
3. Before construction begins:
   a. Review the contract documents for concrete barrier requirements as follows:
      i. Review the electrical plan sheets to identify the locations of electroliers and pull boxes.
      ii. Review the deck drainage layout plan sheets to identify the locations of drainage items.
      iii. Review the bridge concrete barrier plan sheets and **Standard Plans** to identify the details of barrier and rail.
      iv. Review the construction detail plan sheets to identify the transition of barrier between bridge and roadway.
   b. Review *Construction Manual*, Chapter 4, Construction Details, **Section 4-83**, Railings and Barriers, with an emphasis on Sections 4-8302B, Concrete Barriers, and 4-8303D, Concrete Barriers and Railing.
   c. Review concrete mix design submittals for concrete barriers in accordance with the *Contract Specifications*, Section 83-3.02B, Railings and Barriers – Concrete Barriers – Materials – Concrete, Section 90-1.01C, Concrete – General – Submittals, and **BCM 90-1**, Concrete – General.
   d. Coordinate with the Resident Engineer (RE) and District Electrical Engineer to review pull box submittals. For example, ensure the punchouts for 3.5-inch diameter conduits going through pull boxes will be sufficiently set back from the face of the concrete barrier to provide the required 1-inch concrete cover.
   e. Discuss contract requirements for concrete barrier construction and planned schedule of operations with the contractor.
f. Determine adjustments for concrete barrier heights, accounting for as-built deck grades and surface irregularities as follows:
   i. Perform field surveying to obtain as-built bridge deck elevations following completion of deck construction activities by:
      1. Marking the profile points with spray paint at ten-foot intervals along a three-foot offset from the edge of deck.
      2. Then surveying the elevation of each profile point. Refer to the SC Bridge Construction Survey Manual and the SC Field Engineer Training, Section 07, Approach Slab to Punch List, for details.
   ii. Plot the as-built deck elevations on graph paper to obtain the actual deck profile, utilizing an adequate vertical scale such that the deviations are apparent.
   iii. Utilize a spline to smooth the actual deck profile, through the high points, and measure the differences between the as-built deck elevations and splined deck profile. These differences are the vertical fill adjustments for the concrete barrier heights.
   iv. Summarize the adjustments and provide a copy to the contractor prior to construction/installation of barrier rail forms.

   g. Determine the location of permanent reference elevation points and field mark these locations. Refer to BCM C-5.01, Permanent Reference Elevations.

   h. Obtain copper nails that will be installed as permanent reference points on the top surface of the finished concrete barrier.

4. During construction:
   a. For layout prior to placement of bar reinforcing steel:
      i. Verify that the contractor’s concrete barrier layout conforms to the lines shown in the contract documents.
      ii. Verify that locations for any expansion joints, sign structures, poles, posts, and pull boxes are marked so that the bar reinforcing steel can be placed accordingly (e.g., add additional stirrups around pull boxes and expansion joints per the Standard Plans).
      iii. Verify that locations for deck drains and/or inlets are marked to prevent concrete barrier from being constructed directly on top of those components. If this does occur, request a mitigation plan from the contractor.

   b. For the placement of bar reinforcing steel:
      i. Verify that the vertical reinforcing steel embedded into and protruding from the bridge deck, if shown on the contract documents, has been installed
properly. If any vertical reinforcing steel is missing after concrete is placed, discuss drill and bond operations with the contractor.

ii. Verify that reinforcing steel for concrete barriers has been placed in accordance with BCM 52-1, *Reinforcement – General*, and verify that horizontal reinforcement has been lap spliced properly in accordance with BCM 52-6, *Reinforcement – Splicing*.

iii. Verify that epoxy-coated reinforcement (for concrete barriers in freeze-thaw areas or within close proximity to ocean or tidal waters) has been placed in accordance with BCM 52-2, *Reinforcement – Epoxy-Coated Reinforcement and Epoxy-Coated Prefabricated Reinforcement*.

iv. Verify that special reinforcement for items to be embedded into the concrete barrier (e.g., poles or posts for signs and fencing) has been placed.

c. Prior to concrete placement, during construction of forms:

i. For concrete surface texture or architectural treatment to be applied to the surfaces of the concrete barriers, verify that the form liners are in accordance with BCM 51-1.03G, *Concrete Structures – General – Construction – Concrete Surface Textures*. For questions or concerns regarding architectural treatment, contact the landscape architect.

ii. Verify that any conduits and expansion fittings to be embedded into the concrete barrier have been properly installed prior to form construction and that there will be adequate concrete cover.

iii. Verify that any required block-outs have been properly installed for components, such as drains (e.g., scuppers) and pull boxes.

iv. Verify that the horizontal alignment of the form is correct.

v. Verify that vertical adjustments for concrete barrier height are implemented by:

1. Standing at the beginning of the concrete barrier and viewing (eyeballing) the longitudinal profile along the top surface of the barrier for any irregular haunch or bumps. If any irregularities are identified:

   a. Direct the contractor to make any necessary adjustments to the concrete barrier forms to yield a visually smooth profile.

vi. Verify that form clearances to reinforcement are adequate.

vii. Verify that the concrete barrier forms are properly secured to the deck and adequately braced.

d. For concrete placement, curing, and finishing:
i. Verify that the inside of the concrete barrier forms is free of debris immediately prior to concrete placement.

ii. Verify that the correct authorized concrete mix design is delivered to the project site.

iii. Verify that concrete is placed in accordance with BCM 51-1.03(C-D), Concrete Structures – General – Construction – Preparation and Placing Concrete, and cured in accordance with BCM 90-1, Concrete – General.

iv. Verify that initial top surface finishing is performed in accordance with the contract documents. BCM C-5.01.

v. Insert copper nails (to function as a permanent reference elevation points) into the top surface of the concrete barrier, after concrete finishing, but before concrete hardens, in accordance with Permanent Reference Elevations and the SC Bridge Construction Survey Manual.

vi. Verify that final finishing for all concrete barriers is performed in accordance with BCM 51-1.03F(1-4), Concrete Structures – General – Construction – Finishing Concrete, or as authorized for proposed alternative finishing methods.

e. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

5. Following construction:

a. Coordinate with the contractor to witness smoothness testing for completed concrete barriers. Verify that the top and exposed faces of concrete barriers meet the requirements of the contract documents using the 10-ft straight edge.

b. Measure along the completed lengths of concrete barriers to determine monthly payment quantities (typically in LF) for concrete barrier bid items as described in the contract documents. Coordinate with the RE to exercise a partial payment if the final surface finish is scheduled for a later construction phase (e.g., 5-10% withholding for surface finish).

c. Perform field surveying to obtain elevations of the permanent reference elevation points and document on the as-built plans.

6. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized concrete mix design submittals for concrete barriers
2. Vertical adjustments to concrete barrier heights
3. Permanent reference elevation points and elevations
4. Completed concrete barrier rail

**Attachments**

None.
Railings and Barriers – Existing Railings and Barriers – Existing Metal Bridge Railings

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of submittals, quality assurance, materials, construction, and payment for work performed on existing metal bridge railings, including removal and/or reconstruction, and coordinating inspection and release of metal bridge railing with the Materials Engineering and Testing Services (METS) Representative.

Additional related requirements for this process are detailed in the Contract Specifications (CS), Section 75, Miscellaneous Metal and additional guidance is contained in BCM 75, Miscellaneous Metal.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the CS, Section 83-11.03, Railings and Barriers – Existing Railings and Barriers – Existing Metal Bridge Railings, that this BCM is based on as identified in the title block above. The information in the CS typically will not be repeated in the text of this BCM.

Process Inputs

1. Submittals
2. Form CEM-3101, Notice of Materials to be Used
3. Form TL-38, Inspection Request Form
Procedure

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:
   a. Intermittent when work is not over live traffic.
   b. Continuous for work near and/or over live traffic.

3. Before construction begins, the Structure Representative (SR) or delegate must:
   a. Review shop drawing submittal in coordination with the Bridge Design (BD) Structure Project Engineer and the METS Representative as needed; authorize or reject for resubmittal, in writing.
   b. Coordinate with the Resident Engineer and District Specialist for asbestos testing and to determine appropriate removal, if shims are not identified in the Contract. A change order may be needed for a right-of-way delay.
   c. Verify information on Form CEM-3101, Notice of Materials to be Used.
   d. Verify that Form TL-38, Inspection Request Form, has been submitted.
   e. Request Form TL-29, Report of Inspection of Material, from the METS Representative (METS Rep).
   f. Review the following (since the CS requires that refabrication and installation of the railing must comply with the specifications for a new metal bridge railing of the type being reconstructed):
      i. Guidance found in BCM 83-(2.05-2.08), Railings and Barriers – Metal Railings and Barriers – California Bridge Rails, Chain Link Railings, Cable Railings, and Tubular Railings.
      ii. Requirements found in applicable sections of the Contract Specifications, Section 83-2, Railings and Barriers – Metal Railings and Barriers.
      iii. Applicable Standard Plans related to Metal Railings and Barriers, which include sheets B11-7 through B11-52, and B11-65 through B11-78.
   g. Anticipate and inspect replacement metal bridge railings delivered to the job site. If field release is required, request assistance from the METS Rep.
   h. Discuss responsibilities for reconstructing metal bridge railings shop drawings review with the METS Rep:
      i. Request assistance with the review of the welding quality control plan (WQCP), if applicable.
      i. Review the utility plans to identify any existing utilities that must be maintained:
i. During the removal of existing metal bridge railing.
ii. During the reconstruction of existing metal bridge railings.

j. Coordinate with the Resident Engineer and/or third-party utility owner to implement a change order if needed, for existing utilities that are encountered but not shown on the contract plans.

k. Discuss requirements of the authorized work plans for the removal of existing and erection of replacement metal bridge railings with the Contractor prior to starting field work.

4. During construction, the SR or delegate must:
   a. Communicate safety requirements per the authorized workplan with the Contractor for work over traffic and/or railroad.
   b. Use fall protection equipment while performing inspection where work is over traffic and/or railroad.
   c. Verify that proper removal procedures for existing metal bridge rail are followed, especially when asbestos removal and/or salvaging is required.
   d. Verify that reconstructed metal bridge railing complies with the Contract requirements for the type of railing and coating shown.
   e. Coordinate with the Caltrans electrical inspector to verify that all electrical components are in place and compliant with the Contract.
   f. Verify that prefabricated metal bridge railing assemblies are free of defects upon delivery to the project site.
      i. Verify that the Contractor repairs any damage to galvanized surfaces as outlined in the CS, Section 75-1.02B, Miscellaneous Metal – Materials – Galvanizing.
   g. Verify that sections of metal bridge railings (due to geometric shape), are matchmarked, if required.
   h. Verify that metal bridge railings at expansion joints, such as hinges and abutments, are installed with the correct expansion joint details, per the authorized shop drawings.
   i. Perform construction survey to verify a smooth profile for the finish grade of the top of metal bridge railing. As a final check, “eyeball” the top finish grade of metal bridge railing to smooth out the final profile.
   j. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the daily reports per BCM C-7, Daily and Weekly Reports.
5. Following construction, the SR or delegate must:
   a. Survey elevations of permanent reference points and document the information on the as-built plans per BCM C-13, Permanent Reference Elevations.
   b. File all project documentation (correspondence, materials acceptance documentation, daily reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized reconstructed metal bridge railings submittals
2. Reconstructed metal beam bridge rail
4. Daily reports

**Attachments**

None
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QMS BCMs (Aligns with Sections of the Contract Specification)

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Non-QMS BCMs (Will be replaced by QMS BCMs)

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Concrete – General

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for the following:

1. Review and authorization of action submittals pertaining to concrete aggregate gradation, cementitious materials, admixtures, curing compounds, mix designs, delivery, testing, stationary mixer certification, concrete protection, quality control plan, concrete materials quality control summary report, and polymer fibers.

2. Quality assurance of the attributes of concrete, including cementitious material content, shrinkage limitations, uniformity of freshly mixed concrete, compressive strength, prequalification, and curing compounds.

3. Concrete material acceptance criteria when inspecting concrete deliveries and placement of concrete through verification of concrete batch proportioning, mixing, transporting, and concrete water content by penetration or slump testing.

4. Curing and protection of freshly placed concrete.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 90-1, Concrete – General, that this BCM is based on as identified in the title block above. The information in the Contract Specifications typically will not be repeated in the text of this BCM.

Process Inputs

1. Concrete mix design and material submittals as required by the Contract Specifications.
Procedure

1. All work associated with this process is charged as Project Direct – Construction.

2. Inspection of field work for this process is:
   a. Benchmark for:
      i. Batch plant certifications
   b. Continuous for:
      i. Verification of concrete delivery, mixing, discharge, water content and curing operations
   c. Intermittent for:
      i. Material verification and authorization

3. Before construction begins the Structure Representative (SR) or delegate must:
   a. Review the following to gain familiarity with administration practices for concrete placement activities:
      i. Contract documents
      ii. Construction Manual, Chapter 6, Sampling and Testing, for concrete placement activities
      iii. Concrete Technology Manual
      iv. Relevant training such as a Winter Training presentation which covers Concrete Technology.
   b. Discuss and review concrete practices with other engineers and supervisor.
   c. Discuss upcoming material sampling and testing with the District Materials Engineer/Field Tester and cover the following topics:
      i. Determine how much notice will be required for the District Materials Engineer to collect required concrete material samples and perform testing.
      ii. Determine how soon test results will be available after testing.
      iii. Determine which test equipment calibrations will be needed during the project. Reference Attachment 2, Fresh Concrete Field Sampling and Testing Equipment List, for a list of typical equipment required to perform routine fresh concrete sampling and testing.
      iv. Verify batch plant is in conformance according to California Test (CT) 109, Method for Testing of Material Production Plants.
   d. Review materials, submittals, and techniques with SC staff. Verify SC staff are familiar with inspecting concrete placement, performing required submittal
reviews, and have the required testing certifications. To follow are useful resources:

i. District Material Engineer for California Test certifications.

ii. The American Concrete Institute (ACI) - Certification - Certification Programs website to obtain information regarding certification as Concrete Field Testing Technician Grade 1. Note that this is found under the Testing Programs – Field Concrete Testing path.

1. Information on this topic can also be found at the SC intranet, ACI Field Training.

iii. Bridge Construction Engineer, to obtain or update the above certifications and to facilitate the training requirements.

e. Verify that SC staff have the required equipment for the necessary tests. The Resident Engineer (RE) may be able to provide standard concrete testing equipment from the District warehouse. The SC Equipment Manager may be contacted if additional test equipment is needed. Reference Attachment 2, Fresh Concrete Field Sampling and Testing Equipment List, for a list of equipment needed for typical ASTM/CT concrete test procedures.

f. At the preconstruction conference discuss the following with the Contractor:

i. Concrete mix design submittal specification requirements and review times for each concrete mix design submittal. If the Contractor is submitting multiple mix designs, remind the Contractor to prioritize the review schedule. Refer the Contractor to the Contract Specifications, Section 5-1.23, Control of Work – Submittals for additional requirements.

ii. Unique specification requirements (corrosive environments, mass concrete, wet cast-in-drilled-hole concrete piling, etc.) that may require special attention in the concrete mix design submittal and review process.

iii. Prequalification requirements when specified, or when concrete has a described 28-day compressive strength greater than 3,600 psi.

iv. Quality assurance test requirements, such as concrete temperature, aggregate, admixture, air entrainment, concrete strength testing, and water content.

v. Expectations for timely pour notifications to allow coordination of staffing, batch plant inspection, and concrete sampling and testing.

vi. Any concrete placement submittal requirements.


viii. Limitations of concrete batch size based on manufacturer's guaranteed capacity, and the requirements for concrete trucks to have an electrically
or mechanically actuated revolution counter that readily allows verification of the number of revolutions of the drum or blades.

ix. The requirements of *Contract Specifications*, Section 90-1.02G(3), *Concrete – General – Materials – Mixing and Transporting Concrete – Transporting Mixed Concrete*, which stipulates the conditions under which concrete may be incorporated into the work.

g. Verify *Form CEM-3101, Notice of Materials to Be Used*, is received from the Contractor and then forward the form to Materials Engineering and Testing Services (METS).

h. Perform initial review of the concrete mix design submittal. Use *Form SC-4303, Concrete Mix Design Submittal Checklist*, as an initial acceptance tool to provide a comprehensive review of concrete mix design components and to point out gaps in the submittal. Verify the concrete mix design title block indicates the “intended use” (e.g., “CIDH,” “stem and bent caps,” “bridge deck,” “abutment,” “approach slab,” “miscellaneous concrete”) to ascertain cementitious requirements. When it is discovered that required components of the concrete mix design is not included in the submittal, stop the review, and promptly notify the Contractor in writing of the missing components. It is SC practice to expedite the authorization process by reviewing as much of the mix design as possible while waiting for the resubmission of missing components of the mix design, following the initial review.

i. Review and authorize each concrete mix design submittal in accordance with the *Contract Specifications* and the *Construction Manual, Section 4-9001A(2), Check of Mix Design*. Use *SC Forms 4303B-E, Concrete Mix Design Check Spreadsheet* or *METS Concrete Mix Design Check application* in METS J2 database to check mix design components. Refer to the *Concrete Technology Manual, Chapter 3, Review of Concrete Mix Designs*, for background information. Technical assistance during submittal reviews and construction may be provided by *METS Contacts* or the *SC Concrete Material Technical Team B*. The following concrete components and related items should be verified when reviewing a concrete mix design submittal:

i. For cementitious materials perform the following steps as part of the mix design review process:

1. Verify each proposed cementitious material is on the Authorized Materials List (AML).

2. Review the submitted certificate of compliance for each cementitious material. Confirm that the cementitious classification, type, and chemical compositions meet the minimum contract requirements.

3. Using Form SC-4303D, *Concrete Mix Design Check – SCM Evaluation*, in the *Concrete Mix Design Check Spreadsheet*:
a. Verify the mix design cementitious materials meet the mathematical requirements for minimum cementitious content.

b. Consider unique requirements of cementitious materials for corrosive environments, freeze-thaw areas, and deicing chemicals.

ii. For aggregates if the gradation specifications for minor concrete has been waived, advise the Contractor, and document that decision in writing. Perform the following steps as part of the concrete mix design review process:

1. Verify that the Contractor has submitted all required quality control (QC) test results of aggregates prior to starting the authorization analysis. If test results are not available, have the aggregates tested and obtain test results.

2. Review and authorize aggregate gradation (with X-values) submittal. Verify contract conformance by completing Form SC-4303B, Concrete Mix Design Check -Aggregate Gradation.

iii. For water, review water test results and authorize water for use.

iv. For admixtures refer to the Concrete Technology Manual, Chapter 2, Concrete Construction Materials; and Chapter 3, Review of Concrete Mix Designs. Perform the following steps as part of the concrete mix design review process:

1. Verify admixtures are on the AML.

2. Verify that the dosage amounts of admixtures are within the manufacturer’s recommendations.

3. When multiple admixtures are used, verify the admixtures are compatible with each other per information provided in the manufacturer’s recommendations.

v. For polymer fibers, review and approve polymer fiber submittals in accordance with contract documents.

vi. Review and verify shrinkage limitations are met when specified.

1. Refer to the Concrete Technology Manual, Chapter 2, Concrete Construction Materials, Chapter 3, Review of Concrete Mix Designs and Chapter 5, Concrete Construction for background information.

vii. Verify the concrete mix design compressive strength requirements are met when specified concrete strength at 28-days is 3,600 psi or greater.

viii. If the concrete has a described 28-day compressive strength greater than 3,600 psi, or if prequalification is specified, prequalify the materials, mix
proportions, mixing equipment, and procedures proposed for use in the work before placing the concrete, per contract requirements.

ix. For stationary mixer certification, review and authorize each Stationary Mixer Certification submittal in accordance with the contract documents. Refer to Concrete Technology Manual, Chapter 4, Proportioning, Mixing and Transporting, for additional guidance.

j. Notify the Contractor in writing of the authorization or rejection of each concrete submittal. Refer to the Concrete Technology Manual, Chapter 3, Review of Concrete Mix Designs, for review examples. For each authorized concrete mix design, send a courtesy copy to the METS Representative (METS Rep) and the District Materials Engineer. See Attachment 1, Sample Letter to Authorize Concrete Mix Designs.

k. Contact the District Materials Engineer to verify that the batch plant has been CT 109 certified before any production work starts.

l. Confirm that the METS Rep has tested and released the curing compound batch prior to authorizing the material. Authorize each curing compound submittal based on METS test reports and certificates of compliance.

m. Review concrete materials test results and quality control informational submittals in accordance with Contract Specifications, Section 5-1.23, Control of Work – Submittals. Inform the Contractor of unacceptable test results.

n. Print all concrete mix design check records and provide to field inspection staff. The concrete mix design checks produced by the Concrete Mix Design Check Spreadsheet are:

- Form SC-4303B, Concrete Mix Design Check- Aggregate Gradation
- Form SC-4303C, Concrete Mix Design Check- Batch Info
- Form SC-4303D, Concrete Mix Design Check- SCM Evaluation
- Form SC-4303E, Concrete Mix Design Check - Aggregate Gradation Chart

o. Review concrete pour notification from the Contractor, which is typically received 24 hours and ideally 48 hours before the scheduled concrete pour.

i. After verifying the accuracy of the pour notification (correct mix design, item to be poured will be ready at intended time, etc.), coordinate adequate State staff for field inspection.

1. Schedule batch plant inspection and material sampling and testing for the time of the pour.

a. Consider the size of the concrete pour. For pours with anticipated quantities greater than 300 CY, more than one set of cylinder sampling will be required per the Contract Specifications and as
outlined in the Construction Manual, Table 6-1.17, Materials Acceptance Sampling and Testing Requirements: Concrete.

b. It is recommended that sampling concrete for compressive strength testing be performed when the concrete mix design is first used.

p. It is highly advisable to conduct a pre-pour meeting for concrete, grout, or mortar placement with the Contractor and District RE to:

i. Review authorized concrete submittals, concrete placement, logistical considerations, staff qualifications, expectations for timely pour notifications, assess potential risks, and schedule batch plant inspection services and testing requirements.

ii. Review the proposed concrete curing methods. Verify the curing compound has been tested and released.

iii. Review the proposed concrete protection methods when concrete materials, placement restrictions, weather conditions or other adverse conditions warrant extra precautions to protect fresh concrete.

1. Refer to Concrete Technology Manual, Chapter 5, Concrete Construction, for guidance.

iv. Review additional items such as site access, lane closures, flagging, and location of concrete washouts.

q. In preparation for checking concrete batch tickets before a pour, develop a spreadsheet that extrapolates the mix design quantities for the common delivery truck loads. The spreadsheet permits a quick review of load tickets at the job site to verify the mix design proportions for different size loads.

r. During trial batch and concrete placement operations, verify and document the following in daily reports:

i. The areas used for testing meet Stormwater Pollution Prevention Plan requirements.

ii. The concrete batch delivery matches the authorized concrete mix design.

iii. The unit weight for cementitious material content by:

1. Performing CT 518, Method of Test for Density (Unit Weight) of Fresh Concrete.

2. Completing Form SC-4304, Worksheet for California Test 518 Unit Weight of Fresh Concrete. Refer to the instruction tab for guidance, as well as the two Example tabs for completed forms.

iv. Compliance with the test frequency specified in the Construction Manual, Table 6-1.17.
v. The concrete uniformity. Perform at least two penetration (CT 533, *Method of Test for Ball Penetration in Fresh Portland Cement Concrete*) or slump (ASTM C143, *Standard Test Method for Slump of Hydraulic-Cement Concrete*) tests for each concrete placement operation in accordance with *Construction Manual* (Table 6-1.17). Reject concrete materials with failing tests and do not allow the material to be incorporated into the work.

vi. Fabrication of test cylinders for compressive strength tests per:

1. **CT 539, Method of Test for Sampling Freshly Mixed Concrete**
2. **CT 540, Method of Test for Making, Handling, and Storing Concrete Compressive Test Specimens in the Field**, which requires two test cylinders minimum, and should be performed at least once per significant concrete placement operation. The test frequency is specified in the *Construction Manual* (Table 6-1.17).

4. **During Construction the SR or delegate must:**

   a. Collect and review concrete weighmaster batch tickets (for each truck) and a certificate of compliance, usually sent with the last concrete truck.

      i. If concrete is rejected, note reasons for rejecting the concrete and the location of any concrete that was placed prior to the concrete being rejected.

      ii. Assistant Structure Representative must notify the SR if there is a compliance issue; each weighmaster batch certificate (concrete ticket) must be verified for compliance with the authorized mix design in use.

      iii. Refer to *Concrete Technology Manual*, Chapter 4, *Proportioning, Mixing and Transporting* for further guidance.

   b. Field verify application of concrete, grout or mortar curing method meets the requirements of the contract documents and conforms to the project plans as determined at the pre-pour meeting. Refer to BCM 51-1.03H, *Concrete Structures – General – Construction – Curing Concrete Structures*, for guidance.

      i. For the water method verify water application for the required curing time period.
ii. For the curing compound method verify the curing compound is correct for the placement location. Verify curing compound mixing and application per the requirements of the contract documents.

iii. For the waterproof membrane method verify the waterproof membrane is suitable for use.

iv. For the forms-in-place method verify the forms remain in place for the required time period.

c. Field verify the concrete protection plan is followed, if required.

d. After the concrete pour, when the test cylinders have cured for the appropriate amount of time, coordinate compressive strength tests of the cylinders.

i. Fill out Form TL-0101, Sample Identification Card, to accompany the cylinders.

ii. Coordinate testing of the cylinders with the nearest Caltrans Materials Laboratory.

1. Testing is performed per CT 521, Method of Test for Compressive Strength of Cylindrical Concrete Specimens. Note that this test is performed by laboratory staff, not by SC staff.

iii. Obtain strength test results from the District Materials Engineer, or through the Data Interchange for Materials Engineering (DIME); note that an account login is required.

1. Note that Construction Procedure Directive, CPD 22-12, DIME Statewide Implementation, requires certain test results to be posted in DIME beginning in January 2023.

2. Review strength results and compare to contract requirements. Discuss any deficient results with the BCE and the Contractor and determine appropriate course of action (see additional guidance in Procedure step 4.h.).

e. Conduct post-pour review with the Contractor at the next scheduled meeting.

f. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

g. Prior to each progress payment complete quantity sheets and submit to the RE.

h. For measurement and payment, verify compliance with compressive strength requirements. If compressive strength requirements are non-compliant with
the contract requirements because of insufficient strength, take the following steps:

i. Reject the concrete represented by the failed test. Typically, the failed test represents a maximum of 300 cubic yards, but contract documents may modify the concrete volume represented by the cylinders.

1. Determine whether the concrete placed is structurally adequate to remain in place but with an administrative deduction. If in doubt, coordinate with the Bridge Design Structure Project Engineer.

2. If concrete is structurally adequate, ask the Contractor to elect between: replacing the rejected concrete, or accepting an administrative deduction for the concrete represented by the test in accordance with Contract Specifications, 90-1.01D (5)(a), Concrete – General – General – Quality Assurance – Compressive Strength – General.

5. Following Construction, the SR or delegate must:
   a. Update project records (SC-4306, Concrete Pour Record, SC-3701, Test Result Summary) as required. Review records for completion.

6. File all project documentation (correspondence, materials acceptance documentation, daily reports, concrete mix design check records, testing certifications, test equipment calibration records, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized concrete submittals
2. Completed Form SC-4303, Concrete Mix Design Submittal Checklist
3. Completed SC Forms SC-4303B-4303E, Concrete Mix Design Check Spreadsheet
4. Concrete material testing records
5. Daily reports
6. Concrete pour records with batch tickets and certificates of compliance
7. Properly cured concrete
8. Properly protected concrete
9. Record of post-pour concrete review meeting
Attachments

Attachment 1: Sample Letter to Authorize Concrete Mix Designs
Attachment 2: Fresh Concrete Field Sampling and Testing Equipment List
Sample Letter to Authorize Concrete Mix Designs

When writing letters always start with the current template from the Director’s Office

<Date>

<Mr./Ms. Contractor>  
<Title>  
<Organization>  
<Address>  
<City, ST  ZIP>

SUBJECT: EA #XX-XXXXX: Authorization of <CONCRETE SUPPLIER> Mix Design # XXXXXX.

Dear <CONTRACTOR PROJECT MANAGER>: 

The enclosed concrete mix design #XXXXXX from <CONCRETE SUPPLIER> meets the requirements of the 2018 Standard Specifications for the State of California. The following ready mix plant(s) has/have been prequalified to supply this mix to project XX-XXXXX.

☐ Location of Plant, Plant Number  
☐ Location of Plant, Plant Number  
☐ Location of Plant, Plant Number

This mix is authorized for use in the following structures/elements:

☐ Structure XX-XXXX  
  o Structure Element 1 
  o Structure Element 2  
☐ Structure YY-YYYY

While this mix has been prequalified, the mix components and sample cylinders will still be subject to quality testing as described in the contract documents prior to final acceptance in the work. 
Please see the attached list of approved mix designs for your use.
If you have any questions, please contact <STRUCTURE REPRESENTATIVE> at XXX-XXX-XXXX or email XXXX@dot.ca.gov for more information on this mix design.

Sincerely,

Name
Structure Representative

Name
Resident Engineer

Enclosure

Cc: METS Representative/District Materials Engineer
Fresh Concrete Field Sampling and Testing Equipment List

This attachment includes a list of equipment needed to perform the ACI Field Grade 1 ASTM test methods and California Test equivalents. Reference each test method for additional details on equipment size, dimensions, and accuracy. Note that the titles displayed are for the American Society for Testing and Materials (ASTM) tests.

For all the tests below, it is recommended to have:

- Shovel
- Wheelbarrow
- Sponge
- 5-gallon bucket for water

ASTM C138/California Test 518: Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete:

- Scale (220 lb x 0.1 lb)
- Calibrated Vessel with known volume (typically 0.5 cf)
- Round Bottom Scoop
- 24" Long x 5/8" diameter Tamping Rod (6 x 12 cylinders and beams)
- Rubber Mallet
- 12" x 1/2" Strike Off Plate or Graduated Strike Off Bar
- Vibrator is optional but not needed

ASTM C231/California Test 504: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

- Type B Concrete Air Meter and Assembly
- Calibrated Vessel (typically 0.5 cf)
- 24" Long x 5/8" diameter Tamping Rod
- 3 oz Bulb Syringe
- Rubber Mallet
- Round Bottom Scoop
- 12" x 1/2" Strike Off Plate
- Graduated Strike Off Bar
• Trowel
• Vibrator is optional but not needed

ASTM C31/California Test 540: Standard Practice for Making and Curing Concrete Test Specimens in the Field:
• Cylinder or Beam molds as needed
• 24" Long x 5/8" diameter Tamping Rod (6 x 12 cylinders and beams)
• 12" long x 3/8" diameter Tamping Rod (4 x 8 cylinders)
• Rubber Mallet
• Trowel or Hand Float
• Round Bottom Scoop
• Vibrator is optional but not needed
• Per ASTM C31, you are required to measure temperature, slump, and air content when making concrete test specimens so additional equipment is required to perform those tests

ASTM C143/California Test 556: Standard Test Method for Slump of Hydraulic-Cement Concrete:
• Slump Cone Funnel
• Metal Slump Cone Base or any flat and level non-absorbent surface large enough for the anticipated slump
• Round Bottom Scoop
• 24" Long x 5/8" diameter Tamping Rod
• Measuring tool accurate to the nearest 1/4"

ASTM C173/California Test 543: Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method:
• Volumetric Roll-a-Meter
• Rubber Mallet
• 24" Long x 5/8" diameter Tamping Rod
• Strike Off Bar
• Bulb Syringe
• Funnel and measuring cup
• Isopropyl Alcohol (70% alcohol by volume) and Distilled Water
• Round Bottom Scoop

ASTM C1064/California Test 557: Standard Test Method for Temperature of Freshly Mixed Hydraulic Cement Concrete:
• Thermometer which can measure to the nearest one degree
• Container
Concrete – Rapid Strength Concrete

Revision and Approval

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Click here to request previous versions  
Contact SC Technical Team B for questions

Background

This process establishes Structure Construction (SC) responsibilities and procedures for review and authorization of material submittals and quality assurance test results pertaining to furnishing and curing rapid strength concrete (RSC) used in bridge superstructure and approach slab work.

This Bridge Construction Memo (BCM) addresses the delivery of RSC by volumetric proportioning trucks, which are calibrated under the Material Plant Quality Program (MPQP) administered locally in each Caltrans District. The MPQP certification meets the requirements of California Test 109, Methods for Testing of Material Production Plants, for volumetric batch mixer trucks. Once calibrated, the volumetric truck will get an MPQP inspection tag which is valid for 30 days. Trucks must be calibrated for each mix design. If a truck is re-calibrated for a different mix design and then returns to the project, re-calibration is required. The aggregate used in the calibration must also be used in production; changing aggregate requires re-calibration.

Additional unique contract requirements for RSC are detailed in the Contract Specifications:

- Section 90-1.01C, Concrete – General – Submittals, for mix design and prequalification requirements.
- Section 51-1.03C-D, Concrete Structures – General – Construction – Preparation and Placing Concrete.
- Section 51-5, Concrete Structures – Approach Slabs.
- Section 51-1.03H, Concrete Structures – General – Construction – Curing Concrete Structures, for unique requirements of curing RSC for bridge decks.
• Section, 51-1.01D(2)(b), *Concrete Structures – General – Quality Assurance – Quality Control – Rapid Strength Concrete*, for various information, prequalification, opening age, etc. Note: This is NOT for members in flexure, nor approach slabs for acceptance criteria of structure elements.

• Section 51-1.02D, *Concrete Structures – General – Rapid Strength Concrete*, for bridge decks or PCC overlays.

This BCM does not address rapid setting concrete, used primarily for surface patching and bonding dowels, as specified in the *Contract Specifications*, Section 60, *Existing Structures*.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the *Contract Specifications*, Section 90-3, *Concrete – Rapid Strength Concrete*, that this BCM is based on as identified in the title block above. The information in the *Contract Specifications* typically will not be repeated in the text of this BCM.

**Process Inputs**

1. Per the *Contract Specifications*, submittals for:
   a. Volumetric Proportioning
   b. Certifications of Compliance
   c. Weighmaster Certificates
   d. Daily Production Data

**Procedure**

1. All work associated with this process is charged as [Project Direct – Construction](#).

2. Inspection of field work for this process is:
   a. **Continuous** for verification of RSC volumetric proportioning activities at the job site and placement of concrete for structure elements.

3. Before construction begins:
   a. Review the [contract documents](#) and the following reference documents:
      i. *Construction Manual*, Chapter 4, *Construction Details*, [Section 90, Concrete](#)
      ii. [Attachment 1](#), *Volumetric Proportioning of Rapid Strength Concrete*
      iii. [BCM 51-1.01](#), *Concrete Structures – General*
      iv. [BCM 51-1.03C-D](#), *Concrete Structures – General – Construction – Preparation and Placing Concrete*
v. **BCM 51-1.03H, Concrete Structures – General – Construction – Curing Concrete Structures**

vi. **BCM 51-5, Concrete Structures – Approach Slabs**

vii. **BCM 90-1, Concrete – General**

b. Ensure SC field staff are ACI certified with valid test certifications. At a minimum, for RSC the staff must be certified for [California Test 125, Method of Test for Sampling Highway Materials and Products Used in the Roadway Pavement Structure Sections](https://www.dot.ca.gov/hq/engineering/technical/standards/standards.htm), [California Test 233, Method of Test for Surface Moisture in Concrete Aggregates by the Displacement Method (Field Method)](https://www.dot.ca.gov/hq/engineering/technical/standards/standards.htm), and [California Test 533, Method of Test for Ball Penetration in Fresh Portland Cement Concrete](https://www.dot.ca.gov/hq/engineering/technical/standards/standards.htm).

c. Discuss upcoming concrete placement activities with Caltrans District weights and measures coordinator to coordinate plant inspections. If a volumetric truck will be used, ensure that it is calibrated and tagged by Caltrans’ Material Plant Quality Program (MPQP).

d. When calibration is performed more than 100 miles from project limits, remind the Resident Engineer to take the specified deduction for each calibration session.

e. Review and authorize the RSC mix design per **BCM 90-1, Concrete – General**.

f. Review certificates of compliance for aggregate, cementitious material, and admixtures used for calibration testing to ensure the certificates delivered during production are for the same materials.

g. When a non-Portland cement has been submitted as part of the concrete mix design, review and authorize the RSC curing method.

h. For RSC work requiring lane closures, request and review a contingency plan for RSC placement per the [Construction Manual, Chapter 2, Safety and Traffic, Section 2-214D, Construction Contingency Plan](https://www.dot.ca.gov/hq/engineering/technical/standards/standards.htm).

4. During Construction:

a. Verify volumetric truck MPQP is calibrated for the current mix design and that an MPQP acceptance sticker is attached to the truck.

b. Verify weighmaster certificates contain components per the [Contract Specifications](https://www.dot.ca.gov/hq/engineering/technical/standards/standards.htm).

c. Field verify concrete uniformity test results (California Test 533) by comparing two test samples of mixed concrete. Each sample is an average of three tests and the tested samples must be from the same load.
i. The difference in penetration between the two concrete test samples must not exceed 5/8 inch per the Contract Specifications, Section 90-3.02A, Concrete – Rapid Strength Concrete – Materials – General.

d. Verify curing method used for RSC is authorized.

e. Open the lane to traffic per Contract Specifications, Section 51-1.01D (2)(b)(ii), Prequalification of Mix Design.

f. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. File all project documentation (correspondence, materials acceptance documentation, Daily Reports, etc.) in the appropriate category in the project records as specified in the Construction Manual, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Authorized RSC submittals
2. RSC field testing and analysis results/data
3. Daily Reports
4. Authorized Certificates of Compliance, Weighmaster Certificates, and Daily Production Data

**Attachments**

*Attachment 1:* Volumetric Proportioning of Rapid Strength Concrete
Volumetric Proportioning of Rapid Strength Concrete

Rapid Strength Concrete (RSC) is primarily used for rehabilitation work with tight timelines, to minimize impacts to the traveling public. Two types of cement are allowed for use in RSC: Type III or hydraulic. Refer to Contract Specifications (CS), Section 90-3.02A, Concrete – Rapid Strength Concrete – Materials – General. Choosing which to use may depend on project requirements and is typically at the contractor’s discretion. RSC can be designed to achieve early strength and workability as needed.

One of the challenges with RSC is mixing and transporting the material to the project site. RSC sets up fast and using the traditional drum mixer can be difficult. The CS, Section 90-1.02G, Concrete – Materials - Mixing and Transporting Concrete, allow several methods for mixing and transporting concrete. Per the CS, Section 90-3.02B, Concrete – Rapid Strength Concrete – Volumetric Proportioning, volumetric proportioning using volumetric mixers as shown in Figure 1, is allowed in mixing and transporting RSC. For some cases, volumetric mixing is more cost and time efficient than traditional drum mixing, making these mixers an innovative solution for concrete production.

![Volumetric Mixers](image)
Volumetric Proportioning of Rapid Strength Concrete

Volumetric Mixers

The volumetric concrete mixer is a combination materials transporter and mobile concrete mixing plant, mounted on a transport vehicle or a stationary skid mount frame. The mixer carries the component materials of coarse aggregates, sand, cement powder and water, used to produce fresh concrete. These materials can be mixed along with other admixtures to produce a specified concrete mix design, on a continuous or intermittent basis, on site where the mix is to be poured. The mix is proportioned using known volumes of the component materials in the mix design.

The coarse aggregate and sand volumes are proportioned by adjusting the corresponding bin gates to the desired height as determined by a yield calibration test of the machine. The cement powder is accurately blended with aggregate using a uniquely designed auger delivery system. Finally, a metered amount of water is pumped into the mixing discharge chute and mixing auger to combine with the aggregates and cement powder.

Once in the discharge chute, the mixing auger continuously and thoroughly mixes and blends the ingredients to produce a continuous discharge of uniform quality concrete.

The volumetric mixer can be used alone, or it can be used as part of a concrete batching system. In Figure 2, a volumetric mixer is used to mix the concrete; it is then belted into a drum truck where admixtures are added before being transported to the pour site. Refer to Figure 3, for a schematic of a volumetric mobile mixer.

Figure 2. Volumetric Mixer belted into Drum Truck
Volumetric Proportioning of Rapid Strength Concrete

Volumetric mixers have other advantages. For example, volumetric mixers can:

1. Store, proportion, mix and dispense concrete from a single truck.
2. Allow quick and efficient mix design changes.
3. Produce a fresh mix upon delivery because all materials are kept separated until seconds before pouring.
4. Enable the user to move between jobs without having to return to a plant to change mix designs or reload.
5. Enable the user to eliminate overages and shortages and produce the exact amount of product needed.
6. Eliminate “hot” loads by ensuring fresh concrete is always available.
7. Consistently produce the exact mix design every time.
8. Increase efficiency with quick and easy clean out with no waste.
9. Enable the user to mix concrete anytime, day or night.

Figure 3. Schematic of a Volumetric Mobile Mixer
Volumetric Proportioning of Rapid Strength Concrete

Quality Assurance/ Quality Control when using RSC and Volumetric Mixers

When using a volumetric mixer with RSC, a mock-up is helpful in determining what type of equipment and material best suits the specific project (refer to Figure 4). A full-size section representing the work is preferable. During the mock-up, various parameters and unknowns may be determined. The following should be considered for a mock-up:

1. The mock-up should represent a full-size portion of work to be performed.
2. Reinforcement should be included.
3. All equipment and labor used in the mock-up should be the same as used in production.
4. The volumetric mixer should be certified (CT 109) using the same mix design that will be used in production work. For any material change from the approved mix design, the volumetric mixer must be recalibrated/recertified.
5. Concrete mix design with different dosage admixtures should be used to determine which mix design best suits the project for workability and set time.
6. If the concrete mix is for mass concrete (for example, when one dimension of a concrete member exceeds 7 feet), the mock-up should be used to determine peak temperature (must not exceed 160 degrees Fahrenheit) per CS, Section 51-6.01D(2)(b), Concrete Structures – Mass Concrete – General - Quality Assurance – Quality Control - Temperature Monitoring and temperature differential. For additional information refer to the Concrete Technology Manual, Chapter 1, Structure Concrete Characteristics, in the section titled, Heat of Hydration, on page 1-9. Note hydraulic cement will have different heat of hydration than portland cement.
7. Contractors may choose to prequalify the mix design during the mock-up. Refer to the CS, Section 90-1.01D(5)(b), Concrete-General-Quality Assurance-Compressive Strength - Prequalification. Contractors may also want to experiment with different types and dosages of admixtures (could include accelerators for Type III, or retarders for hydraulic cement) to achieve desired strength at age of break.
Quality Assurance during Production

During the work, it is important that quality assurance measures are taken to ensure proper production and placement of concrete. These measures include the following:

1. Volumetric mixers are tested, inspected, and certified (CT 109, Method for Testing of Material Production Plants) by Caltrans Weights and Measures prior to use.
2. All material stockpiles should be covered properly.
3. Sample aggregate stockpile for moisture content.
4. Sample aggregate stockpile for gradation.
5. Observe volumetric mixer and pump settings and operations using calibrations provided by Caltrans Weights and Measures.
Volumetric Proportioning of Rapid Strength Concrete

6. Take the unit weight by certified personnel and equipment toward the beginning of each separate placement (CTM 518, Method of Test for Density (Unit Weight) of Fresh Concrete). See Figure 5.

7. Measure the penetration by certified personnel (CTM 533, Method of Test for Ball Penetration in Fresh Portland Cement Concrete).

8. Determine the temperature of freshly mixed concrete by certified personnel (CTM 557, Method of Test for Temperature of Freshly Mixed Hydraulic Cement Concrete).

9. Sample sets of compressive strength cylinders by certified personnel.

10. Observe concrete placement for proper placement and consolidation.

11. Check weighmaster tickets and certificates of compliance.

12. Have the competent cement representative on site during concrete production.

13. Have the competent volumetric mixer representative on site during concrete production.
Self-Consolidating Concrete

Revision and Approval

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Background

This process works in conjunction with other BCMs to establish Structure Construction (SC) responsibilities and procedures for fulfillment of general requirements for submittals, quality assurance, and materials for self-consolidating concrete (SCC).

Review and authorization of a basic SCC mix design submittal is performed per BCM 90-1, Concrete – General.

Self-Consolidating Concrete construction is performed per BCM 51-1.03C-D, Concrete Structures – General – Construction – Preparation and Placing Concrete, with modifications as specified in Standard Specifications (SS) section 90-5, Concrete – Self-Consolidating Concrete, and contract special provisions.

This process covers the planning work required prior to the actual SCC placement and preparation of quality assurance concrete strength test cylinders used for the trial batch test report. The Materials Engineering and Testing Services (METS) Representative and/or the local District materials lab representative may assist in submittal review and quality assurance activities.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the contract specifications 90-5, Self-Consolidating Concrete, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.
**Process Inputs**

1. SCC Mix design submittal
2. Concrete placement procedure
3. Mix design prequalification trial batch test report
4. Aggregate gradation information submittal
5. Mock-up submittal (if applicable):
   a. Details (falsework, formwork drawings) and placement procedure.
   b. Field Quality Control test sampling and results including:
      i. Fine Aggregate moisture control
      ii. Slump flow test
      iii. Visual stability test

**Procedure**

1. All work associated with this process is charged as [Project-Direct – Construction](#).
2. Inspection of field work for this process is **continuous** inspection for all SCC placement and quality assurance activities at the jobsite.
3. Before construction begins:
   b. Review and authorize/reject the SCC mix design. In addition, verify admixtures are chemically compatible and do not augment or counteract desired qualities. Notify the contractor in writing.
   c. Review and authorize/reject the SCC placement procedure. Verify that the contractor is aware that SCC self levelling flow characteristics can vary with the temperature and that the admixtures may need periodic adjustment to maintain specified flow characteristics. The contractor should also realize that forms for sloped shapes may need a top lid to contain the SCC until it sets. Notify the contractor in writing.
d. Review and authorize/reject the SCC Trial Batch test report based on conformance to the contract specifications, Section 90-5.01D(2)(c), Prequalification of Mix Design. Notify the contractor in writing.

e. Review the certificates of compliance for cementitious materials and aggregate gradations. Notify the contractor in writing when rejecting unacceptable gradations.

4. During construction:
   a. If a mock-up is specified:
      i. Authorize or reject mock-up details and placement procedures. Notify the contractor in writing.
      ii. Determine if temperature controls are needed and if the forms require insulation.
      iii. Plan for matching environmental conditions of the mock-up pour with those of the actual pour.
      iv. Authorize the mock-up design details, concrete placement procedures, and testing plan.
      v. Authorize or reject the mock-up forms based on field inspection for contractual requirements, such as dimensions and mortar tightness. Notify the contractor in writing.
      vi. Inspect SCC placement during mock-up placement activities. Verify that the flow characteristics meet specified requirements.
      vii. Verify test results meet requirements of the contractual documents.
      viii. Inspect mock-up saw-cutting to verify no anomalies with the mock-up such as partially filled forms or voids and honeycombing are found. Reject mockup in writing if anomalies are found.
      ix. Authorize or reject mock-up quality control tests for fine aggregate moisture control, slump flow, and visual stability. File the test results and notify the contractor in writing.
   b. Administer SCC use in construction under BCM 51-1.03C-D, Concrete Structures – General – Construction – Preparation and Placing Concrete.
   c. Verify the authorized mix design is delivered to the project.
   d. Verify the SCC flow characteristics meet specification requirements.
   e. Verify the SCC quality control field testing is performed in accordance with and meets the requirements of the contract documents.
   f. Collect the certification information for each concrete delivery truck.
g. Document all inspection, construction, and quality assurance activities in the Daily Reports per BCM C-4.04, Daily and Weekly Reports.

h. Pay the estimated quantity. Refer to BCM C-4.07, Preparation of Progress Payment Documents.

5. Following construction:

   a. File all test results and Daily Reports in the appropriate category in the project records as specified in the Construction Manual 5-102, Organization of Project Documents.

### Process Outputs

1. Authorized SCC mix design
2. Authorized trial batch test report
3. Authorized mock-up design/procedure submittals
4. Mock-up Acceptance or Rejection
5. Field Testing and Analysis Results

### Attachments

None
Concrete – Lightweight Concrete

Revision and Approval

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Background

This process establishes Structure Construction (SC) responsibilities and procedures for authorization of submittals, quality assurance, and materials used for furnishing lightweight concrete. Lightweight concrete consists of cementitious materials, lightweight coarse aggregate, fine aggregate, admixtures if used, and water.

Due to the nature of the aggregates, use of lightweight concrete is more technical than portland cement concrete. Proper planning and quality assurance can reduce problems that might otherwise occur during proportioning and placement of lightweight concrete.

After the lightweight concrete is furnished, for preparation, placement, and curing lightweight concrete, refer to the following requirements in the Contract Specifications:

- Section 51-1.03C-D, Concrete Structures – General – Construction – Preparation and Placing Concrete
- Section 51-1.03H, Concrete Structures – General – Construction – Curing Concrete Structures
- Section 90-1.01D(5), Concrete – General – Quality Assurance – Compressive Strength

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 90-6, Concrete - Lightweight Concrete, that this BCM is based on as identified in the title block above. The information in the contract specifications typically will not be repeated in the text of this BCM.
Process Inputs

1. Lightweight Concrete submittals, including:
   a. Lightweight Concrete mix design
   b. Prequalification data or reports
   c. Certified copies of the manufacturer’s test reports showing the estimated fresh concrete unit weight that results in the selected air-dry unit weight.

Procedure

1. All work associated with this process is charged as Project Direct – Construction.
2. Inspection of field work for this process is:
   a. Continuous for lightweight concrete placement and testing activities on the job site.
3. Before construction begins:
   a. Review the following for background information and tasks unique to lightweight concrete:
      i. Construction Manual (CM), Chapter 4, Construction Details, Sections 4-9001, Concrete – General, and 4-9006, Concrete – Lightweight Concrete.
      ii. Concrete Technology Manual, Chapter 7, Caltrans Advancements/High Performance Concrete, to determine the need for thermal control plan.
      iii. BCM 51-1.03C-D, Concrete Structures – General – Construction – Preparation and Placing Concrete
      iv. BCM 51-1.03H, Concrete Structures – General – Construction – Curing Concrete Structures
      v. BCM 90-1, Concrete – General
   b. Review the following contract requirements for lightweight concrete with the contractor at the preconstruction conference:
      i. The lightweight concrete mix design submittal must include:
         1. Verification that the Engineer has access to the lightweight aggregate supply for up to 500 pounds of lightweight aggregate for quality testing.
         2. Penetration test results.
      ii. Air-dry unit weight test and unit weight test results are to be included with the lightweight concrete mix prequalification submittal.
iii. Production unit weight test results are to be reviewed during lightweight concrete placement and submitted to the Engineer.

c. Review and authorize or reject for resubmittal the lightweight concrete mix design and prequalification reports. Notify the contractor in writing.

d. Review and accept certificates of compliance for cementitious materials.

e. Review Materials Engineering and Testing Services (METS) test reports for lightweight aggregates compliance with the following test methods required by the Contract Specifications:

   i. ASTM C330/C30M, *Standard Specification for Lightweight Aggregates for Structural Concrete*

   ii. *California Test 214, Method of Test for the Soundness of Aggregates by Use of Sodium Sulfate*

   iii. *California Test 537, Method of Test for the Drying Shrinkage of Lightweight Concrete*

   f. For quality assurance during trial batch, verify the following are completed per test methods required in the Contract Specifications:

      i. Sample lightweight concrete per *California Test 539, Method of Test for Sampling Freshly Mixed Concrete.*

      ii. Unit Weight per *California Test 518, Method of Test for Density (Unit Weight) of Fresh Concrete*

      iii. Penetration per *California Test 533, Method of Test for Ball Penetration in Fresh Portland Cement Concrete*

      iv. Air Content per ASTM C173/C173M

      v. Fabricate lightweight concrete cylinders per *California Test 540, Method of Test for Making and Curing Concrete Test Specimens in the Field.*

   g. Arrange for a lightweight concrete batch plant inspection for trial batches.

h. Verify quality assurance and quality control prequalification compressive strength test results prior to authorization.

4. During Construction:

   a. Verify that the delivered lightweight concrete is the authorized mix design, and

      i. Confirm that the total cementitious material content of delivered concrete is within the allowable limits specified in the contract.

      ii. Confirm the absolute volume of the coarse aggregate does not exceed allowable limits.
b. Sample and test lightweight concrete at the frequency outlined in the CM, Chapter 6, Sampling and Testing, Section 6-107, Materials Acceptance Sampling and Testing, and in accordance with:

i. The CM, Chapter 4, Construction Details, Sections 4-9001, General and 4-9006 Lightweight Concrete:

1. Sample (California Test 539) and prepare concrete specimen(s) (California Test 540) for the compressive strength test per the Contract Specifications, Section 90-1.01D(5).

2. Tests include penetration per California Test 533, air content per ASTM C173/C173M, and unit weight per California Test 518.

   i. Verify that the unit weight of fresh concrete is within 4 pcf of the unit weight shown in the test report.

c. Document all inspection, construction, and quality assurance activities in the Daily Reports per BCM C-7, Daily and Weekly Reports.

5. Following construction:

   a. Verify QA lightweight concrete compressive strength with design strength. Consult with the Bridge Design Structure Project Engineer if concrete strengths are lower than anticipated. Calculate and enforce appropriate payment deductions as outlined in the Contract Specifications, Section 90-1.01D(5)(a), Concrete – General – Quality Assurance – Compressive Strength- General.

6. File all project documentation (correspondence, materials acceptance documentation, Daily Reports, etc.) in the appropriate category in the project records as specified in the CM, Section 5-102, Organization of Project Documents.

**Process Outputs**

1. Lightweight Concrete prequalification submittal review and authorization
2. Lightweight concrete mix design submittal review and authorization
3. Quality Assurance Field Testing (California Test results for acceptance, rejection, or payment)

**Attachments**

None
Control of Cement Content in Concrete

The Standard Specifications (SS)\(^1\) require that the cement content of concrete mixtures be verified in accordance with procedures described in California Test 518. As stated in the SS\(^2\), “…For testing purposes, supplementary cementitious materials (SCM) are considered to be cement. …” Although California Test 518 is titled Method of Test for Unit Weight of Fresh Concrete, it also gives instructions for determining the volume of concrete(s) per batch, and determining the cement content ( \(\text{CCA}_A\) ) in pounds per cubic yard of concrete produced.

Form DS-OS C68, Worksheet for California Test 518, Unit Weight of Fresh Concrete, was originally developed by Materials Engineering and Testing Services (METS) and modified by Structure Construction (SC) (Form SC-3702) to facilitate the calculations process to determine that the cement content complies with specification requirements. (Attachments No. 1 and No. 2 are examples of completed Form SC-3702 (formerly form DS-OS C68.)

Unit Weight Testing
For concrete mixes, the goal is to obtain the required cement content in each cubic yard of concrete. If it were practical to accurately weigh all the ingredients required to produce one cubic yard of concrete, mix them thoroughly, and place them in an accurate cubic yard measure, then determining the proper amount of cement would be easy. If the batch which contained the specified amount of cement overflowed the cubic yard measure, it would actually not contain enough cement per cubic yard. If the batch did not fill the cubic yard measure, it would actually contain more cement than required per cubic yard. In the event that the mix contained too much or too little cement per cubic yard, adjustments would have to be made to produce nearly an exact cubic yard containing the specified amount of cement per cubic yard. Since it is not practical to check the cement content by making use of a cubic yard measure, the unit-weight test is used to provide the necessary data needed to make adjustments to the mix design and to make corresponding adjustments to the load weight.

In effect, these two procedures are the same, except that in the unit-weight test, a small sample, that is practical to handle, is used, and the volume produced per load is calculated by simple proportion. The unit-weight test is limited to the determination of the unit-weight of fresh concrete in pounds per cubic foot, but does include equations that may be used for calculating the volume of concrete per load and the actual cement content of the concrete produced.

In reviewing the calculations, only two factors are needed to calculate the volume of the load. The calculation for volume of load is as shown below:

\[^1\] 2010 SS, Section 90-1.01, General.
\[^2\] 2010 SS, Section 90-1.01D(2), Cementitious Material Content.
W = Unit weight in pounds per cubic foot (the net weight of concrete in the calibrated bucket times the calibration factor)

\[ W_t \] = Total scale weight in pounds per load of all the ingredients in the load of concrete.

S = Volume of concrete produced in cubic feet per load.

Then \[ S = \frac{W_t}{W} \]

By simple proportion the total weight in pounds-per-load of concrete, divided by its unit weight in pounds-per-cubic-foot, equals the quantity in the load in cubic feet. The important thing to remember is that you must have the actual weights of the water, cement and aggregates going into the load.

It is important to note that the unit-weight test does not check batching accuracy. The Field Engineer must first be assured that scales at the batch plant are accurate by the State Bureau of Weights and Measures inspection and seal. Batching accuracy can then be checked by observing the batching operation and by requiring the Contractor to determine the gross and tare weights on the mixer truck. The gross minus tare weight method should only be used as a rough check of batching accuracy, not as the value to be used in the calculations of batch volume.

To determine the cement content of the concrete being produced, the actual weight of cement included at the batch plant will need to be known. The weight of cement should be verified by observation of the scale weights as the batch is being produced. The calculation for cement content is shown below:

\[ *CC = \text{Cement content in pounds per cubic yard.} \]

\[ W_a = \text{Number of pounds of cement in the load (verified by observation or recording equipment record).} \]

\[ S = \text{Volume of concrete produced per load in cubic feet (determined from unit weight as described above).} \]

Then by proportion: \[ CC/27 = W_a/S \text{ or } CC + 27W_a/S \]

*Note: CC = the actual weight of all cementitious materials.

The cement content in pounds per cubic yard is to 27 cubic feet per cubic yard, as the number of pounds in the load is to the number of cubic feet in the load. The number of pounds of cementitious material in the load, must be the actual amount of cement, as determined by plant scales. Weighing is the only way to know exactly how much cement is in the load.

---

\[ ^3 \text{2010 Standard Specifications (SS) Section 90-1.02F(3)} \]
When the unit-weight test is to be performed, the actual batching of the load to be checked should be observed and scale weights recorded for use in determination of load volume. The mixer drum should also be checked prior to batching to be sure that a significant quantity of water is not left in the drum and unaccounted for in batch weights. *If you have not verified by observation or been assured by automatic recording batching equipment records that the intended amounts of cementitious material, water and aggregate were actually batched into the mixer, then the subject test and subsequent calculations cannot be used to determine the cement content.*
**STATE OF CALIFORNIA . DEPARTMENT OF TRANSPORATION**

**WORKSHEET FOR CALIFORNIA TEST 518**

**FORM SC-3702 (Formerly DS-OS C68) (REV. 09/30/14)**

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**F = CALIBRATION FACTOR FOR MEASURE**

1. GROSS WT. OF MEASURE, CONCRETE AND COVERPLATE.  
2. WT. OF MEASURE AND COVER PLATE  
3. NET WT. OF CONCRETE SAMPLE (line 1 minus line 2)  

\[ W = \text{UNIT WT. OF CONCRETE SAMPLE (line 3 times } F) \]

\[ \frac{27992}{148.1} = 189.00 \text{ ft} \]

\[ CY = \text{VOLUME OF CONCRETE PER LOAD IN CUBIC YARD} = \frac{S}{27} = 7.00 \text{ yd} \]

\[ CC = \text{CEMENTITIOUS MATERIAL CONTENT IN LB PER CUBIC YARD OF CONCRETE} \]

\[ \text{PRODUCED} = \frac{W_a}{cy} = 675.00 \text{ Lb/Yd} \]

**NOTES:**

* Refer to *California Test 18*, Step D, *Calibration of Measure*, for calculating the *Calibration Factor*.

**CC** = the actual weight of all cementitious material (cement and supplementary cementitious material).
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<td><strong>1. GROSS WT. OF MEASURE, CONCRETE AND COVERPLATE.</strong></td>
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<td><strong>2. WT. OF MEASURE AND COVER PLATE</strong></td>
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<td><strong>3. NET WT. OF CONCRETE SAMPLE (line 1 minus line 2)</strong></td>
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<td><strong>W = UNIT WT. OF CONCRETE SAMPLE (line 3 times F)</strong></td>
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\[ W_a = \frac{W_4}{W_1 + W_2 + WC_1 + WC_2 + WW_1 + WW_2} = 188.98 \text{ ft} \]

\[ CY = \frac{S}{27} = 7.00 \text{ yd} \]

\[ CC** = \text{CEMENTITIOUS MATERIAL CONTENT IN LB PER CUBIC YARD OF CONCRETE PRODUCED} = \frac{W_a}{CY} = 799.06 \text{ Lb/Yd} \]

**NOTES:**

* Refer to California Test 18, Step D, Calibration of Measure, for calculating the Calibration Factor.

**CC = the actual weight of all cementitious material (cement and supplementary cementitious material).
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Paint – General

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Background

This process establishes Structure Construction (SC) roles and responsibilities for review and authorization of paint furnished for structure work, including quality assurance and materials.

This process addresses review and authorization of paint materials. Processes in the Contract Specifications, Sections 59, Structural Steel Coatings and 78-4, Incidental Construction – Miscellaneous Coatings, describe how the authorized paint materials are applied.

Prior to reviewing this Bridge Construction Memo (BCM), it is essential to review the Contract Specifications, Section 91-1, Paint – General, that this BCM is based on as identified in the title block above. The information in the Contract Specification typically will not be repeated in the text of this BCM.

Process Inputs

1. Contract documents requiring painting
2. Form CEM-3101, Notice of Materials to be Used
3. Baseline Critical Path Method (CPM) schedule and updates

Procedure

1. All work associated with this process is charged as Project-Direct – Construction.
2. Inspection of field work for this process is:
   a. **Benchmark** for review and authorization of paint furnished for structure work, including quality assurance, and materials.

3. Before construction begins:
   a. Review the contract documents for paint material, paint color, and aesthetic requirements.
   b. Review the Construction Manual:
      i. **Table 6-2.1, Inspection of Fabricated and Manufactured Materials (3 of 5)**, for paint.
      ii. **Section 6-2.03A (6), Materials Manufactured to Caltrans-Specified Formulation**.
   d. Contact the Project Architect, the Landscape Architect, and/or the Designer to discuss color, material, and aesthetic requirements.
   e. Contact the METS, **Chemical Testing Laboratory** to:
      i. Review paint-related items that should be discussed at the preconstruction conference.
      ii. Invite the METS Representative to the preconstruction conference.
   f. If a pre-painting meeting is not specified by the contract, contact the contractor to discuss Form CEM-3101, **Notice of Materials to be Used**, quality assurance, and the material requirements with respect to the baseline CPM schedule and updates.
   g. Review Form CEM-3101, **Notice of Materials to be Used**, received from the contractor. If complete, the RE forwards Form CEM-3101 to the METS Materials Administrator according to the detailed instructions on Form CEM-3101.
   h. Verify that METS received Form CEM-3101.
   i. When the authorized paint is received at the jobsite, the Structure Representative (SR):
      i. Requests the contractor to provide the laboratory test report on that batch of paint.
      1. If the contractor is unable to obtain a copy of the test report from the paint manufacturer, provide the batch number (refer to QASI Manual Section 91, Paint, for illustration) to the METS Representative, who will
check with METS Chemical Testing Branch (CTB) to determine whether the test report was received.

ii. Verifies the *Certificates of Compliance* and *Form TL-28*, *Notice of Materials to be Inspected at Job Site*.

iii. Releases the material at the jobsite via *Form CEM-4102*, *Material Inspected and Released at the Job*.

4. During construction:
   a. Before paint is applied:
      i. Verify paint containers and the condition of the paint are in accordance with the detailed requirements in *Contract Specifications*, Section 91-1.02, *Paint – General – Materials*.
      ii. Verify the paint is the same paint that arrived on the jobsite.
   b. Field sampling of paint is not required unless the Resident Engineer (RE)/SR suspect something is wrong with the paint (paint exhibits hard settling, or potential contamination, or other deficiencies). In that case, the SR should:
      i. Notify METS Representative immediately.
      ii. Obtain quart size sampling paint cans from the Construction field office.
      iii. Obtain sample and sample size in accordance with *Construction Manual*, *Section 6-203C (5)*, *Paint*.
      iv. Send the paint sample with Form *TL-0101*, *Sample Identification Card*, to METS-CTB for testing.
      v. After METS-CTB tests the field sample, receive test results sent to the RE and the manufacturer.
   c. Document all inspection, construction, and quality assurance activities, pertinent to this BCM, in the Daily Reports per *BCM C-4.04*, *Daily and Weekly Reports*.

5. File all test results and Daily Reports in the appropriate category in the project records as specified in the *Construction Manual 5-102*, *Organization of Project Documents*.

**Process Outputs Paint test results**

1. Paint test results
2. Certificates of Compliance
Attachments

None
Epoxy – General

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BCM 95-1, *Epoxy – General*, has not been posted yet.

Until it is published see BCM 135-1, *Epoxy Adhesives.*
Building Construction – As-Built Drawings

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B.C.M. 99-01000-1.10, Building Construction – As-Built Drawings, has not been posted yet.

Until it is posted, information related to this topic is found in B.C.M. 9-1.0, As-Built Plans.
Building Construction – General Requirements

BCM 99-1, Building Construction – General Requirements, has not been posted yet.

Until it is posted, information related to this topic is found in:

BCM 9-1.0, As-Built Plans (the Building Contracts Section)

BCM 115-1.0, Inspection of Electrical, Mechanical, Water and Wastewater Work

BCM 132-1.0, Working Drawings and Material Submittals for Buildings

BCM 132-2.1, Inspection of Building Related Transportation Facilities

BCM 132-3.0, Parts List, Service Instructions, Manufacturer’s Warranties and Operation and Maintenance Instructions
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NOTE:
* Designates the Memo was issued as a Bridge Construction Bulletin (BCB). All other Memos were issued as a Bridge Construction Memo (BCM).
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Longitudinal Deck Construction Joints

Expanded Metal Lath Forms

Expanded metal lath may be used to form longitudinal deck construction joints provided the joint is constructed in compliance with the following requirements.

1. A continuous wood strip, the height of the bottom steel clearance, shall be securely fastened to the deck form.

2. Another continuous wood strip, the height of the top steel clearance, shall be fastened securely on top of the top steel. This strip shall be set to grade and held firmly in place by means independent of the reinforcing steel.

3. The expanded metal lath shall be securely fastened between these wood strips.

4. Concrete along the face of the metal lath form must be cured by the water method.

5. Before the second pour is made, wood strips must be removed and any fractured concrete removed. Metal lath that is firmly embedded in concrete may remain in place provided it has the same clearance from the concrete surface as the specified steel clearance. Any loose mesh must be removed.
Friction Testing of Bridge Decks

After deck surfaces and approach slabs have been textured, the engineer tests the coefficient of friction of the concrete surfaces under California Test 342\(^1\). Refer to Standard Specifications\(^2\) for coefficient of friction testing requirements.

**Newly Constructed Bridge Decks**

Coefficient of friction testing must be performed on each deck. The test must be performed at a location which is representative of that portion of the deck surface exhibiting the lowest coefficient of friction. Once the representative area has been tested and shown to meet the specification, more tests will not be required unless, in the opinion of the Structure Representative, the test results are not representative of the bridge deck skid resistance.

Schedule the skid test 25 days in advance.

**Existing Structures Bridge Deck Treatment**

Coefficient of friction testing must be performed on the treated test area for the methacrylate\(^3\) or the trial overlay for polyester\(^4\), and the test result must comply with the specifications. The treated test area or trial overlay will then be authorized and used as a standard of comparison for the production work. Using this comparative process will allow Caltrans to better use the available friction testing resources.

**Methacrylate Resin Bridge Deck Treatment**

The following are some of the requirements for methacrylate resin bridge deck treatment:

- The contractor is to notify the engineer at least 15 days before treating the test area.

---

\(^1\) Method of Test for Surface Skid Resistance with the California Portable Skid Tester

\(^2\) 2018 Standard Specifications (SS), Section 51-1.01D(3)(b)(iii), Coefficient of Friction.

\(^3\) 2018 SS, Section 60-3.03B, Methacrylate Resin Bridge Deck Treatment

\(^4\) 2018 SS, Section 60-3.04B, Polyester Concrete Overlays
• The test area demonstrates:
  1. Compliance with the specifications.
  2. That the work will be completed within the time allowed.

• The engineer performs friction testing of the treated test area. Ten days will be allowed after completion of the test area for the engineer to perform the testing.

• The test area must be authorized before the contractor starts deck treatment activities.

• The authorized test area will be the standard of comparison in determining the acceptability of treated deck surfaces.

• The engineer may perform testing under California Test 342 to verify the coefficient of friction of the treated deck surfaces.

The authorized test area will provide a standard of comparison for the Structure Representative to make a visual inspection between the treated test area and the production work for acceptance. The Structure Representative may perform additional testing to verify the coefficient of friction if the contractor’s materials, methods, or procedures have changed from those used on the test area.

There are additional specification requirements that need to be met before authorizing traffic or equipment onto the treated deck surface (overlay). See BCM 112-5.0, Methacrylate Deck Crack Treatment, for additional information.

See Scheduling Skid Testing below.

**Polyester Concrete Overlays**

The following are some of the requirements for polyester concrete overlays:

• The contractor is to notify the engineer at least 15 days before constructing the trial overlay.

• Trial overlay demonstrates:
  1. Compliance with the specifications.
  2. That the work will be completed within the time allowed.

• The engineer performs friction testing of the trial overlay. Ten days will be allowed after completion of the trial overlay for the engineer to perform the testing.

• Trial overlay area must be authorized before the contractor starts production overlay activities.
• The authorized trial overlay will be the standard of comparison in determining the acceptability of polyester concrete overlay.

• The engineer may perform testing under California Test 342 to verify the coefficient of friction of the polyester concrete overlay.

The authorized trial overlay will provide a standard of comparison for the Structure Representative to make a visual inspection between the trial overlay and the production work for acceptance. The Structure Representative may perform additional testing to verify the coefficient of friction if the contractor’s materials, methods, or procedures have changed from those used on the trial overlay.

Trial overlays should be constructed at a location within the project limits that will facilitate testing and inspection by the engineer and also simulate climate and weather conditions. The depth/thickness of the concrete base for the trial overlay must have the size, strength, and load capacity to accommodate the equipment used for the work. A minimum 4” slab thickness is recommended. After acceptance of all polyester concrete overlay surfaces the trial overlay and concrete base must be disposed of.

See Scheduling Skid Testing below.

**Scheduling Skid Testing**

To meet the 10-day test window requirement, and to ensure that there are no delays to the contract, the tests will have to be scheduled as soon as possible. Between the 15-day notification by the contractor prior to performing the test area or trial overlay, and the 10-day allowance to perform the testing, this should be sufficient time to schedule and complete the test.

Coefficient of friction testing can be arranged by contacting the appropriate staff listed on the instruction tab of Request for Portable Skid Test form.

Structure Construction inspection personnel witnessing the skid test must verify that the skid test machine has valid calibration under California Test 114.
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<td>Inspection of Electrical, Mechanical, Water and Wastewater Work</td>
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*Denotes the document is a Bridge Construction Bulletin*
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Inspection of Electrical, Mechanical, Water and Wastewater Work

It is the Structure Representative’s responsibility to ensure that all electrical, mechanical, water and wastewater (EMW&W) work complies with the plans and specifications. However, EMW&W work is a specialized and complex type of work with which the Structure Representative may not be totally familiar.

In order to be assured that the EMW&W work complies with the plans and specifications, the Structure Representative is encouraged to contact the Electrical, Mechanical, Water and Wastewater Branch (Telephone 916-227-8337 calnet 498-8337) to keep them informed of the work progress, to discuss any problems encountered, and to make arrangements to have EMW&W personnel make periodic inspections of the work as it progresses towards completion.
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Impaired Clearances at Falsework Traffic Openings

To ensure the movement of goods across the State Highway System (SHS) it is necessary to provide traffic openings through construction projects. During bridge construction, openings through the falsework allow the passage of traffic to meet this requirement. When these traffic openings through the falsework restrict the height of vehicles using the SHS, it is necessary to notify the Division of Traffic Operations, Office of Truck Services. The *Highway Design Manual* mandates that traffic openings should have a vertical clearance of at least 15 feet and clearances less than 15 feet require a design exemption. The timely notification of temporary impaired clearances due to falsework is essential to the safe routing of oversize vehicles and ensuring the safety of the traveling public, the contractor’s personnel and Caltrans staff.

The Structure Representative shall submit written notice to the Resident Engineer when falsework will temporarily impair clearance on the State highway or roadway. This notification is accomplished by completing form TR-0029 or TR-0019, *Notice of Change in Clearance or Bridge Weight Rating*. Time requirements for notification of impaired clearance are found in the Standard Specifications, Section 7-1.041, *Public Safety*, and are usually no less than 20 and not more than 90 days prior to the impairment. The *Construction Manual* still requires that the notification to the Transportation Permits Branch be within 15 days, the 5-day difference is for the Structure Representative to complete the calculations and give them to the Resident Engineer.

The detailed procedures for notification of temporary impaired clearances are contained in the:


The notification to the Resident Engineer should give anticipated dimensions of the impaired opening. The anticipated clearance should be calculated from the contractor’s falsework submittal and verified using actual field dimensions. Structure Representatives, when performing the clearance calculations, should include an allowance for: falsework stringer deflection, adjustment of falsework grades, changes in pavement elevations, settlement, etc. The attached form SC-12.6.1, *Report of Falsework Clearance*, provides a methodology for determining the clearance under falsework at traffic openings. It should be filed in Category 12.6, *Falsework Plan*, of the project files.

---

1 2006 Standard Specifications, Section 7-1.09, *Public Safety.*
2 Review the Contract Special Provisions for amendments or changes to these requirements.
The Structure Representative, immediately after the clearance is impaired, shall verify the dimensions of the impaired opening and notify the Resident Engineer of any necessary revisions to the clearance ensuring that allowances for settlement, stringer deflection, etc. continue to be taken into account. If the clearance is less, the Structure Representative should consider halting operations and removing the stringers already set, until clearance issues are resolved. The instructions within this section apply to any falsework being set over a traveled way, even if the resulting clearance satisfies legal height or load limitations. When the temporary impaired clearance is removed, the Structure Representative shall give the Resident Engineer written notice of the restored or revised clearance.

When falsework will not be removed by the tentative end date, an update within 15 days of the tentative end date previously submitted, needs to be made to the Transportation Permits Branch.

Structure Representative Responsibilities

- Determines the theoretical clearance of the falsework traffic opening.
- Verifies that the opening clearance is greater than or equal to the dimensions for traffic openings given in the Contract Special Provisions.
- Completes the form TR-0019 or TR-0029, Notice of Change in Clearance or Bridge Weight Rating.
- Reports the impaired clearance to the Resident Engineer or Transportation Permits Branch or both, depending on District protocols, 15 days prior to erecting falsework.
- Verifies Transportation Permits Branch received the Notice of Change in Clearance or Bridge Weight Rating, (return fax).
- Measures the clearance when the impairment is placed.
- Verifies that the measured clearance is greater or equal to the clearance previously reported.
- Takes appropriate action if the measured clearance is less than that previously reported.
- Submits a revised clearance if it is different or if the ultimate clearance will be less than previously reported.
- Submits a revised clearance prior to falsework being lowered if the clearance will be less than that previously reported.
- Attach a copy of the Contract Special Provision page showing the traffic opening requirements for the structure under consideration to the file copy.
- If applicable attach copies of Contract Change Orders that modify the dimensions of the traffic opening listed on the Notice of Change in Clearance or Bridge Weight Rating to the file copy.
- Have the Bridge Construction Engineer review and initial the Notice of Change in Clearance or Bridge Weight Rating.

Bridge Construction Engineer Responsibilities

- Ensures that the determination of the theoretical clearance is correct.
- Ensures the Contract Special Provision requirements have been met.
• Reviews the *Notice of Change in Clearance or Bridge Weight Rating* and if it is correct, *initials* the *Notice of Change in Clearance or Bridge Weight Rating*.

**Structure Construction Oversight Engineer Responsibilities**

• With Local Agency Structure Representative:
  o Ensures that the determination of the theoretical clearance is correct.
  o Ensures the Contract Special Provision requirements have been met.
  o Reviews the *Notice of Change in Clearance or Bridge Weight Rating*, and if it is correct, *initials* the *Notice of Change in Clearance or Bridge Weight Rating*. 
Department of Transportation
REPORT OF FALSEWORK CLEARANCE
Form No. SC-12.6.1 (New 04/08) Formerly DS-OS C108

Date:

Bridge name:

Br. No. :

Co/Rte/PM:

Direction of travel:

Determination of falsework clearance:

a) Calculated or Measured Minimum vertical clearance: ________________
   Allowances:
   b) Pavement elevation changes (- or 0) ________________
   c) Adjustment of Falsework grades (- or 0) ________________
   d) Falsework settlement (-) ________________
   e) Falsework stringer deflection (-) ________________
   f) Release of sand jacks (wedging) (-) ________________
   g) Calculated ultimate actual clearance
   h) Clearance to report

1 This value must be greater than that given in the Special Provisions.
2 Calculated ultimate actual clearance rounded down to the nearest 3"

The clear horizontal opening is _______ feet wide.

Remarks:
Instructions for Determination of Falsework Clearance

Use this form as an aid in determining the clearance at falsework openings. Reference BCM 120-2.0.

a) Prior to falsework erection this value is calculated by subtracting the falsework depth (soffit plywood, joist, nailers, and stringer) below the bridge soffit from the difference in elevation between the bridge soffit and roadway.

After falsework erection this value is the measured distance between the roadway and the lowest edge of the falsework (generally the bottom flange of the stringer).

b) If there are plans to pave the roadway under the structure prior to removal of the falsework, the net thickness of the overlay will need to be subtracted from the clearance. The net thickness is used to account for any grinding that may take place prior to the placement of the final surfacing.

c) If the falsework is adjusted upwards a value of zero can be used to provide a slight buffer to the clearance.

d) The probable or anticipated settlement of the falsework.

e) Although the stringer deflection is generally compensated by the use of camber strips, the stringer itself will still deflect.

f) If traffic will be allowed under the structure between the time sand jacks (wedging) is blown (removed) and stringers are removed, this allowance needs to be included.

g) This is equal to the value of: value a) minus the summation of values b) through f).

h) This is the value of g) rounded down to the nearest 3”, i.e. 16'-5.75” would become 16'-3” and 16'-1” would become 16' - 0”.

This is the value that should be used in form TR-0029, *Notice of Change in Clearance or Bridge Weight Rating*, when reporting to the Resident Engineer.
BRIDGE CONSTRUCTION BULLETIN

File: BCM 120-2.1
FALSEWORK

Approved: ROBERT A. STOTT
Deputy Division Chief
Offices of Structure Construction

Date: May 20, 2010
Expires: July 1, 2012

Supersedes:

Subject: Reporting of Impaired Clearances at Falsework Traffic Openings

Background

To ensure the movement of goods across the State Highway System (SHS) it is necessary to provide traffic openings through construction projects. During bridge construction, openings through the falsework allow the passage of traffic to meet this requirement. When these traffic openings through the falsework restrict the height of vehicles using the SHS, it is necessary to notify the Division of Traffic Operations, Office of Truck Services. The Highway Design Manual mandates that traffic openings should have a vertical clearance of at least 15 feet and clearances less than 15 feet require a design exemption.

Recent events including field changes of the vertical clearance to less than 15 feet and incorrectly reporting the actual vertical clearance have required the Offices of Structure Construction to implement a quality assurance step into the process of reporting changes to vertical and horizontal clearances. The quality assurance review will require the Bridge Construction Engineer to review the “Notice of Change in Clearance or Bridge Weight Rating” before initial submission to the Resident Engineer or Truck Services.

Current Practice

Structure Representative:
- Determines the theoretical clearance of the falsework traffic opening using the guidance in BCM 120-2.0
- Verifies that the opening clearance is greater than or equal to the dimensions for traffic openings given in the Contract Special Provisions.
- Completes the form Form TR-0019 or TR-0029.
- Reports the impaired clearance to the Resident Engineer or Office of Truck Services or both depending on District protocols 15 days prior to erecting falsework.
- Verifies Office of Truck Services received the “Notice of Change in Clearance or Bridge Weight Rating.” (return fax).
o Measures the clearance when the impairment is placed.
o Verifies that the measured clearance is greater or equal to the clearance previously reported.
o Takes appropriate action if the measured clearance is less than that previously reported.
o Submits a revised clearance if it is different or if the ultimate clearance will be less than previously reported.
o Submits a revised clearance prior to falsework being lowered if the clearance will be less than that previously reported.

New Practice

In addition to the above procedures the following additional duties have been added to the roles of:

Structure Representative:
  o Attach a copy of the Contract Special Provision page showing the traffic opening requirements for the structure under consideration to the file copy.
  o If applicable attach copies of Contract Change Orders that modify the dimensions of the traffic opening listed on the “Notice of Change in Clearance or Bridge Weight Rating” to the file copy.
  o Have the Bridge Construction Engineer review and initial the “Notice of Change in Clearance or Bridge Weight Rating”.

Bridge Construction Engineer:
  o Ensures that the determination of the theoretical clearance is correct.
  o Ensures the Contract Special Provision requirements have been met.
  o Reviews the “Notice of Change in Clearance or Bridge Weight Rating” and if it is correct initials the “Notice of Change in Clearance or Bridge Weight Rating.”
  o Ensures remaining steps of the process are understood.

OSC Oversight Engineer
  o With Local Agency Structure Representative:
    o Ensures that the determination of the theoretical clearance is correct.
    o Ensures the Contract Special Provision requirements have been met.
    o Reviews the “Notice of Change in Clearance or Bridge Weight Rating” and if it is correct initials the “Notice of Change in Clearance or Bridge Weight Rating.”
    o Ensures remaining steps of the process are understood.

Related Guidance

Bridge Construction Records and Procedures, BCM 120-2.0, Impaired Clearances at Falsework Traffic Openings
Bridge Construction Records and Procedures, BCM 2-20.0, Notice of Change in Structure Clearance or Permit Rating
Construction Manual, Section 3-705, Public Safety
Standard Specifications, 7-1.09, Public Safety
Contract Special Provisions, Maintaining Traffic and/or Order of Work
Highway Design Manual, Section 204.8, Grade Line of Structures
Falsework Shear Values for Bolts/Anchors in Concrete

General Information
It is extremely important to consider the effect on concrete of bolts loaded in shear parallel to the face of the concrete especially within 6 inches of a concrete edge. Examples of these loading conditions are bolts inserted in the edge of decks which may support vertical falsework loads, or for pins which may be placed in decks and loaded horizontally as shear resistance for K-Rail.

Bar reinforcing steel under, and perpendicular to, the axis of a bolt imbedded in an edge of deck provides some resistance to shear failure of the concrete. Bar reinforcing steel under, but parallel to the bolt axis (without perpendicular reinforcing), provides little additional resistance to concrete shear failure. Unreinforced concrete will offer the least resistance to concrete shear failure.

Bolts or anchors inserted into concrete with impact drills or hammers will generally exhibit lower shear resisting capacity because of potential fracturing of the concrete. The lowest shear resisting capacity may well be furnished by wedge fit type anchors in holes made by impact tools since the wedging action can induce additional fracturing of the concrete.

Research
Bolts of 60 ksi tensile strength, approximately 5/8" in diameter and approximately 11-7/8" long, were cast about 7-7/8" deep at various edge distances (d) up to about 6 inches in unreinforced concrete blocks. The bolts were load tested at right angles to the block surfaces after the concrete had gained sufficient strength. Published test results of concrete failure due to the lateral loads on the bolts showed that the modes of failure consisted of concrete failure with and without wedge cones, or with pullout cones, or by shear failure of the bolts.

Test results for concrete shear strengths adjusted to an averaged concrete compressive strength $f'_{c}$ of approximately 3,000 psi have been plotted in Figure 1. Assuming that the shear strength of concrete is a function of $f'_{c}$, a family of curves related to the 3,000 psi curve were generated and included in Figure 1. The curves of Figure 1 represent ultimate values which need to be adjusted with an appropriate safety factor which is determined from Table 1.
One of the most common usages of embedded bolts is depicted in Figure 2. Figure 2 depicts one direction of loading with respect to the concrete surface and shows dimension d which represents the distance from the edge of the concrete to the center line of the bolt.

**Permitted Use**

Determine the distance the loaded bolt will be from the loaded edge 1 or change in section, of the concrete. The term “bolt” shall be meant to include inserts, rods, or other similar devices. Haunched concrete sections similar to the underside of bridge deck overhang sections, should not be given additional value. Select a concrete shear strength related to an appropriate ultimate concrete strength curve from Figure 1. Divide the selected ultimate concrete shear strength value by an appropriate safety factor as determined from Table 1.

Table 1 lists minimum safety factor values to be used for cast-in-place bolts. A minimum safety factor of 2 may be used where reinforcing is located normal to the axis of the bolt in the concrete shear loaded zone provided the reinforcing is located between the concrete face and the midpoint of the embedded bolt length. This reinforcing must extend through the concrete failure zone (See Figure 2) to sound concrete. Otherwise use a safety factor of 2.25 or higher.

A minimum safety factor of 2.75 may be used when reinforcing steel located parallel to the bolt axis (without reinforcing normal to the bolt axis) will be within the shear loaded zone and will have a length reaching to at least the midpoint of the embedded bolt. If no parallel reinforcing will be within a shear loaded zone use the higher safety factor of 3.0.
Safety Factors:

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<th>Reinforcing Type</th>
<th>Cast – In – Place Bolt</th>
<th>Bolt Insert</th>
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</thead>
<tbody>
<tr>
<td>Bar (s) within 2&quot; of the concrete face located normal to the bolt axis on the loaded side of the bolt.</td>
<td>2.0 – 2.5</td>
<td>2.25 – 2.50</td>
</tr>
<tr>
<td>Bars parallel to the bolt axis on the loaded side of the bolt (no normal reinforcing).</td>
<td>2.75 – 3.0</td>
<td>2.75 – 3.0</td>
</tr>
<tr>
<td>No reinforcing on the loaded side of the bolt.</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Torque tightened bolts, regardless of location of reinforcing</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Table 1

Shear loaded zones are depicted in Figure 2 and are described as follows:

Cone Pullout - A cone with the apex situated behind the embedded end of the bolt with the center line of the cone on the axis of the bolt and with sides sloping a minimum of 45° away from the bolt axis.

Trapezoidal Wedge - A trapezoid volume with the base on the concrete surface a distance \( d \) from the bolt center line, having sides sloping inward at 45° angles meeting a plane of length equal to the bolt diameter at the opposite side of the bolt, and with this area having a volumetric length equal to the length of the embedded portion of the bolt.

![Cone Pullout](image1)

![Trapezoidal Wedge](image2)

**FIGURE 2**

When information about reinforcing on the loaded side of a bolt cannot be verified the highest safety factor will be used. No increase or reduction in the safety factor value, will be given to bolts with embedded bolt heads.
Figure 3 illustrates a single bolt placed in a deck overhang. Bolts shall not be spaced closer than 8 times the d dimension or 3.5 times the sum of the embedment lengths of adjacent bolts whichever is larger. The 8 times the d dimension is a recommendation made in the published test results. The 3.5 (two times the tangent of 60°) times the sum of the embedment lengths is based on evidence that the concrete can fracture or fail in shear at an angle of 60° to the axis of the bolt.

Since one of four types of failure modes occurred during testing no adjustments need be made for various bolt sizes up to 5/8" in diameter. For bolts larger than 5/8" diameter use dimension d as being equal to the distance from the edge of the concrete to the nearest portion of the bolt hole (In Figure 3 this dimension would be d minus one-half the bolt diameter).

It is always a good idea to test load a typical section of falsework supported by bolts or inserts to twice the anticipated loading at a safe location.

**Example:**

Assume 5,000 psi concrete in a deck overhang with no bottom mat reinforcing for which holes for 5/8" bolts are to be drilled 3.75 inches from the soffit with air tools for torque type bolt inserts that are to be used for supporting a falsework system for removal of concrete railing. Determine bolt capacity and minimum bolt spacing for 5 inches of maximum embedment.

From Figure 1 the ultimate value for shear failure may be selected as 10.1 Kips, and from Table 1 the safety factor value should be no less than 3.0.

Assumed safe working load for the bolt = 10.1/3.0 = 3.4 Kips. Minimum bolt spacing is the larger of 8(d) or 3.5(5" + 5"):

\[
8(3.75) = 30.0 \text{ Inches}
\]

\[
3.5(5'' + 5'') = 35.0 \text{ Inches} + \text{This governs}
\]
References:


Additional Information

Consult the Bridge Construction Records and Procedures Manual Memo 135-5.0 and Memo 168-2.0 regarding bolts in concrete. Additional information on concrete anchorage devices may be found in Section 75-1.03 of the Standard Specifications. While these references pertain to permanent installations, the guidelines are worthy of note. Installation for temporary work do not require Translab approval. It is important however, that manufacturer's recommendations be followed except where there will be obvious deviations from this memo.
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<td>12-05-17</td>
<td>BCM 122-3.0, Converted from BCB to BCM and updated.</td>
<td>Steve Altman</td>
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**MEMO NO.**  **ISSUE DATE**  **TITLE**

- 122-1.0  06/01/1997  Submitting Shoring Plans
- 122-2.0*  10/15/2002  Support from Roadway Geotechnical Engineering
- 122-3.0  12/05/2017  Torvane Usage for Sloped Excavations

---

* Denotes Bridge Construction Bulletin (BCB).
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Submitting Shoring Plans

General Information

Review of shoring plans shall be in accordance with the guidelines and policy set forth in the Office of Structure Construction Trenching and Shoring Manual.

Shoring Which is Not Adjacent to or Under a Railroad

When the Structure Representative has completed reviewing the shoring plans and calculations, and has determined that the shoring plans meet specification requirements, a letter shall be sent to the Contractor stating that the drawings have been reviewed and approved. This letter authorizes the Contractor to begin constructing shoring. Note that the Contractor must not begin shoring construction until such time as this letter has been issued to the Contractor. The letter should state that the approval is to the extend provided under Section 5-1.02 of the Standard Specifications. This letter should also direct the Contractor's attention to his/her responsibilities under Sections 5-1.02 of the Standard Specifications. It should remind the Contractor of the requirement that the shoring must conform to the shoring plans, that the materials used must be of the quality necessary to sustain the stresses required by the shoring design, and that the workmanship shall be of such quality that the shoring will support the loads imposed on it without excessive movement (See Attachment No. 1 for an example of a properly prepared shoring approval letter.)

For shoring that is not adjacent to or under a railroad, it is mandatory that one copy of the shoring plans, and one copy of the Structure Representatives calculations be submitted to the Sacramento Office of Structure Construction, immediately after they have been reviewed and approved by the Structure Representative.

A letter of transmittal must accompany all shoring plans and calculations that are submitted to the Office of Structure Construction Falsework Review Unit. Include a copy of the approval letter that was issued to the Contractor.

The Structure Representative should retain one set of the approved shoring plans and calculations in the job files.

Shoring Adjacent to or Under Railroads

When shoring is adjacent to or crosses under a railroad, additional requirements must be complied with. Any shoring within 15' of the centerline of tracks is considered adjacent.
The Structure Representative will check the shoring plans, and if necessary, return them to the Contractor for correction. After shoring plans and calculations have been reviewed by the Structure Representative and he/she is satisfied that the shoring plans meet specifications, the following items are to be sent to the Office of Structure Construction.

1. Five copies of Contractor's shoring plans if the Union Pacific (Southern Pacific), Burlington Northern Sante Fe or Western Pacific railroad are involved.

2. Three copies of Manufacturers' data relative to manufactured devices.

3. Three copies of Contractor's calculations.

4. Three copies of the Structure Representative's calculations.

Note: One copy of the above is for the Sacramento Office of Structure Construction's use, and the other copies are forwarded to the railroad by the Office of Structure Construction. In the event that railroad personnel at the job site need copies of the above information, they are to obtain it from their headquarters.

When the above noted data is submitted to the Office of Structure Construction, it shall be accompanied by a letter of transmittal in which the Structure Representative will list the information submitted, and state that the shoring plans and calculations have been reviewed and that they are considered to be satisfactory. The Office of Structure Construction will review this data. The Structure Representative should not stamp the shoring plans 'Approved' until they have been notified that the railroad has reviewed and accepted the shoring plans.

Incomplete or unsatisfactory data will be returned to the Structure Representative for correction. Upon confirming that the plans and calculations are complete and satisfactory, the information will be forwarded to the railroad for their review and acceptance.

When the Sacramento Office of Structure Construction and railroad reviews are complete, and the Sacramento Office of Structure Construction advises the Structure Representative that the railroad considers the shoring plans to be satisfactory, the Structure Representative will send a letter to the Contractor stating that the plans have been reviewed and approved. This letter authorizes the Contractor to begin constructing the shoring. Note that the Contractor must not begin shoring construction until such time as the approval letter has been issued to the Contractor. (See Attachment No. 1 for an example of a properly prepared shoring approval letter.)

**Shoring Review Unit**

A Shoring Review Unit will be operational in the Sacramento Office and this unit will perform the following functions:

1. Participate in shoring research projects and provide input relative to changes in specifications and policy.
2. Review all shoring plans and calculations for shoring adjacent to or under railroads and forward the plans and calculations to the railroad for their review and approval. The Shoring Review Unit provides the liaison between the job and the railroad.

3. "Spot Check" shoring plans and calculations for shoring not adjacent to or under railroads. The plans to be "spot checked" are selected at random with the objective of ascertaining that current shoring directives and policies are being complied with.

4. Act as consultant to the Structure Representative and provide guidance with complicated shoring problems and resolve questions involving shoring policy.
June 1, 1997
Co-Rte-PM
00-000104

Sample Construction Co.
Sample Lane
Sample, CA 00000-0000

Gentlemen:

The shoring plans for the temporary retention of soil and embankment material at Abutment 1 of General Avenue Overcrossing, Bridge No. 2B-X4X, dated August 14, 1989, have been reviewed and are approved to the extent provided in Section 5-1.02 of the Standard Specifications. [Add the following when using the contractor’s/consultant’s soil parameters; This approval is based upon the soil parameters submitted by your consultant.] [Add when needed for trench shields. Note that your submittal did not include calculations from the trench shield design engineer. It is therefore understood that your licensed engineer has verified that the shields themselves are capable of sustaining the loads allowed by the shield manufacturer.]

Your attention is directed to your responsibilities pursuant to Section 5-1.02 and 7-1.09, of the Standard Specifications as well as the Construction Safety Orders.

You are reminded that the shoring must be constructed to conform to the shoring drawings, that the materials used must be of the quality necessary to sustain the stresses required by the shoring design, and that the workmanship shall be of such quality that the shoring will support the loads imposed on it without excessive movement.

Sincerely,

Y.Y. Resneer
Resident Engineer

By

W.W. Strurep
Structure Representative

c:
Subject: Support from Roadway Geotechnical Engineering

Shoring systems requiring the use of slope stability (i.e. excavation exceeding the Cal OSHA sloping or benching requirements) should be reviewed by the Roadway Geotechnical Engineering unit for adequacy. To obtain assistance from the Roadway Geotechnical Engineering unit, contact the appropriate Geotechnical Design Branch (North, South, West) that your project is in using the following link:

http://onramp.dot.ca.gov/hq/esc/gs/design.shtml

cc: BCR&P Manual Holders
    R. Pieplow, HQ Const.
    Consultant Firms
    J. Van Velsor, Geotech.Services
Subject: Torvane Usage for Sloped Excavations

The Torvane (or Shearvane) is a soil-testing tool utilized for rapid determination of cohesive soils’ undrained shear strength (Su). The use of a Torvane is an acceptable practice according to Cal/OSHA\(^1\) for determining the maximum allowable slope of an excavation.

Projects utilizing a Torvane will also require the following conditions be met and addressed with each shoring submittal:

- Tension cracks must be prevented from developing at the top of the excavation.
- Water must be prevented from ponding at the top of and the toe of the slope.
- Soil must be consistent and homogeneous throughout the excavation.
- Cal/OSHA requirements must be adhered to at all stages of the excavation.

In situations where the contractor is proposing to use a Torvane, consult the Trenching and Shoring Senior Specialist in the HQ Structure Construction at (916) 227-8060 for assistance.

\(^1\) Cal/OSHA §1541.1, Appendix A (d)(2)(D) (https://www.dir.ca.gov/title8/1541_1.html).
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<td>Removed BCM 124-2.0 and 124-3.0</td>
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Memo No        Issue Date       Title                                                                                   
130-1.0        01-12-2023       FOUNDATION TESTING AND INSTRUMENTATION BRANCH – Deleted and Replaced by BCM 49-3 on 12-22-22   
130-2.0        09-04-18         PILE LOAD TESTS – Deleted on 09-04-18                                               
130-3.0        06-30-14         PILE HAMMER DATA – Deleted on 06-30-14                                               
130-4.0        03-30-22         PILE DRIVING ACCEPTANCE CRITERIA – Deleted and Replaced by BCM 49-2 on 03-30-22   
130-5.0        03-30-22         STEEL H-PILES LUGS – Deleted and Replaced by BCM 49-2 on 03-30-22         
130-5.0 Att. No. 1 03-30-22       PILE LUG – Deleted and Replaced by BCM 49-2 on 03-30-22                      
130-6.0        12-22-22         PAYMENT FOR PILING – Deleted and Replaced by BCM 49-3 on 12-22-22           
130-7.0        12-22-22         CIDH CONCRETE PILING – Deleted and Replaced by BCM 49-3 on 12-22-22          
130-8.0        12-22-22         CIDH PILE MITIGATION COMMITTEE – Deleted and Replaced by BCM 49-3 on 12-22-22  
130-9.0        12-22-22         CIDH PILE INSTALLATION PLAN AND CONCRETE TEST BATCH – Deleted and Replaced by BCM 49-3 on 12-22-22  
130-10.0       12-22-22         TESTING OF CIDH PILING – Deleted and Replaced by BCM 49-3 on 12-22-22          
130-11.0       12-22-22         SIMPLE REPAIR OF CIDH PILING – Deleted and Replaced by BCM 49-3 on 12-22-22
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<td>Working Drawings and Material Submittals for Buildings</td>
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<td>132-2.0</td>
<td>12/10/1987</td>
<td>Joint Review of Building Projects</td>
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<td>05/01/1998</td>
<td>Inspection of Building-Related Transportation Facilities</td>
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<td>132-2.2*</td>
<td>07/29/2010</td>
<td>Clean Renewable Energy Bond (CREB) Project Inspection</td>
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<td>132-3.0</td>
<td>08/05/1985</td>
<td>Parts Lists, Service Instruction, Manufacturer’s Warranties, and Operating and Maintenance Instructions</td>
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<td>132-4.0</td>
<td>05/10/1982</td>
<td>Changes Involving Building Projects</td>
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*Denotes the document is a Bridge Construction Bulletin

Robert A. Stott, Deputy Division Chief
Offices of Structure Construction
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Working Drawings and Material Submittals for Buildings

The submittal of shop plans or equipment lists as specified in the Standard Specifications, the General Conditions, and/or the Special Provisions, requires that each submittal be completely identified. The Structure Representative should caution the Contractor early in the contract (this could be done at the pre-job conference) that this is a contract requirement, and that failure to comply will result in delay of approval of his submittals. (Attachment No. 1 to this Bridge Construction Memo is a sample of an equipment submittal which properly identified the equipment that the Contractor proposes to use.) The Contractor should also be informed that failure to make submittals that are not complete and not grouped in logical order also tends to delay the approval process.

The procedure for review and approval of working drawings and material submittals for buildings is a coordinated effort between the Architecture and Transit Branch, and Construction.

Attached is Memo to Architects A-5-11 (Attachment #2) Review of Working Drawings and Material Submittal for Buildings. The design memo covers the procedures required for review and approval of working drawings and material submittals, including responsibilities of Structure Representatives on construction projects. Structure Representatives should comply with the applicable instructions in Memo to Architects. A-5-1 in-so-far as possible.

Unless otherwise stipulated in the Special Provisions, the Contractor (subcontractor or fabricator) is to submit all working drawings and material submittals directly to the Office of Structure Design, Document Unit, P.O. Box 942874, Sacramento 94274-0001. This includes original submittals and resubmittals. The Structure Representative is not to accept submittals unless it is so stipulated in the Special Provision.

The working drawing and material submittals approval procedure is administered by the Special Services Group of Office of Structure Design. The group maintains a record of all working drawings and/or material submittals, and distributes copies to all interested parties, during all phases of the approval procedures. This relieves the Structure Representative of tedious administrative details necessary to insure that working drawings are distributed to the right people at the right time. One copy of all submittals will be forwarded to the Structure Representative on the same day that they are received in Sacramento.

The responsibility for checking working drawings and material submittals is shared by the Architect and the Structure Representative. Working drawings and/or material submittals shall not be returned to the Contractor until the Architect has discussed and resolved the details with the Structure Representative. The comments returned to the Contractor must be acceptable to both the Architect and the Structure Representative.
Agastat timing relays 7000 series

Model Number Code

- **AGASTAT 7000 Series Timing relay**
- **Contact Arrangement**
  1. Single Pole, Double Throw
  2. Double Pole, Double Throw
  3. Four Pole, Double Throw
- **Call Voltage**
  - A: 110 V 60 Hz
  - B: 110 V 50 Hz
  - C: 220 V 60 Hz
  - D: 220 V 50 Hz
  - E: 380 V 60 Hz
  - F: 380 V 50 Hz
  - G: 120 V 60 Hz
  - H: 120 V 50 Hz
  - I: 6 V 60 Hz
  - J: 24 V DC
  - K: Dual Voltage (combines A & D)
- **Time Range**
  - A: 1 to 1 Sec.
  - B: 5 to 5 Sec.
  - C: 1.5 to 5 Sec.
  - D: 5 to 50 Sec.
  - E: 20 to 500 Sec.
  - F: 1 to 10 Min.
  - G: 3 to 30 Min.
  - H: 1 to 60 Min.
  - I: 0 to 120 Cyclic
  - J: 0 to 120 Sec.

- **Optional Features**
  - T: Aux. Switch Options
    - LL
  - Q: Optional Features
    - G2: Total Eng.
    - H: Screw Terminals
    - M: Dusttight
    - N: Watertight
    - X: Panel Mount Kit

Note: As shown above, the Contractor must show all options, accessories, and modifications to be furnished. Arrows, circles, or written notes may be used to identify the characteristics of the furnished item.
MEMO TO ARCHITECTS:

Procedure

The instructions in this memo apply to shop drawings and material submittals for buildings. Generally, this will apply to all projects prepared by Architectural Design.

Note:

The procedures covered in this Memo will also apply to Mechanical & Electrical (Building or related) projects. The responsibilities may be covered appropriately by inserting “M & E Engineer” whenever any reference is made to “Architect.”

Structure Representative = Construction representative or Resident Engineer.

To provide uniform treatment in checking shop drawings and material submitted for buildings, the following procedure shall be followed:

1. The responsibility for checking shop drawings is shared by the Architect and the Structure Representative. Shop drawings shall not be returned to the Contractor until the Architect has discussed and resolved the details with the Structure Representative. The comments returned to the Contractor must be acceptable to both the Architect and the Structure Representative.

A brief file memo shall be written by the Architect to document controversial decisions or to keep other involved parties informed. For example, a memo is required for any change or clarification of details in contract plans. A copy of the memo is to be sent to the Structure Representative.

2. All submittals of shop drawings and materials will be received by the Documents Unit for distribution. The initial distribution of drawings will be:

   1 copy to RE or Structure Rep
   *4 copies to Architect

   *Including Mechanical/Electrical submittals, Structural submittals, and Landscape/Irrigation submittals.

   Architect will make distributions.

Replaces Memo to Architects A – 5 – 1
Dated September 1981
The number of samples of each material may vary. The Documents Unit will submit all samples to the Architect, who will determine and record the disposition.

The Architect will check the drawings and:

a) Sheets that do not require correction. All four copies will be stamped “Approved” and distributed as shown below.

![Approval Stamping Example](image)

1 copy will be retained by the Architect
3 copies will be returned to the Documents Unit who will make the following distribution:

1 copy to RE or Structure Rep
2 copies to Contractor

b) Sheets that have minor corrections. The Architect will stamp each of these sheets as shown and indicate all corrections in red on all four copies. The distribution will be the same as 2a.

![Approval Stamping Example](image)

c) Sheets that have revisions. Only those sheets that require the corrections will be stamped as shown. Notes added to the sheet shall make it clear why the submittal is not approved. The distribution will be the same as 2a.
d) Corrected copies received from the Contractor will be processed identical to the procedures outlined in 2, 2(a), 2(b) or 2(c) as required.

3. For contracts under General Conditions, the following stamps will be used under 2(a), (b) or (c):

   a) 

   ![Approval Stamp]

   PRINTS REVIEWED BY STATE OF CALIFORNIA
   DEPARTMENT OF TRANSPORTATION
   OFFICE OF STRUCTURES DESIGN
   APPROVED
   PURSUANT TO SECTION 2-1.04 OF THE GENERAL CONDITIONS
   DATE

   b)

   ![Approval Stamp with Notations]

   PRINTS REVIEWED BY STATE OF CALIFORNIA
   DEPARTMENT OF TRANSPORTATION
   OFFICE OF STRUCTURES DESIGN
   APPROVED
   SUBJECT TO NOTATIONS INDICATED IN RED
   PURSUANT TO SECTION 2-1.04 OF THE GENERAL CONDITIONS
   DATE

   c)

   ![Not Approved Stamp]

   PRINTS REVIEWED BY STATE OF CALIFORNIA
   DEPARTMENT OF TRANSPORTATION
   OFFICE OF STRUCTURES DESIGN
   NOT APPROVED
   PLEASE RESUBMIT
   DATE
4. For Contracts under General Specifications (under $25,000.), the following stamps will be used under 2(a), (b), or (c):

(a)

PRINTS REVIEWED BY STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
OFFICE OF STRUCTURES DESIGN

APPROVED
Pursuant to Section 5.02 of the General Specification

__________ DATE __________

(b)

PRINTS REVIEWED BY STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
OFFICE OF STRUCTURES DESIGN

APPROVED
Subject to Notations Indicated in Red
Pursuant to Section 5.02 of the General Specification

__________ DATE __________

(c)

PRINTS REVIEWED BY STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
OFFICE OF STRUCTURES DESIGN

NOT APPROVED
Please Resubmit

__________ DATE __________
Guide for Checking shop Drawings

As a means of establishing uniform practice and avoiding omissions, but not as a substitute for common sense, the following outline is submitted as a general guide for the checking of the shop drawings. Some items are included which should fall within the duties of the Structure Representative. An overlap may avoid an oversight. These items will be reviewed in the discussion between the Architect and the Structure Representative.

If the individual Project Architect feels that certain factors need not be considered, or that others should be added, it is his prerogative to do so, providing the Structure Representative is agreeable.

1. Read the Standard Specifications (or General Conditions) and the Special Provisions for the particular job. The Special Provisions may modify the usual procedure. Read the correspondence file. There may have been changes approved by the Office of Construction since the contract was let. Call Structure Representative to establish a working relationship and to become familiar with any pending changes or special problems.

2. Changes from the contract plans or specification, regardless of magnitude, should not be allowed unless they have been discussed and approved by the Structure Representative and the Project Architect. Revisions may be satisfactory structurally or architecturally, but create administrative problems. Changes requiring Contract Change Orders as determined by the Structure Representative need special attention. These change orders could be grouped into two categories:

   a) Those involving changes requested by the State and minor changes requested by the fabricator where there is no question on approval of the change order by both parties. The shop drawings can be approved, but the note “Contract Change Order to be processed” must be added to each detail sheet involved.

   b) Those involving changes requested by the Contractor, other than those covered in 2a. These should be returned to the Contractor with the note “Request must be made by the contractor for a Contract Change Order.” The Contractor may ask that the shop drawings be held by Architectural Design pending such negotiation. Architectural Design should not hold any plans without such a request.

3. All submittals shall be properly identified. This is covered in the Special provisions under Section 2-1.04 General Condition projects and 12-1.06 of Standard Specification projects. Bridge Construction Memo 132.1.0 instructs the Structure Representative to caution the Contractor of the importance of this identification (this could be done at the pre-job conference). Tabulated below are specific actions to be taken to assure proper identification:
a) If the project designer does not attend the pre-job conference be sure to notify the R.E. prior to the meeting to stress the importance of properly identifying shop plans.

b) Inform the Contractor (via the Documents Unit) on the first returned transmittal of sets received with marginal identification. A call to the R.E. to discuss the problem is also in order at this time.

c) Return seriously unidentified shop plans (via the Documents Unit) without checking (unstamped) when the practice continues after sufficient warning. This option should only be used as a last resort and only after getting the Senior’s approval. When you exercise this* option a call to the R.E. and H.O. construction is mandatory.

Earl R. Latham
Joint Review of Building Projects

Near the completion of a building project, the Structure Representative should arrange for a joint review of the project with representatives of other organizations who have a vested interest in the facility. The purpose of this review is to accomplish the following:

1) Review the operation of the facility.

2) Inform the Maintenance Regional Manager or the operators of the facility of the beginning date of the one year guarantee period and who to contact for guarantee work (this should also be covered in the transmittal letter required in Bridge Construction Memo 132-3.0).

3) Discuss manufacture's warranties, service instructions, etc.

4) Discuss work that may be required after contract acceptance.

5) Review all design features that should be handled differently on future projects. These features should also be noted in the comprehensive letter which gives suggestions for improving the design or construction of building projects. (Refer to Bridge Construction Memo 2-8.0.)

The Structure Representative should arrange for the following to attend the review:

1) Maintenance Regional Manager or his representative for building projects which will be operated and maintained by State Maintenance forces.

2) A representative of the organization that will be operating and maintaining the facility for building projects not operated and maintained by State Maintenance forces.

3) The project architect. The Architect will arrange for Headquarters representation at the review in accordance with instruction in the Transportation Architecture Manual (See Attachment No. 1).

At his discretion, the Area Bridge Construction Engineer may determine that minor construction projects do not warrant this joint review. Routine projects having a value under $35,000 such as Minor B contracts would fall into this category. If the review is not held, it is still required that input is obtained from Structure Design and that the appropriate people are informed about the operation of the facility and about the guarantee provisions and who to contact for guarantee work.
It is important that the Maintenance Regional Manager be kept informed regarding job progress on building projects which will be operated and maintained by State Maintenance forces. Therefore, he should be contacted prior to the start of the project work and encouraged to make periodic visits to the job site as the work progresses.
MEMO TO ARCHITECTS:

The attached Bridge Construction Memo 132-2.0 outlines a joint review upon completion of building projects. The Architect shall arrange for headquarters representation at this review. Typical representation would be:

Office of Business Management (OBM) Projects

Architect
Structures M & E Engineer(s)
OBM or H.Q. Maintenance Representation

Safety Roadside Rest Areas

Architect
Structures M & E Engineer(s)
Landscape Architect
Sanitary Engineer
H.Q. Maintenance Representation

Truck Weight & Inspection Stations

Architect
Structures M & E Engineer(s)
CHP Representative
Interagency Liaison with the CHP
H.Q. Maintenance Representation

Also attached is Bridge Construction Memo 132-3.0 that gives background on parts lists, service instructions, manufacturer's warranties and operating and maintenance instructions.

Earl R. Latham
Design Supervisor

Attachment
Subject: Inspection of Building-Related Transportation Facilities

It is the Structure Representative’s responsibility to ensure that all building-related transportation facilities work complies with the plans and specifications. However, some of this work is specialized and complex which the Structure Representative may not be totally familiar.

In order to be assured that the construction of building-related transportation facilities complies with the plans and specifications, the Structure Representative is encouraged to arrange a meeting between themselves and the ESC Project Design Team (Architect, Mechanical, Electrical, etc.) prior to start of construction of the facility. This meeting can be arranged by contacting either the Transportation Architecture Branch (Telephone 916-227-3962, calnet 498-3962) or the lead architect for the project as shown on the General Plan Sheet. This pre-construction meeting between the Office of Structure Construction, Transportation Architecture Branch and Electrical, Mechanical, Water and Wastewater Branch should be used to discuss clarifications to the plans or specifications and should be held prior to the pre-construction meeting with the Contractor.

A similar meeting between the above parties should be arranged at the completion of the project to review administrative and technical issues that may need refinement prior to future use of details, as well as procedures that worked well and should be considered for future projects. This meeting should be held in addition to the meeting required for the “Joint Review of Building Projects” as outlined in Bridge Construction Memo 132-2.0.

Structure Representatives are also referred to Bridge Construction Memo 115-l .0, Inspection of Electrical, Mechanical, Water and Wastewater Work.

C: BCR&P Manual Holders
   Consultant Firms
   RETravis, Transportation Architecture Branch
   DLScharosch, Electrical, Mechanical, Water and Wastewater Branch
   BGauger, Construction Program Manager
Subject: Clean Renewable Energy Bond (CREB) Project Inspection

California Department of Transportation (Caltrans) has initiated a program dedicating $20 million to solar energy systems at 70 facilities throughout the state, providing California taxpayers an estimated $52.5 million in avoided energy costs over 25 years.

Instead of burning fossil fuels to produce electricity, the photovoltaic panels will harvest energy from the sun, producing more than three million kilowatt-hours of electricity each year and eliminating 2.8 million pounds of greenhouse gases annually.

Construction of these systems will be accomplished by 60 different contracts. The contract types will include Minor A, Minor B, and Major. A few of the contracts will have multiple sites.

It is the Offices of Structure Construction’s (OSC) responsibility to provide contract administration and inspection for the CREB contracts. Therefore, the OSC Staff will act as the Resident Engineer (RE) and Structure Representative (SR).

The CREB projects are unique and challenging and a guide has been developed to assist the RE/SR with the technical and administration aspects of the CREB projects. The information in the “CREB Project Inspection and Administration Guide” will be updated as needed and is located at the intranet link:

Parts Lists, Service Instructions, Manufacturer’s Warranties and Operating and Maintenance Instructions

The special provisions for building projects generally require that certain operating and maintenance instructions be submitted in duplicate.

The special provisions for building projects also require that parts lists, service instructions and manufacturer's warranties for products installed in the work shall be delivered to the Engineer.

It is the Structure Representative's responsibility to see that the required parts lists, service instructions, manufacturer's warranties and operating and maintenance instructions are furnished by the Contractor.

If lists, warranties, or instructions are furnished in duplicate, one copy is to be sent to the District Maintenance Engineer and the other copy is to be given to the operators of the facility. If only a single copy is furnished, it should be given to the operators of the facility.

The parts lists, service instructions, manufacturer’s warranties and operating instructions, furnished to the operator of the facility, and/or to the District Maintenance Engineer, should be accompanied by a transmittal letter. This letter should list all of the instructions, warranties, or parts lists furnished, and give the name, address and phone number of the Prime Contractor. A copy of this letter should be forwarded to the Sacramento Structure Construction Office.
Changes Involving Building Projects

Before making any changes involving building projects, the Structure Representative must contact the appropriate section of Structures Design, Architectural and Transit Branch, to inform them of the proposed change, and to obtain their concurrence for the proposed change. Contact with Structures Design may be made either in writing, by telephone, or in person.

When the Contract Change Order Letter of Transmittal is prepared, the Structure Representative must include the following information: Name of person contacted in Structures Design, the method of contacting the person in Structures Design, and a statement that the person contacted concurred with the necessity for, and the provisions of the proposed change.

See Bridge Construction Memo 7-2.0 for additional information concerning Structure Construction change order policy.
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<td>Deleted BCM 135-3.0</td>
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Memo No  Issue Date        Title                                                                                     
---    ----                  ---------------------                                                                                   
135-1.0 01/20/1983       EPOXY ADHESIVES                                                                                     
135-2.0 04/16/1990       BRIDGE DECK EXPANSION JOINTS AND JOINT SEALS                                                       
135-2.1* 01/20/2000     RELEASE AND REPORTING OF VALUES FOR TYPE B JOINT SEALS                                            
135-3.0              COMPRESSIVE DEFLECTIONS OF FIBERGLASS OR STEEL REINFORCED ELASTOMERIC BEARING PADS – Deleted on 11-23-2022 and will be replaced by BCM 51-3.02  
135-4.0              Blank                                                                                                        
135-5.0 04/11/2003      MECHANICAL ANCHORAGE DEVICES                                                                                   

NOTE:

* DESIGNATES THE MEMO WAS ISSUED AS A BRIDGE CONSTRUCTION BULLETIN (BCB). ALL OTHER MEMOS WERE ISSUED AS A BRIDGE CONSTRUCTION MEMO (BCM).
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Epoxy Adhesives

General Information and Instructions for Use

Epoxy adhesives are very good construction materials. They are, however, somewhat complicated, so there are certain rules that must be followed when using them. Some of these rules are seemingly insignificant, but experience has shown that if they are not closely followed, failure is likely to occur. As a step toward reducing epoxy failures, the adhesive selection, mixing and placing requirements for good performance will be reviewed.

Epoxy adhesives in their pure form are very hard and extremely brittle, and have undesirable properties for structural use. These physical properties can be altered to fit a wide spectrum of hardness and flexibility by judicious selection of hardening and flexibilizing agents. It is only natural, then, that there is a correct epoxy adhesive formulation for each type of job requirement: high strength epoxy to resist high stresses, flexible epoxy to resist high thermal changes.

All State Specification epoxies are of the two component type. One component is the epoxy resin and the other is the hardening agent. To these components are added coloring, stiffening agents, and flexibilizers as required. Some epoxies are designed as 1:1 mix ratio of the components, others as a 2:1. They are also designed to have a specific pot life at a certain temperature. When the two components are combined, there are two very important rules which must be followed: (1) mixing proportions as shown on the container must not be changed, (2) the components must be thoroughly blended. One should never try to alter the pot life of an epoxy by changing the prescribed mixing ratio. Doing so would result in a very undesirable epoxy. State Specification epoxies with designed pot lives from a few minutes to about 40 minutes are available. Hence, if the epoxy on hand is either too fast or too slow for a designated job, it should not be used; one which has a pot life that is more compatible with the job requirements should be obtained. The temptation to add solvents to reduce viscosity, extend working time or improve application characteristics must be avoided. Such usage could cause poor adhesion, high shrinkage and a "cheesy" effect.

The surface receiving the epoxy adhesive must be clean, sound, and dry. Probably the most frequently ignored requirement for a receiving surface is cleanliness. This is especially true when saw-cutting has been done. It is often assumed that a freshly sawed surface is clean since it has been continuously washed by the saw-blade cooling water, when actually a fine residue is left by the water. To insure a clean saw cut surface, it should be sandblasted before application of the epoxy. Cracked or loose sections of concrete near the surface should be located by striking the
concrete with a hammer or by dragging a chain over it. Hollow sounds are indicative of fractured concrete. Loose concrete must be removed.

In respect to strength and permeability, rules which have been developed for portland cement concrete are also applicable to epoxy concrete. The primary difference between the two concretes is that cement, with water for hydration, is the binder in one whereas epoxy is the binder in the other. Similar conditions produce similar results in each. For instance, a uniform gradation of sand and aggregate produces a stronger product than does a single or gap gradation; the richer the mix the less permeable the final product, etc. It follows then that regular concrete sand and gravel, thoroughly dried, usually produces a good epoxy concrete mixture. The maximum size aggregate, as in regular PCC, is determined by job conditions: Depth of section, reinforcing steel restrictions, etc.

The ratio of epoxy to aggregate for a strong, dense mix depends to a great extent on the gradation and maximum size aggregate used. Rule of thumb epoxy/aggregate-ratios (by volume) for good aggregate gradation of various maximum sizes are: 1/5 for 1 inch 1/4 for pea gravel, and 1/3 for 20 mesh sand. Whenever possible, make sample mixes using different ratios of mixed epoxy and aggregates. By comparing these sample mixes, it will be possible to select the mixed epoxy/aggregate mix that is most appropriate to the work. Since the viscosity of epoxies varies considerably with temperature, the mixing ratio of mixed epoxy to aggregate may have to be adjusted to maintain workability whenever there is a drop in temperature. When making the sample mixes, use the same compactive effort that it is anticipated will be used when placing the mix on the job. A good mix design is evident if the sample exhibits a mixed epoxy rich surface when compacted in this manner. A mixed epoxy rich surface results when the mix contains more mixed epoxy than is necessary to coat the aggregate and fill the voids. If an epoxy patch is placed on an exposed deck, an epoxy rich surface will be dangerously slippery.

Required skid resistance can be obtained by broadcasting dry sand on the surface while the epoxy is still fluid enough to receive it.

In an epoxy concrete mixture, it is most important that the epoxy resin components be blended first and then thoroughly mixed into the sand or sand and aggregate. Sides and bottom of mixing containers should be scraped clean during the mixing operation. The mixing operation within the limitation imposed by the pot life must be completed and the mixed epoxy/aggregate placed and compacted before the pot life is exceeded. The results of improper mixing are: non-uniform curing, cheesy or sticky areas, brittle areas poor adhesion and poor performance. The sand and aggregate has to be clean and dry to ensure proper bonding by an epoxy adhesive. Often it is incorrectly assumed that since epoxy will successfully bond wet concrete to dry concrete, good epoxy concrete can be obtained with damp aggregate. This is a false assumption.

In an epoxy rich mixture, there appears to be enough free epoxy to provide bond to the concrete surface against which it is to be placed. However, experience has shown that this is not true. Therefore, to ensure proper bond, the surface must be primed with pure epoxy adhesive just prior to placing the epoxy aggregate concrete.

Epoxy concrete varies as its counterpart PCC in placing characteristics. Epoxy concrete is too sticky and viscous to be effectively vibrated with a spud type vibrator. Surface vibration with a
flat plate has not been tried, but may work. The most effective proven way to place epoxy concrete is to work it around reinforcing steel and into corners by hand. Rodding it with a 1 x 1 helps, but generally the springing or bulking characteristic of the material makes rodding somewhat ineffective. Rodding is most effective after the material has been in place a few minutes and some bleeding of the pure epoxy has occurred.

When epoxy concrete is to be placed in thickness greater than 2" it should be placed and compacted in lifts of 2" or less thickness.

The surface of an epoxy concrete can be finished with either a wood float or steel trowel as desired. The steel trowel is superior to a wood float in sealing the surface of an epoxy mixture.

Temperature is a critical parameter in the curing of epoxy, the higher the temperature the faster the cure (and generally the higher the strength.) This fact becomes important when epoxies are used for patches or seals on decks and the controlling factor for opening the deck to traffic is curing of the epoxy.

Curing of epoxy can be accelerated by externally applied heat. Best results for placement in cold weather is to heat the concrete receiving surface, preheat the epoxy components and aggregates before any mixing is done, and then heat the mixture after it is placed. Preheating the individual components will probably significantly decrease pot life. Experimentally determine the reduction of pot life at the temperature of application. The in-place heating should not be done by direct flame onto the epoxy, but rather by radiant heaters, or by heated air such as is provided by heating a steel plate elevated above the epoxy surface, or by heating the inside of a "tent" erected over the work. Heat lamps directed towards the epoxy is also another good source of heat. The heat of the PCC surface at time of placement, heat of the components before mixing, or heat of the epoxy concrete after placing, should not be greater than about 110° F. When heating the PCC surface, a heater which will not contaminate the surface should be used.

When epoxy is used to bond fresh concrete to hardened concrete, the fresh concrete should be as dry as working condition will allow and must be placed while the epoxy is still fluid. If the epoxy reaches a firm but still tacky state, a new coat of epoxy must be applied onto the hardened concrete before the concrete is placed. If, on the other hand, the epoxy cures beyond the tacky state, it should be sandblasted before the new epoxy coat is applied.

Epoxy concrete dams at expansion joints or epoxy repaired joint spalls should be protected during the epoxy curing period from harmful pressures caused by joint closure as the structure expands. Easily compressed plastic foam materials placed in the joint provides good protection. Forms against which the epoxy concrete is to be placed shall be coated with paraffin or silicone grease, or covered with polyethylene sheet to prevent bond. The epoxy concrete should not be allowed to flow under the forms and encroach into the space reserved for joint closure. If the material is allowed to flow into this space, failure of the repair is certain when the joint closes against it.

Epoxy injection or pressure sealing cracks with epoxy can be done with 8040-O1E-01, 8040-O1E-02, or 8040-O1E-03 material. However, most epoxy injection on contract jobs is done by a subcontractor specialist using epoxy he normally uses for injection work. The Transportation
Laboratory should be consulted before permitting the use of other than State Specification epoxies for injection or any other type epoxy work. The coefficient of thermal expansion for epoxy adhesives is roughly 5 times that of concrete. This large a difference can be tolerated for most epoxies down to approximately 15° F because they are still flexible enough at this temperature to "give" under the stress induced by volume change differences. However, since the flexibility of epoxies varies as the temperature, the coefficient difference becomes critical at lower temperatures. Without proper flexibility in the epoxy system, the differential volume change will usually cause shear failure in the concrete, which is generally weaker than the epoxy. There is still sufficient residual flexibility at the lower temperatures in the epoxies designed to bond new concrete to old when their in-place thickness is 1/8 inch or less. These epoxies, however, cannot be used in greater thickness, or in epoxy concrete, or in epoxy mortar; more flexible epoxies are available for these uses.

The exact plastic flow characteristic of epoxy is still undetermined. Hence, until more knowledge is gained on this subject, epoxies should not be used in a manner that will subject them to sustained axial loads.

Where there is no abrasion and a protective coating is required, such as area of edge of deck to drip groove and around scuppers, Design has been using an epoxy enamel such as found in Section 91-4.04 of the Standard Specifications.

Rules, regardless of how complete they may be, are effective only to the extent to which they are followed. In the epoxy use rules discussed, each is a vital link in the process which produces a successful job. Consequently, the degree of success, as measured by in-use performance, of an epoxy application is dependent on the attention given to the adhesive selection, mixing and placing requirements.

For additional information concerning epoxies, contact Tom Shelly (916) 739-2346, ATSS 497-2346, of the Transportation Laboratory.

**Safety Precautions**

The following precautions are to be followed by all field personnel who are involved with the use of epoxy resin materials:

- The exposed parts of the face, neck and hands should be protected with barrier creams and plastic or rubber gloves be worn during the mixing, blending and placing operations.

- When resins or solvents come in contact with the skin, it should be washed with soap and water. Do not use solvents to clean epoxy from the skin, use soap and water.

- Goggles or face shields should be worn to prevent vapor or liquid splashes from coming in contact with the eyes. If uncured resins or solvents do come in contact with the eyes, they should be flushed continuously for ten minutes and then receive medical attention.

- Contaminated clothing, rags, gloves, etc., should not be reused.
• Good ventilation must be provided for the preparation and use of epoxy resin concrete; and since there entails a fire hazard, fire-fighting equipment must be maintained at all operations.

Following are listed seventeen safety rules which should be followed to offset the hazards inherent in the use of epoxy resins:

1. Inform workers of the hazards of epoxy resin operations and show them how to avoid contact.

2. Provide special isolated areas in the plant for mixing, molding, curing, casting, and tooling of epoxy resins.

3. Install ventilated hoods in mixing areas to prevent the spread of hazardous vapors.

4. Limit mixing to only a few workers.

5. Ventilate grinding, sawing, drilling or polishing operations where epoxy resins are used.

6. Supply protective sleeves and cotton liners under rubber gloves to workers in molding operations.

7. Provide water-soluble skin protective gels.

8. Supply neutral or acid soap instead of alkaline, powdered or abrasive cleansing agents.

9. Don't permit workers to use acetone or solvents to cleanse the skin.

10. Replace clean-up rags with disposable paper towels.

11. Institute a strong housekeeping program that immediately washes up spills and keeps tables, machinery, tools, floors, walls and windows free of particles and dust.

12. Provide goggles and respirators when epoxy resins are sprayed.

13. Cover benches and seats in mixing areas with disposable paper.

14. Throw away empty epoxy resin containers and drums.

15. Enforce a program of individual worker sanitation which requires washing before eating, before relief periods, after work, and after any contact with epoxy resins.

16. When possible, mechanize blending, mixing, and pouring operations.

17. Prohibit the wearing of clothing soiled by epoxy resins.
Bridge Deck Expansion Joints and Joint Seals

Construction Policy:

A. General

All deck expansion joints and joint seals, except for special cases, will be specified by seal type and M.R. (Movement Rating). The success or failure of joint seals will depend greatly on the enforcement of the specifications. Questions concerning joint seals will be handled in normal channels through the Construction Engineers and the Structure Construction Office.

It is the Structure Representative's responsibility to:

1. Determine the proper groove width or installation width for the joint seal used, and to complete the applicable portions of the Joint Movements Calculations sheet (Form DS-D129).
2. Install movement recording scribes on all expansion joints.

B. Special Details

Check details such as water stop, formed joint openings, hinge restrainers, rollers or rockers, conduits, etc., for proper setting and movement capacity. All components in an expansion joint must be capable of withstanding more than the anticipated movement for a particular joint.

Joints to be sealed under rehabilitation contracts must first be cleaned of all existing seal material, joint filler, dirt and debris to the top of the waterstop. If the joints do not have a waterstop, or the waterstop is damaged, it is essential that the joint be cleaned down to the bearing or hinge seat. Care should be taken so that existing utilities and encroachments spanning joints are not damaged by the cleaning operations. Carefully inspect the condition of the existing joint and the face of the saw cut. It may not be necessary to resaw cut the joint. If not, a change order may be written to eliminate the saw cutting with a credit to the State.

All dimensions of the existing joint must be verified to be compatible with the new seal, including the depth. All joint damage shall be repaired as directed by the Engineer. Sawcutting or grinding may be required in addition to abrasive blast cleaning of joints. Cleaning joints below the existing damaged waterstop and repairing the existing joint damage shall be considered to be specified extra work. Cost of repair of damage caused by the contractors operations shall be borne by the contractor. Getting a satisfactory joint may require the repairs of spalls, cracks, and
expansions dams, and this is usually classed as other work. Supplemental funds should have been provided for all above noted extra work.

C. Saw Cutting

1. Type "A" and "AL" Seals

   Joints to be sealed with type "A" Seals are to be saw cut to the dimensions shown on the contract plans. If for some reason the saw cut width has to be increased slightly to maintain a uniform groove width or to expose good sound concrete, it is essential to maintain a 1 to 3 depth to width ratio of the polyurethane seal.

   Joints sealed under rehabilitation contracts with type "A" (modified) seals, shall have a groove width ≥ one inch and ≤ 1.75 inches. Joint seal depth shall equal 1/3 the joint width but must be ≥ 1/2 inch, (see Attachment No. 5).

   The 1 to 3 depth to width ratio does not apply to the type "AL" seal. (Saw cut not required).

2. Type "B" Seals

   In new construction, type "B" seals are to be saw cut as follows:

   Joint movement calculation sheets, which include saw cut information, will be furnished by Design upon the request of the Structure Representative, when they are not included in the R.E. Pending File. (Attachment #2 is an example of a completed Joint Movement Calculation Sheet.)

   Saw cutting shall not be started until the Type "B" seal material has been tested and released. The Transportation Laboratory will furnish each job with a copy of the test report showing the M.R. (Movement Rating) of the Type "B" seal groove width limits, (W1 & W2) which are necessary to determine the saw cut widths. The M.R. of the Type "B" seal must be equal to or greater than that shown on the contract plans.

   The minimum saw cut (groove) depth is to be checked by cutting, a 1/2" to 1" section of the actual seal to be used and placing it between two flat surfaces, such as 1" x 4" x 8", e.g. Place the top of the seal to the dimensions shown on the contract standard plan and compress it to the W2 position. At this position determine the saw cut depth required per the standard plans.

   At the time saw cutting is to begin, determine the groove or saw cut width as described on the joint movement calculation sheet shown in the example (Attachment No. 2). Mark and check the initial saw cut so that it can be used later to check the tolerance of the completed joint. This is very important because the joints are usually moving while the saw cutting is in operation. It is the Contractor's responsibility to adjust the cut accordingly to match the initial saw cut width and maintain the tolerances specified for the completed joint.
In new construction projects joint geometry is readily controllable, i.e. the size of the saw cut is set to accommodate the joint seal. Rehabilitation projects differ from new construction projects in that the width and condition of the joints require special consideration. The new joint seal must provide the required movement rating and also must be of sufficient size to fit the existing joint after saw cutting.

Rehabilitation projects require that both the Minimum \( W_1 \) (the maximum joint width at minimum temperature, after prestress shortening), and the M.R. be indicated on the plans. To ensure a correct fit, the \( W_1 \) of the joint seal must be greater than the minimum \( W_1 \) of the joint.

The Special Provisions require that the joint size be verified prior to ordering the seals. A joint should be re-measured only after that joint and its adjacent joints have been cleaned. Record the concrete temperature at the time of measurement.

Calculate the minimum \( W_1 \), required for the joints using the actual measurements.

\[
\text{Min } W_1 = W_e \frac{(T_{str} - T_{min})}{1} \frac{1}{(2) (100)}
\]

Where:

- \( \text{Min } W_1 \) = Maximum joint width in inches
- \( W_e \) = Existing joint width in inches (measured at the widest point)
- \( 1/2 \) = Minimum practical concrete removal (1/4 inch each side of the joint)
- \( T_{str} \) = Structure temperature, deg F (measured at the time the existing joint width was measured, \( W_e \))
- \( T_{min} \) = Minimum temperature at structure site – from form DS-D129
- \( 1 \) = Temperature range at structure site - from form DS-D129
- \( 2 \) = Thermal movement in inches/100 feet - from form DS-D129
- \( 4 \) = Contributory length in feet - from form DS-D129

Compare these recalculated \( W_1 \)'s with the minimum \( W_1 \)'s shown on the plans. If they agree within 0.1 inch, the data shown on the plans does not need to be revised. If the new \( W_1 \)'s do not agree with the values shown on the plans, prepare a contract change order to revise the \( W_1 \)'s and state whether or not the movement ratings have changed.

If a calculated \( W_1 \) exceeds 4.25 inches, a compression seal should not be used. Contact the chairman of the Joint Seal Committee for a recommended course of action to follow.

Again, saw cutting should not start until test data for the seal to be used is available. Saw cut widths should be set to provide the minimum joint width possible. Due to the variables involved, saw cut widths should be calculated using the formulas given below and the narrower width chosen, provided it will work.

\[
S_1 = W_1 - \frac{(T_{str} - T_{min})}{1} \frac{1}{(2) (100)}
\]
\[ S_2 = W_2 + \frac{1}{100} \left( \frac{T_{\text{max}} - T_{\text{str}}}{1} \right) (2) (4) \]

\[ S_3 = W_e + 1/2 = \text{Minimum practical saw cut width} \]

Where:

- \( S_1, S_2, S_3 \) = possible saw cut widths
- \( W_1 \) = \( W_1 \) taken from test report (R-29)
- \( W_2 \) = \( W_2 \) taken from test report (R-29)
- \( W_e \) = Existing joint width in inches (measured at widest point)
- \( 1/2 \) = minimum practical concrete removal (1/4 inch each side of joint)
- \( T_{\text{str}} \) = Structure temperature, deg F (taken at the time of measurement of \( W_e \))
- \( T_{\text{min}} \) = Minimum temperature at structure site - from form DS-D129
- \( 1 \) = Temperature range at structure site - from form DS-D129
- \( 2 \) = Thermal movement in inches/100 feet - from form DS-D129
- \( 4 \) = Contributary length in feet - from form DS-D129.

**D. Installation**

1. **Type "A" and "AL" Seals:**

   Be thoroughly familiar with the contract specifications and details and enforce them.

   It is essential that the polyethylene foam be placed at a uniform depth to preclude excessively thin or thick sections. There is a successful relationship between the cohesion and the adhesion of the polyurethane seal if the proper shape and dimensions shown on the Standard Plan are maintained. Cut templates out of plywood to check the surface depths of the polyethylene foam and the polyurethane.

   Type A (modified) seals require placing the joint seal and rod stock 3 inches up into the curb or rail on the low side of the deck at the curb or rail joint that lines up with the deck joint.

2. **Type "B" Seals:** (Attachment #1 gives the properties for some brands of Type "B" seals.)

   Again be thoroughly familiar with the contract plans and specifications and enforce them.

   Repair all spalls and grind chamfer in advance of installing the seal.

   As a final check, prior to installation, it is recommended to use a thin section of joint seal material and use it to check the saw cut depth throughout the length of joint. Place the seal section in the planned position and check to see that the dimensions shown on the Standard Plan are maintained. Most joint seal failures result from improper saw cuts or from the seal being placed too near the deck surface.
Bend type "B" seals 6 inches up into the curb or barrier rail on the low side of the deck. If the curb or rail joints don't line up with the deck joint, an attempt must be made to abut the joint seal to the face of the curb or rail so that it will provide a water tight seal.

3. **Joint Seal Assemblies:**

   Details of a joint seal assembly are shown on the contract plans. The Structure Representative is to calculate the installation width of the joint seal assembly. Calculations are to be shown on the *Joint Movements Calculations* (DS-D129) sheet using a Wᵢ equal to 1/2 inch minimum at maximum temperature.

   The Special Provisions permit alternate joint seal assemblies which the Contractor may use in lieu of the joint seal assembly detailed on the Contract Plans.

   If the Contractor proposes to use an alternate joint seal assembly, the Structure Representative shall send two copies of the initially submitted working drawings to Structures Design for a determination as to the adequacy of the proposed alternate joint seal assembly. When submitting the working drawings, point out that they detail a contractor proposed alternate joint seal assembly, and that they are submitted for an informal review by the Joint Seal Committee and by Structures Design. If an alternate joint seal assembly is incorporated in the contract work, the Structure Representative should make the necessary changes on the "As Built" plans to indicate the details of the alternate joint seal assembly. An additional sheet may be necessary to show the "As Built" details. Do not submit the shop plans as "As Built" plans.

   Note that prestressed concrete structures are expected to initially shorten about 0.50 in./100 ft. due to stressing. The total long-term shortening is anticipated to be 1.00 in./100 ft. for post-tensioned bridges and somewhat less for pretensioned bridges. The difference between the long-term shortening (1.00 in.) and the initial shortening is equal to 0.5 in./100 ft. This is the value shown on the *Joint Movements Calculations* form (DS-D129) as "Anticipated Shortening for Post Tensioned Concrete Structures". For unusual situations when a substantial amount of time has elapsed between stressing and the placement of joint seals, an estimate may be made of the amount of prestress shortening that has occurred. Refer to Attachment No. 10 for an example.

4. **Modular Joint Seal Assemblies (MR over 4")**

   Refer to the Special Provisions for details concerning the installation of modular joint seal assemblies. Any questions can be directed to your area Senior or the Joint Seal Committee.

5. **Open Joint and Experimental Test Seals**

   Obtain the necessary brochures on installation procedures from your Construction Senior or the Chairman of the Joint Seal Committee if they are not included in the R.E. Pending File.
The proper installation width of open joints or experimental joint seals will be calculated from the *Joint Movement Calculation Sheet*. Determine the minimum width at maximum temperature (\(W_2\)) and insert this in Column 5. The adjustment of the width for temperature at time of installation will be the same as for the Type B Seal.

### E. Expansion Joint Scribes

Scribes are to be placed at all expansion joints as shown on the attached instruction sheet (Attachment No. 3). Placement of the scribes at a location other than that shown may be required when special barrier rails are used. Use the 8" steel railing scribe, 3/4" x 8" 24 gauge (Item No. 6635 1760 5) and 4" aluminum scribe plate, 1 1/2" x 4" 16 gauge (Item No. 6635 1790 8) for joints having a movement rating of 2" or less. Use the 10" steel railing scribe, 3/4" x 10" 24 gauge (Item No. 6635 1780 7) and 6" aluminum scribe plate, 1 1/2" x 6" 16 gauge (Item No. 6635 1770 6) for joints having a movement rating greater than 2". Use 681-80-44 Rapid Set Epoxy (Item No. 8040 0100 4) to attach the scribes and plates to the rail. Scribes, plates and epoxy should be obtained from the District through the Resident Engineer. Order one scribe per expansion joint and epoxy at the rate of 1 unit (1/4 pint can of "A" and 1/4 pint can of "B") per 20 scribe units. Skewed, or extra wide structures may require a scribe unit on the joint on both sides of the structure.
# APPROXIMATE PROPERTIES

## FOR

### PREFORMED ELASTOMERIC JOINT SEALS

#### TYPE B₁

Manufacturer's Nominal Properties for Design Data Only

(See Note 4)

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<th>Catalog Number Depth (See Note 1)</th>
<th>Uncompressed W₀ (See Note 3)</th>
<th>Uncompressed D₀ (See Note 3)</th>
<th>Approx. M.R. (See Note 2)</th>
<th>W₁ Max. Groove Width</th>
<th>W₂ Min. Groove Width</th>
<th>Recommended Saw Cut</th>
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*W.B. - Watson Bowman

Notes:

1. Brand Names other than those listed may be available.
2. The actual Movement Rating equals (W₁-W₂). W₁ shall be the smaller of the values determined as follows:
   a. 0.85 times the manufacturer's designated minimum uncompressed width of the seal (W₀).
   b. The width of seal on the third successive test cycle of the pressure-deflection test, when compressed to an average pressure of 3.0 pounds per square inch.

W₂ shall be the width of seal determined on the third successive test cycle of the pressure-deflection test, when compressed to an average pressure of 4 times the pressure measured at the seal width W₁.

3. Data shown may change significantly due to variations in extrusions. Dimensions must be verified in the field.
4. Do not use these properties in lieu of actual test results. This is for additional information only. Actual values for W₁, W₂, and M.R. are obtained from test results performed by the Transportation Laboratory on the Report of Inspection of Material (Form TL-29).
**Bridge Construction Records & Procedures Manual**

**Attachment No. 2**

**Page 8 of 13**

---

### Temperature Extremes

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<th>Location</th>
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<th>Control Length (ft)</th>
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<th>Seal Type, A, B, Others or Open Joint</th>
<th>Catalog Number</th>
<th>W1 (inches)</th>
<th>W2 (inches)</th>
<th>Structure Temp (°F)</th>
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1. **Design:** F. C. Boyd
2. **Specifications:** A. J. Pugh
3. **Joint Seal Committee Chair:** C. W. Jones
4. **P. E. Pending File:** S. Hatney
5. **P. E. to D. C.:** Complete & Return to Division
6. **Joint Seal Committee Chair:**
7. **Maintenance:**

---

**Expense Authorization:**

- **Number:** 03-000000
- **County:** Sac
- **Route:** 5
- **P. I.:** 0.2/2.4
- **Bridge Name & No.:** Dry Creek O.C. 0029

**Type of Structure:**

- Reinforced Concrete Box & CIP/S
- AL - 70T Piles / AT - Spd. Pgs.

**Temperature Extremes:**

- **Max:** 110 °F
- **Min:** 23 °F

**Thermal Movement:**

- **Steel:** 87 °F
- **Concrete (Conventional):** 87 °F
- **Concrete (Prestressed):** 87 °F

**Anticipated Shortening:**

- **Steel:** 0.55 in. / 100 ft
- **Concrete (Conventional):** 0.55 in. / 100 ft
- **Concrete (Prestressed):** 0.50 in. / 100 ft

---

**To Be Filled In By Designer:** F. C. Boyd

- **Date:** 5-1-76

**To Be Filled In By BR:** M. T. Trustworth

- **Date:** 7-8-78

---

**Show Line Drawing of Structure on Reverse Side, Show Points of No Movement and Contributory Length. Retain Copy for Design Calculations File.**

**Information From Transportation Lab Reports.**

**Groove Saw Cut Width.**

---

**Measure Superstructure Temperature by Placing Steel of Concrete Thermometer 6° C into Expansion Joint.**

**If alternative assembly is used, select correct Ws from sketches shown on Attachment No. 3.
CALCULATION OF POINTS OF NO MOVEMENT

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<tr>
<th>L (ft)</th>
<th>P (kip)</th>
<th>D (in)</th>
<th>E (plint)</th>
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<th>P (Col)</th>
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<td>615</td>
<td>6.00</td>
<td>2.333</td>
<td>3</td>
<td>432</td>
</tr>
</tbody>
</table>

Assumptions:
1. Super str. is rigid
2. Col's fixed top & bottom
3. Axil strain will slide @ a
4. E (plint) = 4 x 10^6

Notes:
- Width Str. = 78 ft
- Dia. Col. = 9 in
- X = Point of No Movement

BCM 135-2.0
ATTACHMENT No. 2
04/16/90
PAGE 9 OF 13
**NOTES:**

1. Install one scribe at each deck joint on the most convenient side of the roadway i.e., widest shoulder. Use 8" scribe and 4" plate for joints having movement rating of 2" or less. Use 10" scribe and 6" plate for joints having movement rating greater than 2".
2. Place scribe on top of the concrete portion of the barrier railing.
3. Sand or wire brush surfaces of scribe and concrete to insure good adhesion.
4. Mix only enough epoxy for one scribe and plate when using the 681-60-44 Rapid Setting Epoxy. (5 min, pot life @ 70°F)
5. Use weight on a piece of paper to hold the scribe down on the concrete surface while the epoxy is setting.
6. Mark the Initial Position of the scribe, date, and concrete temperature on the plate as shown with a scriber. Measure the concrete temperature by placing the bulb of a concrete thermometer 6" + into the deck section, if possible, or at any convenient location to obtain the approximate superstructure temperature.
SAMPLING AND TESTING OF TYPE "B" JOINT SEALS

The following revised instructions for sampling and testing Type "B" joint seals have been issued by the Transportation Laboratory. The procedures are currently in use. If there are any questions call Richard Spring at (916)739-2314.

1. Following the manufacturing of a given quantity of various sizes (Movement Ratings) of joint seal materials for use on Caltrans contracts, such as:
   
<table>
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<tr>
<th>Movement Rating</th>
<th>Length</th>
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<tr>
<td>MR=1&quot;</td>
<td>1500 LF</td>
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<tr>
<td>MR=1 1/2&quot;</td>
<td>1000 LF</td>
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<tr>
<td>MR=2&quot;</td>
<td>1000 LF</td>
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</tbody>
</table>

   The manufacturer will notify our Caltrans Laboratory (Richard Spring (916)739-2314).

2. Mr. Spring will arrange for an independent inspection agency to contact the manufacturer for the purpose of sampling the various lots of materials at the source.

3. The sampling agency will obtain one 3' long sample of each size and lot of material for every 500 LF and send to our laboratory for testing along with the manufacturer's test report. The manufacturer’s lot number will appear along the length of the seal.

4. Following satisfactory testing, the manufacturer will be notified and the material will be set aside for stock to be used on Caltrans contracts only.

5. As the manufacturer receives orders and makes shipments to the individual contracts, form letters will be sent to our Caltrans Laboratory and with the shipment to the jobsite. This letter will contain the following information:
   
   a. Name and address where the seal is being sent.
   b. State Contract Number.
   c. Size, quantity and movement rating of the seal.
   d. The Lot Number identifications.
   e. The Trans Lab's test number (SM number).

   Upon receiving the letter from the supplier as to where the seal is being sent, the TransLab will send to the RE or Structure Rep a copy of the test report for the particular lot of material. Included on the test report will be the $W_1$ and $W_2$ values for the seal. The RE or Structure Rep should verify the lot number on the seal with the test report lot number.
JOINT SEAL TYPE A MODIFIED (MR 1/2"

No Scale

Notes:

1. If required, sawcut or grind transverse joints to the minimum (W) shown. Clean and abrasive blast joint.

2. Install commercial quality closed cell polyethylene rod stock with glazed surface. Diameter = joint width + 1/4".

3. Install joint seal. Place joint seal 3" up into curb or rail on low side of deck.

For details not shown see R6-21
Prestress Shortening

Assume long term total shortening is 0.10/100'.

If saw cut made at following weeks:

- 6 weeks: 0.10'
- 15 weeks: 0.20'
- 30 weeks: 0.30'
- 52 weeks: 0.50'

Projected Rate

Additional opening of expansion joint after joint placement per 100' of contributory length.

Stressing: in per 100 ft

Elastic due

Stressing due

PAGE 13 OF 13

B C M 1 3 5 - 2 . 0
ATTACHMENT No. 3
04/16/90
Subject: Release and Reporting of Values for Type B Joint Seal

The last paragraph of Sheet 2 of 7 of Bridge Construction Memo 135-2.0 is modified to read:

Saw cutting shall not be started until the Type B seal material has been verified as having successfully been tested by the Division of Materials Engineering and Materials Testing Services (DMETS). The contractor/subcontractor will need to provide information to the Structure Representative regarding the manufacturer, lot number, date of manufacture and movement rating of the joint seal intended to be used prior to bringing the seal to the job site. The Structure Representative will verify the successful testing by contacting DMETS at 916.227.7263 and to obtain the $W_1$ and $W_2$ values for the lot of seal that will be used by the contractor. The movement rating (M.R.) $(W_1 - W_2)$ of the Type B seal must be equal to or greater than that shown on the contract plans.

When contacting DMETS for $W_1$ and $W_2$ information, the Structure Representative (caller) should have the following information readily available:

- Manufacturer of the Type B Seal.
- Lot number shown on the side of the Type B Seal.
- Date of manufacture.
- Movement Rating for the seal.

If requested, a copy of the DMETS test report for the Type B seal can be sent to the Structure Representative. It is important to note that the Type B Joint Seal will arrive at the jobsite without any state inspection release tags and no report of inspection document (TL-0029).

Background:
Type B joint seal is normally supplied by one of two sources from producers in the Midwest. As part of the manufacturing process, the various sizes of Type B Joint Seals are identified on the side of the seals with a Lot Number which represents a certain quantity. A sample of each lot of material is sent to DMETS in Sacramento for testing. Following the successful testing, the manufacturer is notified that the lot or lots of Type B Joint Seals are acceptable. At the time testing is performed, the lab does not know on which state contracts the Type B Seals will be used, therefore no information can be sent to the Structure Representative.

c:  BCR&P Manual Holders
    Consultant Firms
    PStolarski, Chief Division of Materials Engineering and Testing Services
    RWWolfe, Acting Chief Office of Structural Materials
    BPieplow, Acting Construction Program Manager

“Providing the technical expertise for quality built structures”
MECHANICAL ANCHORAGE DEVICES

Expansion anchorage devices seldom develop the full tensile strength of a stud or a bolt, and are therefore less desirable than cast-in-place bolts and inserts. For this reason, expansion anchorage devices are generally used only for attaching fixtures such as signs, ladders, utilities, and temporary railings to hardened concrete.

Inspections by Structures Maintenance Engineers have disclosed instances of loose anchorage devices for bridge-mounted signs. The lack of proper anchorage had gone undetected because a headed bolt was used instead of a threaded stud. When the bolt was tightened against the fixture mounting plate, it pulled the anchorage loose from the concrete. The anchorage then pressed against the other side of the plate, and further tightening gave the impression that the fixture was securely attached when actually it was loose.

In order to minimize this problem, plans call for a threaded stud instead of a headed bolt. The Standard Specifications require that the expansion anchor be recessed 1/2" to 1" below the concrete surface after it has been expanded. This allows the inspector to observe if the anchorage has been seated initially, and if it is properly holding at the time the fixture is attached. The plans also call out the diameter of the stud. Galvanizing requirements are given in the specifications.

In the event that the aforementioned details are not shown on the project plans, the Structure Representative should insist that studs and nuts be used instead of bolts. Note that the stud diameter should be 5/8" if the plans call for a 5/8" anchorage device. The other aspects of the expansion anchorage shall conform to the project plans and specifications.

Note that when anchorages are expanded by driving the expansion element over an expander plug, a sufficient thickness of concrete must be provided behind the plug to resist the driving force. The drilled hole for the anchorage must also be true to size and shape so to assure the fullest bearing of the expanded anchor against the concrete.

All concrete anchorage devices shall be subject to the approval of the Engineer. Current approval lists can be found at [http://www.dot.ca.gov/hq/esc/approved_products_list/](http://www.dot.ca.gov/hq/esc/approved_products_list/). On the page are ‘Cartridge Epoxies’ and ‘Mechanical Expansion Anchors’ that link to the latest approved products. If the proposed MEA does not appear on the working list, approval shall be contingent upon the submittal to the Engineer of sample concrete anchorage devices, manufacturer's instructions, and certified results of tests indicating compliance with specification requirements.
In summary, the Structures Representative should be sure that all expansion anchorage installations conform to the following:

1. Be sure the anchorage device is listed on the approved working list (Website given).

2. Proper size hole is drilled.

3. Use threaded studs and not headed bolts.

4. Use galvanized studs. (Not black steel)

5. Be sure the expansion part of the anchorage is properly recessed below the surface after it has been expanded.

6. Never accept a stud of smaller diameter than the stud or anchorage device size called for on the plans.

Another useful resource can be found in the Bridge Design Aids. Pages 81 through 92 of Chapter 5, Concrete Design, show a properly installed anchorage and indicates where anchors may be used and what will be shown on contract plans. The complete manual is available on Structure Design’s website at the following address: http://onramp.dot.ca.gov/hq/esc/sdsee/design_technical_services/publications/bridge_design_aids.shtml
# Table of Contents

## Revision and Approval

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<th>Approved By</th>
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<td>Removed 145-7.0, <em>Adjustable Template for Checking Profiles of Ducts in Post-Tensioned, Prestressed, Concrete Girders</em></td>
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Support Systems for Portions of Permanent Bridges Which are Temporarily Unstable

Occasionally portions of permanent bridges are unstable during some stages of construction. Examples of such unstable portions of bridges are sloping abutments, and bent columns, where these components are hinged at the footing and not yet stabilized by completion of the superstructure. Numerous other conditions of instability of portions of the permanent structure may occur during individual phases of construction.

It is essential that the Structure Representative determine if, when, and where such conditions of instability may occur. When it is determined that a portion of the permanent structure will be unstable, the Contractor should be required to submit working drawings showing details of his proposed temporary support system. (Section 5-1.02 of Standard Specifications) The Structure Representative shall review these working drawings to ascertain that the proposed support system is adequate to provide the necessary stability. It is especially important that these procedures be followed when there is an unstable portion of a bridge adjacent to a railroad or to an area occupied by public traffic.

Contractors frequently make use of wire rope "guys" to temporarily support unstable portions of bridges. The Structure Representative should be alert to the fact that a poorly designed wire rope "guy" system, or the improper installation of wire rope "guys", may result in a catastrophic failure of that portion of permanent structure that is being stabilized by the "guy" system.

For information concerning the proper use of wire rope, refer to the report prepared by John MacNeill entitled *The Use of Wire Rope Guys and Restrainers for Concrete Forms and Structural Components*, dated May, 1975. This report is available to all registered Civil Engineers of the Office of Structure Construction.
Contractor Designed Temporary Bridges or other Temporary Facilities

If the Contractor proposes to construct a temporary bridge or other temporary facility across a traveled way being used by public traffic, the Contractor shall furnish the Structure Representative with working drawings and calculations detailing the location and design of the structure.

The Structure Representative will forward the aforementioned working drawings to the Sacramento Structure Construction Office for review by the Office of Structure Construction Falsework Section. The drawings should be forwarded with a letter describing loads to be supported, date Contractor wishes to begin construction, the design criteria used, and any other information pertinent to the review.

Temporary bridges or other temporary facilities not shown on the contract plans shall conform to Section 5-1.02, Plans and Working Drawings and Section 7-1.09, Public Safety, of the Standard Specifications.

Construction of the temporary bridge or other temporary facility should not be started until after the working drawings have been approved by the Engineer.
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### Revision and Approval

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**Memo No** 150-1.0  
**Issue Date** 05/30/2018  
**Title** Weight Overload Guidelines for Bridges on Construction Projects
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Weight Overload Guidelines for Bridges on Construction Projects

Introduction

This memo provides Structure Construction (SC) guidelines on the administration of the “weight limitation” provisions of a construction contract. These guidelines are to ensure uniform review and proper allowance for movement of construction equipment over structures that are within the project limits and are not open to traffic.

For structures that are either open to traffic or partially open to traffic, within the project limits, these guidelines can also be used for reinforced concrete slab bridges and culverts, and for reinforced concrete bridges with girders provided that:

1. The bridge has three or more girders. Non-redundant 2-girder systems or bridges with girder spacing greater than 14 feet must be forwarded to SC headquarters (HQ) for further analysis.

2. Clear spacing between overload vehicle and the edge of travelled way open to adjacent traffic must be a minimum of 10 feet or actual girder spacing, whichever is greater.

Overload cases that vary from the guidelines provided herein must be forwarded to SC HQ in Sacramento for further analysis. Structure Construction HQ will refer the request to the Structure Design Engineer for new structures or structures being modified by contract, and to Structure Maintenance & Investigations (SM&I), Permit/Rating Office for existing structures.

Standard Specification Weight Limitations

The Standard Specifications (SS)\(^1\), sets forth weight limitations for earthmovers, trucks, and truck and trailer combinations. It identifies what vehicles will be permitted to cross the existing, new, partially completed, or partially demolished bridge structures that are not open to traffic. This also provides that other construction equipment may be permitted to cross bridge structures subject to the weight limitations and conditions of the California Department of Transportation Permit Policy (see Transportation Permits Manual\(^2\)), whether open to the public or not.

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\(^1\) 2015 SS, Section 5-1.37B, Load Limits.

\(^2\) Transportation Permits Manual, Section is dependent on the equipment.
The provisions of SS\(^3\) apply only within the project limits. The *California Vehicle Code*\(^4\) governs operation of vehicles (including construction equipment) on State highways beyond the project limits.

**Overloads**

Overloads on bridge structures within construction contracts may be either repetitive, occasional, or stationary. When reviewing overloads, consideration should be made for the potentially reduced capacity of a partially completed or demolished structure. Listed below are guidelines for evaluating common overloads:

**A. Repetitive Overloads**

Repetitive overloads usually occur in connection with an earthmoving operation, and thus usually involve earthmoving equipment; aka Material Hauling Equipment (MHE).

1. **Bridge Structures Designed and Rated for HS20\(^5\) and Permit Live Loading or for HL93 and Permit Live Loading:**
   According to SS\(^6\), load limits are only applicable for bridges that have the capacity to handle HS20 live loading. Any new structure that is designed for either HS20 and permit live loading or HL93 and permit live loading and any existing structure that has an inventory level load rating factor of 1.00 or higher for either HS20 or HL93 loading and permit ratings of “PPPPP,” has adequate capacity for the load limits.

   The following must be submitted to SC HQ for review, when using earthmoving equipment on:
   - A new or partially completed structure that exceeds the limitations specified in the SS\(^6\).
   - An existing structure that:
     - Does not have an HS20 Operating Rating Factor of 1.67 or an HL93 Operating Rating Factor of 1.30 or higher, and
     - Does not have permit ratings of “PPPPP”.

2. **Structures Designed for Overloads**
   Under the provisions of SS\(^7\), the Contractor may request the redesign of a structure to increase its load carrying capacity to accommodate heavy construction vehicles such as earthmoving equipment. The Contractor must be willing to pay for the cost of redesign and increased cost of construction, and the Contractor’s equipment cannot exceed the

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\(^3\) 2015 SS, Section 5-1.37B, Load Limits.
\(^4\) *California Vehicle Code*, Division 15, Size, Weight and Load.
\(^5\) HS20 = HS20-44 = HS20-S16 = HS20-S16-44; Note H20 is not equal to HS20.
\(^6\) 2015 SS, Section 5-1.37B(1), Load Limits-General.
\(^7\) 2015 SS, Section 5-1.37B(2), Increased Load Carrying Capacity.
stresses produced by the following construction (design vehicle). Additional information relative to construction overload design is given in *Memo to Designers* 8 15-15.

At the present time, the design vehicles used to represent the construction equipment loading are:

- A three-axle vehicle having a maximum axle load of 130 kips and a total gross load of 330 kips for spans greater than 54 feet.
- A two-axle vehicle having a maximum axle load of 130 kips and a total gross load of 200 kips for spans of 24 to 54 feet.
- For spans under 24 feet, the design is based on a single 130 kip axle.

The following are the procedures to be followed when the Contractor requests a redesign of a structure, or structures, to increase the load carrying capacity:

a. The Contractor submits a letter to the Resident Engineer requesting that the structure be designed to increase its load carrying capacity. In this letter, the Contractor must name the structure or structures to be redesigned, give specific details of the loads, and the positioning of the loads on the structure. The Contractor must also state that they are willing to pay the cost of redesign and the increased cost of construction.

b. The Structure Representative submits a copy of the Contractor’s letter to the Deputy Division Chief of Structure Construction and if appropriate forwards it to Structure Design along with a memo requesting that the structure be redesigned. The Structure Representative should also request that the Contractor be advised of the estimated cost of redesigning the structure. At this point, the Contractor should be informed of the estimated cost and a formal agreement should be reached prior to proceeding with the redesign.

c. After the redesign has been completed, and upon receiving revised contract documents and the estimated maximum cost of redesigning the structure, the Structure Representative will prepare a Contract Change Order. The Contract Change Order will authorize the structural alterations to accommodate the construction overloads. If the final cost to the Contractor for the redesign is known, then the credit to the State should be included. Otherwise, a supplemental Contract Change Order should be written when the final costs are completed. (See Attachment 1 for a sample of this type of Contract Change Order).

**B. Occasional Overloads**

Occasional overloads will include the movement of construction equipment (concrete trucks, cranes, paving equipment, etc.) across structures from one work site to another. Also included for consideration are track equipment overloads, such as pavement grinders and excavators.

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8 *Memo to Designers 15-15, Materials Hauling Equipment Loading.*
1. **Concrete Trucks**
Concrete trucks traveling on the highway with full loads generally need to use booster axles to meet the axle weight requirements in Division 15 of the California Vehicle Code (CVC). When discharging concrete, the booster wheels need to be raised, which increases the loads on the remaining axles, resulting in axle loads that exceed the legal load allowed by the Permit Policy. The SS\(^9\) allows trucks over legal (exceeding CVC weight limitations) limit on bridges, not open to traffic, with up to 28,000 pounds for single axles and 48,000 pounds for the tandem axles. This limits most trucks to hauling a maximum 7 1/2 to 8 cubic yards. These trucks should be weighed to confirm allowable specification loading.

Any exception to the guidelines should be referred to SC HQ. (See *Processing Requests for Construction Equipment Overloads* below for further details.)

2. **Cranes and Concrete Pumps**
Fully equipped truck cranes are permitted to cross HS20, Operating Rating Factor of 1.67; HL93, Operating Rating Factor of 1.3 or greater; and full purple rated permit capacity rated (PPPPP) bridge structures on construction projects provided they conform to Permit Policy. Full purple rated permit capacity must be for all the 5, 7, 9, 11, and 13 axle vehicles. The following general guidelines may be used to determine if truck cranes or concrete pumpers traveling on the bridge meet Permit Policy, as follows:

- Tandem axle weights less than 54,000 pounds.
- Single axle weight less than 28,000 pounds.
- No group of three axles within an 18 foot distance (see table diagrams below).
- Three axle groups less than 18 feet are treated as a tandem axle group limited to 54,000 pounds.

Cranes are often stripped down (counterweights and other components removed) and sometimes the boom is supported on a trailer in order to achieve allowable permit weights. The Engineer should verify that the crane is configured in its traveling condition when moving on the bridge.

Any exception to the guidelines should be referred to SC HQ (See *Processing Requests for Construction Equipment Overloads* below for further details.)

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\(^9\) 2015 SS, Section 5-1.37B, Load Limits.
3. **Track Equipment**

Track Equipment, such as pavement grinders and excavators, occasionally need to cross or work on a bridge. For bridges designed and/or rated for HS20 or HL93HS-20 loading, the Engineer may approve this equipment, provided that it meets the following conditions:

a. Maximum gross weight is less than 66,000 pounds.

b. Maximum load on 12”-wide, or larger, tracks is less than 6,000 lb per foot.

c. Maximum load on 10” tracks is less than 5,000 lb per foot.

Any exception to the guidelines should be referred to SC HQ. (See **Processing Requests for Construction Equipment Overloads** below for further details.)

In addition, when track equipment crosses or works on a bridge, considerations must be given to the track type and its effect to the deck surface. Protective covers maybe required to protect deck surface.
4. Material Transfer Vehicles (MTV’s)

The Construction Manual\textsuperscript{10} discusses the Resident Engineer’s responsibility to protect Caltrans’ structural assets when the contract requires the use of MTVs or other types of heavy paving equipment. MTVs are being specified more frequently since Standard Specifications Section 39, \textit{Hot Mix Asphalt}, was revised in April 2014 to require the use of MTVs. The most commonly used MTVs have axle loading double the legal limit when empty, and triple the legal limit when loaded.

MTV’s typically exceed the load limits specified in the SS\textsuperscript{11} and thus must be submitted to SC HQ for review. Field review and approval may be allowed provided that the request from the Contractor meets the following conditions:

a. MTV is either a Roadtec SB2500 or a Weiler E2850 or lighter.

b. MTV carrying a maximum of 5 Tons of asphalt in hopper.

c. MTV is traveling 5 mph or less when crossing the bridge.

d. MTV is the only construction equipment on the bridge. Adjacent legal traffic is not allowed.

e. Bridge(s) to be crossed are rated to meet or exceed HS20 Operating Rating Factor of 1.67 or HL93 Operating Rating Factor of 1.30 and a 5-axle permit P5 permit rating of 1.00 or greater. Any new structure that is designed for permit loading will meet this requirement.

f. The bridge structure is an RC slab, an RC culvert-type structure, or a multi-girder type where girder spacing is between 7 and 9 feet.

g. If the bridge is a multi-girder type structure meeting the 7 to 9 feet girder spacing, the MTV wheel lines must be aligned with the bridge’s girder lines during the crossing.

Note: The MTV models noted above are assumed to have an 8-foot center-to-center wheel gage. Wheel lines should be equally spaced off girder lines within the allowable 7 to 9 foot range. Girder lines must be determined and marked out on the deck by the Structure Representative (SR) or Assistant Structure Representative (ASR) prior to the MTV crossing(s) and must be monitored by Caltrans (CT) field personnel at all times.

C. Stationary Cranes and Concrete Pumps

Cranes are also used in a stationary position to do work from bridges, including pile driving, lowering falsework, and lifting girders. Cranes lifting in a stationary position cause high outrigger loads. Outrigger loads greater than 40,000 pounds should be referred to SC HQ (see \textit{Processing Requests for Construction Equipment Overloads} below for further details). The Engineer may review proposals for outrigger loads less than 40,000 pounds provided that the bridge is designed for permit loads and/or has full permit capacity (PPPPP). The Contractor must be required to provide calculations for outrigger loads. Outrigger loads may be distributed in one of three methods:

\begin{itemize}
  \item [10] \textit{Construction Manual, 3-519B, Load Limits.}
  \item [11] \textit{2015 SS,} Section 5-1.37B(1), \textit{Load Limits-General.}
\end{itemize}
a. Outriggers that produce loads less than 25,000 pounds may be placed on timber mats. The mats should be 12” by 12” minimum and placed parallel to the girders. The minimum length of the mat is 5 feet; the minimum width must be equal to or greater than the outrigger plate width.

b. Outriggers that produce loads greater than 25,000 pounds should be placed on beams that distribute the load fairly equally to two girders.

c. Outriggers placed upon concrete bent caps of box girder bridges do not require mats or beams to distribute loads.

Submittals for stationary loading to be referred to SC HQ should include the following information:

- Location of crane outriggers tied into reference locations (CL bent or abutment, CL bridge, or edge of deck etc.).
- Calculations for outrigger loads.
- Manufacturer’s information for the crane and a description of how the crane will be outfitted and configured (boom length and counterweights).
- Weight of what will be lifted and maximum extension of the boom.
- Proposed method for distribution of outrigger loads.
  - How the configured crane will be moved into position while complying with SS12.

### Processing Requests for Construction Equipment Overloads

As previously noted, requests from Contractors to utilize construction equipment not exceeding the limitations presented above may be approved at the job level by the Structure Representative. All other requests are to be forwarded by the Structure Representative to the SC HQ. Structure Construction HQ will forward the necessary information to the Structure Design Engineer for new structures or structures being modified by contract, and to Structure Maintenance & Investigations (SM&I), Permit/Rating Office, for existing structures, to make a decision.

Prior to referring the request to SC HQ, complete the appropriate Bridge Overload Analysis Transmittal form (see Attachments 2 & 3).

Include a letter requesting overload analysis and a complete description of the equipment. The Contractor’s request must be explicit as to the nature of the overload and the conditions under which it will be moved. The information required includes:

- The type, the make, and the model of equipment.
- The axle spacing, axle width out and out of tires.

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12 2015 SS, Section 5-1.37B, Load Limits.
• The axle loads (obtained by scale weight if possible).
• The width and number of tires.
• Operating conditions, etc.

It is imperative that CT Engineers and the Contractor make all efforts to submit any overload request in a timely manner. Review time of an overload submittal can take from several days to several weeks or more depending on the completeness of the submittal and the complexity of the overload scenario. There is currently no contractual language regarding overload review time.

Permission to cross bridge structures with construction equipment that does not exceed the limitations presented above will also be granted by means of a letter to the Contractor from the Resident Engineer (see Attachment No. 4 for an example letter). However, if special conditions or limitations are to be imposed, they should be incorporated into a letter similar to the example letter authorizing the use of earthmoving equipment.

Since construction overloads will often affect areas of responsibility of both the District and SC, it is important that both be fully informed. Particular care should be taken by the Structure Representative to ensure that copies of all correspondence related to overloads are furnished to interested District personnel.
Example of a Change Order Recommendation to Authorize a Bridge Redesign

Note: The actual change order will come from the District Resident Engineer. The Structure Representative or Bridge Construction Engineer might be asked to recommend verbiage for the Change Order.

As provided in Standard Specifications Section 5-1.37B(2), *Increased Load Carrying Capacity*, modify substructure of the Van Koeverying Avenue Undercrossing, Bridge 54-1001, as shown on Sheets 2 and 3 of this change order to accommodate construction overloads.

It is agreed that the Contractor will furnish all labor, equipment and material, and perform all work required to accomplish the structural alterations at no cost to the State.

It is further agreed that the State will be credited by means of a supplemental Contract Cost Change Order the actual cost for redesigning the Van Koeverying Avenue Undercrossing to accommodate construction overloads. The design costs shall be a maximum of $10,000.
Bridge Overload Form (Stationary)

STATE OF CALIFORNIA • DEPARTMENT OF TRANSPORTATION • STRUCTURE CONSTRUCTION
BRIDGE OVERLOAD ANALYSIS TRANSMITTAL (STATIONARY)
FORM SC-1201-01 (NEW 05/16/18)

DATE SUBMITTED:______________________
DATE RESPONSE REQUIRED:______________________ (7 day minimum review time)
SUBMITTED BY:______________________
TITLE:______________________
PHONE:______________________

CONTRACTOR NAME:______________________
TYPE OF STATIONARY OVERLOAD:______________________
REASON FOR OVERLOAD:______________________
MAXIMUM OUTRIGGER LOAD:______________________

BRIDGE PERMIT LOAD RATING (COLOR RATING):______________________

DESCRIPTION OF WORK AND STAGE OF CONSTRUCTION:

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<th>CONTRACTOR SUBMITTAL CHECKLIST</th>
<th>YES</th>
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<td>LOCATION OF OUTRIGGERS (REFERENCED TO BRIDGE):</td>
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<td>CALCULATIONS FOR OUTRIGGER LOADS</td>
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<td>MANUFACTURER'S INFORMATION FOR EQUIPMENT:</td>
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<tr>
<td>LOAD WEIGHT AND MAXIMUM BOOM EXTENSION</td>
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<td>PROPOSED METHOD FOR DISTRIBUTION OF OUTRIGGER LOADS:</td>
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<tr>
<td>METHOD OF MOVING STATIONARY OVERLOAD INTO POSITION THAT COMPLIES WITH LOAD LIMITATIONS:</td>
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IF "NO" IS CHECKED FOR ANY OF THE ABOVE, THEN REQUEST MISSING INFORMATION FROM CONTRACTOR

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<td>HAVE LOADS BEEN COMPARED TO MAXIMUM ALLOWABLE IN BCM 150-1.0?</td>
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<td></td>
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<tr>
<td>ARE AS-BUILTS, CONTRACT PLANS, AND CURRENT BRIDGE CONFIGURATION PROVIDED?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IS LIVE LOAD (CONSTRUCTION, TRAFFIC, ETC) DURING THE BRIDGE OVERLOAD PROVIDED?</td>
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IF YES WAS ANSWERED TO ALL QUESTIONS ABOVE THEN FORWARD TO SC-HQ FOR REVIEW
(email to: OSC.Administration@dot.ca.gov with cc to Office Senior Engineer Liaison for project District)

FOR HQ USE ONLY

<table>
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<th>AUTHORIZED OR REJECTED:</th>
<th>AUTHORIZED BY:</th>
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<td>SC-HQ REVIEWER:</td>
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<td>SENT TO SM&amp;I/DESIGN DATE:</td>
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https://des.onramp.dot.ca.gov/structure-construction/structure-construction-forms
Bridge Overload Form (Moving)

**STATE OF CALIFORNIA • DEPARTMENT OF TRANSPORTATION STRUCTURE CONSTRUCTION**

**BRIDGE OVERLOAD ANALYSIS TRANSMITTAL (MOVING)**

**JOB STAMP**

**DATE SUBMITTED:**
**DATE RESPONSE REQUIRED:** (7 day minimum review time)
**SUBMITTED BY:**
**TITLE:**
**PHONE:**

**CONTRACTOR NAME:**
**TYPE OF MOVING OVERLOAD:**
**REASON FOR OVERLOAD:**
**OCCASIONAL OR REPETITIVE:**

**BRIDGE PERMIT LOAD RATING (COLOR RATING):**

**DESCRIPTION OF WORK AND STAGE OF CONSTRUCTION:**

---

**CONTRACTOR SUBMITTAL CHECKLIST**

| LOCATION OF MOVING LOAD (REFERENCED TO BRIDGE): | YES | NO |
| AXLE/TIRE EQUIPMENT | | |
| AXLE SPACINGS AND AXLE LOADS | | |
| AXLE WIDTH AND NUMBER OF TIRES PER AXLE | | |
| TRACK EQUIPMENT | | |
| TRACK TO GROUND CONTACT LENGTH | | |
| TRACK LOAD | | |
| TRACK WIDTH | | |
| TRACK TO TRACK GAGE/DISTANCE | | |

If "NO" is checked for any of the above, then request missing information from contractor.

---

**STRUCTURE REPRESENTATIVE REVIEW CHECKLIST**

| HAVE LOADS BEEN COMPARED TO MAXIMUM ALLOWABLE IN BCM 150-1.0? | YES | NO |
| (IF LOADS ARE LESS THAN MAXIMUM ALLOWABLE THEN AUTHORIZE AT PROJECT LEVEL) | | |
| ARE AS-BUILTS, CONTRACT PLANS, AND CURRENT BRIDGE CONFIGURATION PROVIDED? | | |
| IS LIVE LOAD (CONSTRUCTION, TRAFFIC, ETC) DURING THE BRIDGE OVERLOAD PROVIDED? | | |

If yes was answered to all questions above then forward to SC-HQ for review (email to: OSC.Administration@oct.ca.gov with cc to Office Senior Engineer Liaison for project District)

---

**FOR HQ USE ONLY**

| SUBMITTAL RECEIVED DATE: | AUTHORIZED OR REJECTED? |
| SC-HQ REVIEWER: | AUTHORIZED BY: |
| SENT TO SM&I/DESIGN DATE: | AUTHORIZED DATE: |
| SM&I/DESIGN REVIEWER: | RETURN TO FIELD DATE: |

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[https://des.onramp.dot.ca.gov/structure-construction/structure-construction-forms](https://des.onramp.dot.ca.gov/structure-construction/structure-construction-forms)
Month date, year

<Contractor Information>
Title if not in line above
Organization
Address
City, ST ZIP

Dear:

Your request dated (date) for permission to cross the (name of bridge), Br. No. (xxx), with construction overloads is approved in accordance with the provisions of Section 5-1.37B, Load Limits, of the Standard Specifications, subject to the following conditions:

1. The approaches at each end of the bridge must be completed to the grade required to provide a smooth transition to the bridge roadway, and must be maintained in a smooth and uniform condition at all times while construction equipment is in use, for a length of not less than 150 feet measured from the bridge ends. Local depressions in the approaches in the vicinity of the bridge ends will not be permitted.

2. Construction equipment, either loaded or unloaded, must be operated at all times at a speed and in a manner so that no bouncing of the equipment occurs while the equipment is crossing the bridge.

3. Construction equipment must be confined to the construction equipment lane by means of substantial, temporary physical barriers.

4. Only one construction overload will be permitted on the bridge at any time.

5. On completion of the operation that requires the use of a construction overload, the bridge roadway must be cleaned and physical barriers used in connection with the construction equipment lane must be removed and disposed of away from the job site.

Note: Other conditions or restrictions may be added as necessary to suit particular job circumstances.

"Provide a safe, sustainable, integrated and efficient transportation system to enhance California’s economy and livability."
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NOTE:

   ALL OTHER MEMOS WERE ISSUED AS A BRIDGE CONSTRUCTION MEMO (BCM).
Bridge Painting – Estimating Work Done

The attached summary sheet (Attachment #1) shows the percentage of the total work included in each phase of a typical bridge painting operation for paint systems used by the Office of Structure Construction.

Although the information shown is approximate only, it is sufficiently accurate for estimating purposes and may be used when computing amounts due on progress pay estimates for work performed under lump sum items.
### SUMMARY SHEET
PERCENT OF WORK IN LUMP SUM ITEMS

**Shop Blast with Inorganic Zinc Water-Borne Finish**

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<td>Blast Clean</td>
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<td>40</td>
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<tr>
<td>Shop undercoats</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Spot clean and undercoats in field</td>
<td>12</td>
<td>82</td>
</tr>
<tr>
<td>First finish coat</td>
<td>9</td>
<td>91</td>
</tr>
<tr>
<td>Final finish coat</td>
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<td>100</td>
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**100% Repaint with Water-borne Paint**

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<th>Percent</th>
<th>Cumulative Percent</th>
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</thead>
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<tr>
<td>Blast clean</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>First undercoat</td>
<td>10</td>
<td>70</td>
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<tr>
<td>Second undercoat</td>
<td>10</td>
<td>80</td>
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BROKEN OR SLIPPED PRESTRESS STRANDS

Structure Construction’s policy when prestressing strands break and it has been determined by the Engineer that it is structurally satisfactory to leave the broken strands out, is to give the contractor the option to replace the broken strands or request a contract change order with a rebate to the State.

The rebate should be arrived at as follows:

\[
\text{Rebate} = \frac{\text{Total Lineal feet broken strand}}{\text{Total lineal feet strand on the job}} \times \text{Contract item price for prestressing}
\]

In the case of slipped strand, when it has been determined that it is not feasible to re-grip and stress to the required force and all the other acceptance criteria are met, the same procedure may be followed.
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Pumping Plant Electrical and Mechanical Equipment Materials Lists and Working Drawings

Materials lists and working drawings for electrical and mechanical equipment, as required by Section 74-1.04 of the Standard Specifications, shall be checked and approved by the Mechanical and Electrical Section.

Normal procedure is for the Contractor (subcontractor or fabricator) to submit all working drawings directly to the Office of Structure Design, Document Unit, P. O. Box 942874, Sacramento 94274-0001. The Structure Representative is not to accept submittals.

Near the beginning of contracts that have pumping plant electrical and/or mechanical work involved, a representative of the Mechanical and Electrical Section will consult with the Structure Representative and give any necessary instructions at that time.
Electrical Service for Pumping Plants

The contract "Special Provisions" specify the requirements for furnishing electrical service to pumping plants and also specify the provisions for handling the electrical service charges. Generally, the service charges become the obligation of the State upon acceptance of the contract, but may become the State's obligation at some other time during the life of the contract if so specified in the "Special Provisions".

The Structure Representative must notify the District Resident Engineer, so that he may notify the District Office sufficiently in advance to allow time for making arrangements with the utility company for continuing, changing, or discontinuing the service.
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Discussion of Basic Construction Terms and Topics for High-Strength Bolted Connections

Discussion of Structural Bolts

There are many types of bolts used for structural applications. Quality for all of these is ensured through compliance with specified American Society for Testing and Materials (ASTM) standard specifications. These national specifications clearly denote specific mechanical properties, chemical composition, and dimensions for each type of fastener.

Where lower strength fasteners are required, ASTM A307, mild steel fasteners and anchor bolts are commonly used. These are usually not preloaded, have a minimum yield strength of 36 ksi, are extremely ductile, and can be welded (when S1 supplementary requirements are specified) and zinc coated.

The main type of high-strength structural bolt frequently specified in Caltrans contracts for steel joints in bridges, overhead sign support structures, and buildings, is designated as ASTM A325, and is available only in a heavy hex headed style and in diameters from ½" through 1-1/2". A325 bolts are almost always specified for major structures, and have a minimum tensile strength of either 105 or 120 ksi, depending on the bolt diameter; the minimum proof load is either 81 or 92 ksi. Because Caltrans wants to insure maximum plastic ductility of fasteners in structural joints in the event of a large earthquake, we specify A325 fasteners or F1852 tension control (TC) bolts almost exclusively. These can be zinc coated to insure a long life in corrosive coastal environments. While an A490 structural bolt is available, its lower ductility and inability to be zinc coated make it less desirable for use in coastal regions where long-term corrosion protection is vital and earthquakes are likely to occur.

Where larger sizes of high-strength fasteners or threaded rods having properties identical to those of A325 bolts are required, an A449 series of bolt and rod is readily available. Mechanical properties and chemical composition of this fastener are identical to those of A325 bolts; it is available in a wider variety of sizes, from ¼" to 3" diameters, can be ordered in a number of different head styles, and can be zinc coated.

Another type of high-strength bolt and threaded rod which is quenched and tempered alloy steel, and is called an ASTM A354 is also readily available; it comes in two grades - BC and BD and in diameters from ¼" to 4". Because the tensile strength of Grade BD fasteners may exceed 150 ksi, they cannot be zinc coated. These two grades of fasteners are frequently used for large bolts or rods, where high strengths are required.
Discussion of Various Topics Related to High-Strength Bolting

In the following paragraphs, various topics related to high-strength bolting are discussed:

**Types of Connections:**
A bolted connection may be designed as either a **bearing type** or a **slip critical** connection. Caltrans Standard Specifications require that all connections made with high-strength bolts shall be considered as (slip-critical) **friction-type** joints, and shall be tensioned as a typical slip-critical joint, unless otherwise designated on the contract plans or specifications. To ensure that adequate friction is developed between joint plies, faying (contact) surfaces of all high-strength bolted connections shall be free of rust, mill scale, dirt, grease or any other material foreign to the steel, before assembly. Specifications may require faying surfaces of bolted connections to be coated with either hot-dip zinc coating that has been hand wire brushed prior to assembly, or with an approved inorganic zinc primer prior to assembly.

**Bolt Holes:**
Bolt holes shall be either punched full size, drilled full size, sub-punched and reamed, or sub-drilled and reamed. Flame cutting of holes is not permitted. Reference Section 55-3.14A, “Bolt Holes” of the Caltrans Standard Specifications, and Table 1 in Section 3(c) of the RCSC Specification. For high-strength bolts, the diameter of standard bolt holes is 1/16" larger than the nominal diameter of the bolt shank.

**Thread Stickout:**
Determining and purchasing the correct bolt lengths for each different joint is the responsibility of the contractor. The amount of exposed thread beyond the outer face of the nut is called “thread stickout”. After high-strength bolts have been installed and tensioned, the permissible range of thread stickout permitted is from flush to not more than 1/4 inch beyond the outer face of the nut. Note: On TC bolts frequently there are a few partial threads adjacent to the groove where the splined tail breaks off. Therefore for TC bolts, thread stickout shall be measured from the outer face of the nut to the first full thread near the sheared end of the bolt (after the splined end has been sheared off).

**Hardened Washers:**
According to Section 55-3.14 of the Standard Specifications, one (flat) hardened washer (ASTM F436 or F436M) must be installed under the nut or bolt head, whichever is the element turned in tightening. A maximum of one additional hardened washer may be installed under the non-turning element of the fastener assembly to correct excessive thread stickout. Regardless of the method used to tension the bolt, or the type of connection design, lock washers are not an allowable substitute for hardened washers. Lock washers generally do not have adequate surface contact area, or sufficient corrosion resistance, and due to different steel chemistry and thinner protective coatings, corrode at a higher rate than adjacent steels. If the slope of the exterior face(s) of the connected parts exceeds 1:20 (approximately 3 degrees) relative to the bolt or nut face, a hardened beveled washer(s) meeting requirements in ASTM Specification F436 shall be inserted against each sloped surface.
Snug-Tight Condition:
No matter which of the approved tightening methods is used to tension high-strength bolts, the first step in tightening a joint is the same - bring all plies in the joint in contact by snuggling the fasteners. This requires all fasteners in a joint to be brought to a snug-tight condition using a systematic tightening sequence (starting from the center of the joint). "Snug-tight" is defined as the full effort of a person using a spud wrench or a few impacts of a pneumatic wrench applied to the nut. While snuggling fasteners, if plies are not initially in contact, care should be taken to avoid bending of the connection parts. Following snuggling, all plies in a joint must be in firm contact with each other.

Systematic Tensioning Pattern:
All bolts in a joint need to be tensioned in a systematic manner to produce a consistent even tension in each bolt. The tensioning pattern may be done in a crisscross or alternating fashion, and needs to be systematic to produce an even tension in all bolts. This tightening pattern should be used to bring bolts to the snug condition, and also to their final minimum required tension. In joints having a rectangular or square bolt pattern, bolts must be tensioned, starting at the center (most rigid part) of the joint and proceeding toward the free edges. For joints having a circular bolt pattern, a crisscross alternating pattern is appropriate. Writing a sequential number on each fastener in a large joint is a good way to insure all bolts are tensioned in their correct order, and none miss their turn. To insure that all fasteners are fully tensioned, this final tightening process may require more than one cycle.

Fastener Storage and Handling:
Storage: Regardless which of the approved methods is chosen to tension high-strength bolts, the condition of the fastener components (especially threads on both the nuts and bolts) is critical; all fastener components must be furnished and maintained in good condition until installed and final inspection has been performed. The original lubricant on all fastener components must be kept intact as supplied from the manufacturer, and all fastener components must be stored so that they do not get rusty or dirty. As soon as fastener containers are received at the job site, they must be stored in the original containers and protected from dirt and moisture. Containers should always be covered and be kept off the ground.

Handling: Fastener components from different lots must never be inter-mixed. Only those fastener components that are to be used in one shift are allowed to be removed from containers. Components not used during that shift must be returned to their original containers. The following information must appear on the outside of the shipping/storage containers:

1. Manufacturer’s name and address.
2. Contents (size and numbers).
3. Component lot number.
4. Rotational capacity lot number.

Note: All components of galvanized fastener systems (including bolts, nuts, washers, and DTIs) must be shipped and kept together as an assembly.
Lubrication:

Plain (black) Fasteners: Most plain or “black” fastener components have been heat-treated and all parts are coated by the manufacturer with a thin film of water-soluble (oily) lubricant that can be easily washed-off if exposed to moist elements. Prior to being installed, threads on bolts and nuts shall be oily to the touch, as received by the manufacturer. Should the bolts, nuts, or washers show signs of improper storage, such as rust and dirt accumulation, or absence of original lubricant on the threaded fastener components, this shall be cause for rejection.

Zinc-coated Fasteners: All zinc-coated nuts used on high-strength zinc-coated bolts must be coated by the manufacturer with a lubricant that is clean and dry to the touch, unlike black bolts that are furnished in an oily condition. To make identification easier, a colored dye, or an ultraviolet dye that can be seen with a black light, is required in the lubricant used for all galvanized nuts. No attempt should be made to tension a high-strength, zinc coated bolt whose nut has not been lubricated with a dry lubricant or properly “tapped” oversize. Without the proper lubrication applied on the nut threads and base, the fastener threads can gall, strip or seize, causing the bolt to shear off before the required bolt tension is reached.

Rotational Capacity (RoCap) Test:

At the job site, a rotational capacity test must be done on each lot of both plain and galvanized fasteners to confirm that the nut lubricant, and thread fit and condition as received from the manufacturer will result in proper tensioning without galling or stripping of threads or shearing of the bolt and that the bolt has good ductility. The quality and amount of lubricant and thread fit and condition can vary considerably between various manufacturers and fastener lots, therefore, the use of torque values obtained from charts or tables, or by testing other lots of fasteners is not allowed.

Reuse of High-Strength Fasteners:

Black A325 nuts and bolts may be reused once if allowed by the Engineer. However, neither A490 fasteners nor galvanized A325 fasteners shall be reused after they have been tensioned. Reuse of black A325 bolts and nuts should only be considered if they are in good condition (clean and with lubricant), the bolt threads are not excessively elongated (checked by spinning the nut by hand over the entire length of bolt threads), and each fastener lot is retested and passes the new pre-installation and rotational capacity tests. Once installed, neither TC bolt assemblies nor direct tension indicators (DTIs) may be reused.

Inspecting a Completed Bolted Joint:

Section 55-3.14, “Bolted Connections” of the Caltrans Standard Specifications states, “Bolt tension shall be verified by applying a job inspecting torque to nuts at locations selected by the Engineer. Inspection of each joint should be done as soon as possible, just after tensioning of all fasteners in a joint has been completed. At least 10% of the fasteners in each joint shall be checked. Verification of bolt tension shall be done by the Contractor in the presence of the Engineer and in such a manner that the Engineer can read the torque wrench gage or see gaps around the DTI during checking.” The job inspecting torque shall first be determined by the Contractor by testing five fasteners.
from each lot of bolts according to the procedure detailed in Section 9 (b)(3) of the RCSC Specification. To verify adequate tension in each of the fasteners selected for inspection in a completed joint, a suitable manual torque wrench (dial or digital read out only) is used to apply the job inspecting torque value to nuts (or bolt head, if turned). During the inspection, if any of the nuts turn, then 100% of the bolts in the connection shall be tested, and all bolts found to be under tensioned shall be tightened, and then re-inspected.

**Definition of Terms Commonly used in High-Strength Bolting**

Term's commonly used in high-strength bolting operations and specialized tools need to be clearly understood. The following is a list of terms and tools that are frequently used when dealing with high-strength bolts. Inspectors and construction personnel need to be familiar with these - what they are and how to use them. They include:

**Bolt tension calibrator:** A machine to measure bolt tensions (i.e., Skidmore-Wilhelm, or Norbar).

**DTI (direct tension indicator):** A device installed on high-strength bolts to monitor bolt tension. It must conform to requirements in ASTM F959/F959M.

![Typical direct tension indicator (DTI)](image)

**Electric installation tool for tension control (TC) bolts:** An electric tool used to install TC bolts.

**Faying surfaces:** Contact surfaces between structural plates within a high-strength bolted joint.

**Grip length:** The total thickness of all plies in a joint, including washers (distance between the underside of the bolt head and the inside face of the nut).

**Pre-installation testing:** A test series performed on each lot of fasteners, and at the beginning of a shift or job in which the installer demonstrates that with the actual
installation equipment and lot of fasteners to be used on the structure, he can properly install them and obtain the proper tension.

**Job inspecting torque:** A torque value established for each lot of fasteners, and used after a joint has been completed to check that bolts have been tightened to at least the minimum tension.

**Match marking:** A series of four marks made on the outer surface of a joint, after all fasteners in a joint have been snug tightened to monitor the amount the nut has been turned. Match marking is required if the turn-of-nut tensioning method is used.

**Mechanical deposited and hot-dip zinc coating:** Two different coating processes where zinc metal is applied to surfaces of fastener components.

**Rotational capacity (RoCap) test:** A preliminary test performed both by the manufacturer and at the job site on new fasteners to insure that there is proper lubrication on fastener threads and that there is adequate ductility.

**Snug tight:** The preliminary tightening stage that all fasteners in a joint must be taken to, that produces a tension in each fastener of about 10% of its final tension, and that brings all plies of a joint into firm contact.

**Tension Control (TC) fastener:** An alternative high-strength fastener system, which includes a nut, washer, and bolt with a splined end. It must conform to requirements in ASTM Specification F1852.

![Typical twist-off type TC fastener system](image)

**Thread stickout:** Amount of threaded bolt tail projecting beyond the outer face of the nut on an installed bolt.

**Torque multiplier:** A tool used to amplify tightening effort applied to tension (install) or inspect large high-strength bolts.

**Torque wrench:** A tool (dial or digital type permitted) used to tighten and inspect high strength bolts.
Inspection Procedure for Checking Tension in High-Strength Bolts

Introduction

Following is a brief summary of information that will aid personnel charged with the responsibility of inspecting high-strength bolted connections.

Phases of Inspection

There are three main phases of inspection necessary when high-strength fasteners are installed. These are: 1) Preliminary inspection and testing, 2) Inspection during high-strength fastener installation, and 3) Inspection after high-strength fasteners have been installed.

Phase 1 - Preliminary Inspection and Testing

1. Sampling components and laboratory quality assurance testing:
   Fasteners arriving at the job site should be sampled and tested by Caltrans to insure compliance to American Society for Testing and Materials (ASTM) requirements prior to use.

2. Pre-installation testing:
   After the satisfactory quality of fasteners is confirmed, the Contractor is required to perform pre installation testing. A calibrated bolt tension-measuring device (Skidmore-Wilhelm or Norbar) is required for this testing. This testing will demonstrate that the Contractor has proper equipment and knowledgeable personnel to correctly install high-strength fastener systems being used and can obtain the proper fastener pre-tension for all lots of fasteners to be used. This includes insuring that "snug-tight" tension is correct, impact wrenches and torque wrenches produce the adequate minimum tension, the correct size of calibrated wrench is used (it should take about 10 seconds to fully tension a fastener with a pneumatic or hydraulic wrench).

3. Rotational capacity (RoCap) testing:
   This test will verify that the quantity and quality of lubricant and numerous other variables affecting nut factors including thread fit and condition and coating type and thickness will allow fasteners to be tensioned without galling or stripping.

   When doing RoCap testing for all lots of fastener systems, a calibrated bolt tension measuring device (calibrated within the last year and traceable to the National Institute of Standards and Technology) shall be used. If fasteners are too short to fit in a bolt tension
meter and obtain a full nut, then the short bolt test procedure, as outlined in the current Caltrans Standard Special Provisions shall be used.

**Phase 2 - Inspection during High-Strength Fastener Installation**

The Inspector shall verify that:

1. The contractor has chosen an acceptable type of high-strength fastener systems as permitted in the contract. Acceptable types may include:
   a) Black bolt (ASTM A325) [with a suitable nut (ASTM A563) and washer (ASTM F436)].
   b) Zinc-coated bolt (ASTM A325) [with a suitable nut (ASTM A563) and washer (ASTM F436)].
   c) Tension control (TC) fastener assembly (ASTM F1852).
   d) Black or mechanically zinc-coated bolt (ASTM A325) [with a zinc-coated Type 325 DTI (ASTM F959), suitable nut (ASTM A563) and washer (ASTM F436)].

2. The contractor is using an approved method of installing high-strength bolts and maintains proper installation technique throughout the project. Approved installation methods include:
   a) Turn-of-nut.
   b) Calibrated wrench [impact wrench (pneumatic, hydraulic, or electric) with positive shut-off system or manual torque wrench - dial or digital only]
   c) Direct tension indicators (DTI’s) with black or mechanically zinc-coated bolts.
   d) Tension control (TC) fastener assemblies.

3. All high-strength bolts are installed with a flat hardened washer under the nut or bolt head, whichever is the element turned in tightening. A maximum of one additional hardened washer may be installed under the non-turning element of the fastener assembly so as to prevent the nut from “bottoming out” within the thread transition zone on the bolt shank. (Lock washers are not an allowable substitute).

4. A back-up wrench is used on each fastener to prevent the non-turning element (usually the bolt head) from turning while the fastener is being tensioned.

5. Installation tests have already been run for all equipment and workers involved, and for each different lot of fasteners used. If a different lot of fasteners or installation equipment is used, or new or different installation crewmembers begin work, new pre-installation tests must be conducted.

6. All fasteners in a joint are installed and tensioned at one time. (It is not acceptable to partially install some of the bolts in a joint, or to “stuff” bolts in a joint and let them remain loose for long periods untensioned).

7. All fasteners, no matter which type are used, shall first be taken to a “snug-tight” condition in a systematic tightening pattern, and then fully tensioned in stages using a systematic tightening pattern.
8. Faying surfaces of all plies in each joint and are in firm contact with each other after the members have been brought to a “snug-tight” condition (defined as the full effort of a person using a spud wrench or 12” flex-handle and socket).

9. No short cuts are taken in the proper installation procedure.

10. The fasteners are properly stored after each shift is done and are not allowed to be exposed to degrading elements (especially rain, fog, dampness, dirt, wind, or extreme temperatures).

**Phase 3 - Inspection after High-Strength Fasteners Have Been Installed**

After all fasteners have been installed and fully tensioned, a final inspection check is done to ensure the job was done properly. This includes 1) a visual check to confirm all plies of a joint are in firm contact, especially around bolts, 2) a check of tension in 10% of the fasteners in each connection (but not less than two) using a torque wrench (dial or digital gage) to confirm that minimum required bolt tension has been attained. This torque requires that a “job inspecting torque” be determined by the contractor for each different lot of fasteners used. A bolt tension calibrator should be used to establish the “job inspecting torque”. Bolt tensions in a joint should be inspected immediately after a joint has been completed. If nuts on any of the bolts checked during the inspection move prior to reaching the job inspecting torque, the remainder of the fasteners in the connection should be inspected and retensioned. Directions for establishing a job inspecting torque value and adjusting tensions in loose bolts are found in paragraph 9(c) of the RCSC Specification (Reference 4 of Attachment No. 3) and shall be followed. Methods for inspecting short bolts are contained in the Structural Bolting Handbook [SBH] (Reference 10 of Attachment No. 3) and require the use of DTIs. Joint seams shall be caulked if needed after fastener tensions in the connection have been inspected and the joint has been approved.

Besides checking bolt tension, the thread stickout should be checked to verify that it is between 0 (flush) and 1/4” beyond the outer face of the nut and that it is the same for all fasteners of similar length. An equal amount of thread stickout in each bolt is an indication that bolt tensions are consistent. Variations in bolt stickout are an indication that some fasteners may be undertensioned, or that joint plies are not in firm contact. Additionally, variations in the thread stickout could indicate that fasteners from different lots have been improperly utilized within the same joint.

It is the contractor’s responsibility to provide all required testing equipment and to perform the tests in the presence of the Engineer. If needed, the Division of Structure Construction has bolt tension calibrators and torque wrenches that are available for use by Caltrans personnel for quality assurance inspection.

Attachment No. 1 contains answers to frequently asked questions regarding high-strength fasteners. Attachment No. 2 is a list of specifications and references for high-strength bolting.
COMMON QUESTIONS AND ANSWERS CONCERNING HIGH-STRENGTH FASTENERS

1. Q. What is a Pre-Installation Test (also called an Installation Verification (IV) or Calibration Test)?
   A. The pre-installation tests are performed by the Contractor’s personnel using the same installation equipment and witnessed by the Engineer. At least three fasteners from each lot shall be tested in a bolt tension calibration device; if bolts are too short to be installed in such a device, then DTIs and the procedure outlined in the SBH (Reference No. 10 of Attachment No. 3) shall be followed. Rules and required testing frequency are described in Section 8(d) of the RCSC Specification (Reference No. 4 Attachment No. 3). These pre-installation tests will determine the ability of the Contractor’s personnel, equipment and procedures used in the actual construction to properly install the same high-strength fasteners used in the structure, according to the approved installation method specified or chosen.

2. Q. What is a Rotational Capacity (RoCap) Test?
   A. This test must be performed by the manufacturer/supplier according to the procedure in the Caltrans Standard Special Provisions. The Contractor is also required to perform the RoCap test at the job site using the same test procedure. This test will verify that the various lots of fastener assemblies when finally ready to be installed at the job site, are capable of withstanding a prescribed nut rotation without failure of the fastener (insures good ductility of fastener), that nuts have been properly lubricated in order to prevent seizing or galling of the threads, and that bolts and nuts are properly tapped and heat treated to prevent thread stripping.

3. Q. Do RoCap tests need to be done on TC bolts, and on fasteners on which DTIs have been installed?
   A. Yes.

4. Q. How many bolt assemblies are necessary for each test required?
   A. Pre-Installation Test: 3 minimum per lot (perhaps checked daily)
   Rotational Capacity Test: 2 minimum per lot
   Job Inspecting Torque determination: 5 minimum per lot (discard 2 test values)

5. Q. May any fastener components which have been used for any tests (including any Pre Installation, torque/ tension calibration, RoCap, or determination of Job Inspecting Torque) be reused?
   A. No.

6. Q. Why are torque values from torque-tension tables or formulas not permitted to be used to established proper torque?
A. Each lot of bolts, nuts, and washers is different (amount and type of lubricant, fit and roughness of threads, and thickness, roughness and type of corrosion-protective coating may vary). A standard table or formula relating torque and tension cannot accurately predict the many variables for a particular lot of fasteners; therefore, values chosen from tables or calculated from a theoretical formula are not acceptable. If an emergency situation arises, contact the fastener specialist at Caltrans Division of Materials Engineering and Testing Services (METS).

7. Q. Who determines the bolt length to be used in a connection?

A. It is the Contractor’s responsibility to provide the correct bolt length, unless the Designer has specified the length in the contract documents. Caltrans specifications require that the final thread stickout shall be a maximum of 1/4” and at least flush with the nut face. This insures full bolt thread engagement with the nut, and also provides a maximum number of threads (at least 3 to 5) within the grip length to insure good ductile capacity of the bolt if loaded in extreme conditions.

8. Q. If a bolt is too long, can additional washers be added?

A. One washer is required to be placed under the nut (or turned end) of the fastener. Caltrans allows only one additional washer to be added (under the unturned fastener end) as a minor adjustment for proper thread stickout.

9. Q. What should be done when fastener holes in joint plies are misaligned?

A. The Designer should be contacted and address this condition. It may be permissible to ream misaligned bolt holes up to 1/32” over the diameter normally required for a standard hole. Further reaming to permit use of the next size larger fastener may be acceptable if ample spacing, edge distance, and remaining net section are available in the joint and if allowed by the Engineer. Bolt holes shall only be modified by implementing the placement of holes as stated in Section 55-3.14 of the Caltrans Standard Specifications (Reference 1 of Attachment No. 3).

10. Q. Are warped plates allowed in a bolted joint?

A. Generally, firm contact between plies cannot be attained during the snugging operation, as required, when warped plates or improper fit-up are present in a bolted connection. Gaps around bolt holes and between plies of a friction-type connection are not acceptable. Proper fit-up of a joint prior to bolting is required. Heat straightening and shimming may be possible corrective measures, which can be used to correct warped plates prior to bolting. The Engineer, however, should use prudent judgement as to the acceptability of any material, given the design considerations. The Paragraphs 3.5.1.14 and 3.5.1.15 of the American Welding Society (AWS) Code D1.5 address the general issue of warped plates for mechanically connected joints and splices.

11. Q. What measures should be taken if Contractor does not handle or store fasteners properly?

A. Section 8(a) of the RCSC Specification requires that fasteners be stored properly. The Inspector at the job site should immediately notify the Contractor if any fastener
components are improperly handled or stored, and should document any instances of improper storage or handling in a diary. Proper handling and storage includes:

1) storing fasteners out of the weather in their original containers, off the ground, preferably in a closed building with a roof.
2) removing only as many fasteners from their original containers as can be installed during a work shift.
3) returning unused fasteners to their original containers in protected storage at the end of the shift, and
4) Not altering the original lubricant in any way from the way it was in the as-delivered condition. These requirements are all covered in Section 8(a) of the RCSC Specification.

12. Q. What should be done to fasteners that have become dirty or rusty, or have lost their original lubricant?

A. Fastener components that have not been properly stored may have been exposed to moisture, dirt, or dust, and as a result, may have had lost their original lubricant, or become dirty or rusty. Any changes in the original lubricant or thread condition on most fastener components, especially ones such as Tension Control (TC) fasteners, will affect their torque-tension relationship and how they function and may prevent adequate minimum tension from being attained. Fasteners which have become dirty, rusty or whose original lubricant has changed or been altered should be rejected by the Engineer. Whether the rejected fasteners can be restored to a satisfactory useable condition will vary depending on the degree of degradation and damage. If they are deemed salvageable, how they are to be restored to a useable condition and who can do the restoration will vary, depending on the type of fastener, the type of restoration work required, and the facilities available to the Contractor to rework the fastener components. Each case may require the Engineer to assess what facilities and capabilities the Contractor has available and whether he can do a satisfactory job.

Black fasteners are generally easier to clean and relubricate than zinc-coated ones, and in some cases, this operation can be done by the contractor. Light dust or dirt on fasteners can often be removed and fasteners may be relubricated. Rust on fasteners generally results from improper storage and exposure to moisture. The degree of rust damage and the effect of pitting is often more difficult assess and correct. The degree of rust and pitting will determine whether fasteners are salvageable. Light rust on the male threads can often be removed successfully, and fasteners may be relubricated and reused. Moderate to heavy rust that causes heavy pitting usually cannot be corrected and fasteners should be rejected. Rust on the internal threads of nuts is much more difficult to assess or remove; rusty nuts that cannot be thoroughly cleaned or restored should be rejected. Any restoration of damaged fasteners to their original condition and retesting is the responsibility of the contractor. If the Engineer deems that fasteners can be saved, the Contractor is responsible for assuring that the fasteners are thoroughly cleaned and uniformly relubricated, and then for performing additional pre-installation and rotational capacity tests at his expense, to prove the modified fasteners are acceptable.

Often the Contractor is not equipped to perform satisfactory cleaning and relubrication at the job site. Reworking fasteners that have been rejected due to excessive dirt, rust,
or lack of proper lubrication requires certain minimum facilities and equipment. These may include a suitable indoor site, equipment and manpower to 1) thoroughly clean the fasteners (i.e., remove all dirt and rust with appropriate cleaning solvent), 2) apply a uniform amount of suitable lubricant similar to what was originally applied to the fasteners, 3) maintain lot integrity of each fastener component requiring cleaning, and repackage each component and remark containers. The Contractor may wish to rework lots of rejected fasteners, but the Engineer needs to judge whether the Contractor is capable of doing a satisfactory job. If the Engineer does not feel that the Contractor is capable of satisfactorily cleaning and relubricating rejected fastener lots, the Engineer should advise him why.

Each component of a black fastener system is originally provided with a water-soluble oil to protect it from rust and to reduce friction when nuts are being snugged and tightened. For zinc-coated fasteners, only the nuts are lubricated with a special dyed, dry lubricant that is clean to the touch.

The type and quantity of lubricant applied by the original manufacturer to nuts on TC fastener systems is very critical and important. Therefore, any lot of TC fasteners that have been rejected for dirt, rust, or improper lubrication should only be reworked, retested, and recertified by the original manufacturer. Any alteration of the original lubricant by anyone other than the original manufacturer voids any certification or warranty made by the manufacturer of a TC fastener system, and should never be allowed. The Engineer should reject TC fastener systems failing to meet any of the required job site tests. The Contractor may return any rejected lot of TC fasteners to the manufacturer for reworking, retesting, and recertification.

The contractor should be aware that some types of lubricant used on fasteners cannot easily be removed from exposed fastener surfaces after installation and prior to painting the bolts. Some lubricants, such as beeswax, are not water-soluble, are extremely difficult to remove, and may require harsh solvents.

Additionally, lubricants should not be sprayed or applied to bolts that have already been installed in a connection, as the lubricant could seep into the faying surfaces of the joint and result in a loss of friction on faying surfaces of a slip-critical joint.

13.

Q. Can a Contractor alter (either add or remove) the original lubricant present on fasteners that he received from the manufacturer?

A. No. The original lubricant on the fasteners must not be altered. The manufacturer or responsible party for each fastener system has applied a certain amount and type of lubricant to each fastener in a lot, has tested each lot, and certified that the fasteners comply with all appropriate specifications and ASTM requirements. The original fasteners must be properly stored and maintained to preserve their original condition for all preliminary testing, installation, and tension verification checks on each completed joint. The contractor is not permitted to alter any original lubricant on high-strength fastener systems in any way, either for preliminary testing, or before or during installation. If a particular lot of fasteners should fail any of the preliminary tests required and done at the job site, the Engineer should reject the lot.
14. Q. May one type/grade of high-strength fastener be substituted for another?
   A. Generally not. Each grade/type has its own specific material composition, strength and dimensions. Because of smaller head dimensions and shank diameter tolerances, Society of Automotive Engineers (SAE) grades of fasteners (Grades 5 and 8) generally should not be interchanged with ASTM high-strength bolt types. Any request for substitution of a type or grade of bolt different from what was originally specified should be submitted to the Engineer for review prior to acceptance. For further information, contact the high-strength fastener specialist at the Division of METS.

15. Q. If the exterior surface of any steel member is sloped/angled greater than 1:20, can high-strength bolts be used?
   A. Yes; however, if the slope of the exterior face of any member exceeds 1:20 (about 2.9 degrees), relative to the washer-faced bearing surface of the bolt or nut face, a hardened beveled washer must be used between the exterior face of the sloped steel part and the bolt head and/or nut to compensate for the excessive slope, and reduce the slope(s) to less than 1:20.

16. Q. May high-strength bolts that were used/tightened once, be reused?
   A. Neither ASTM A490 nor galvanized A325 bolts may be reused. Only plain “black” A325 high-strength bolts should be considered for reuse. Reuse of any black A325 bolts and nuts should only be permitted if the Engineer determines the bolts are in good condition, the bolt threads have not been significantly elongated plastically (this can be checked by spinning the nut by hand over the entire length of bolt threads), and each lot of used fasteners is re-tested and passes the pre-installation and rotational capacity tests. All fastener components used for pre-installation or rotational capacity tests, or for determining job inspecting torques shall be discarded.

17. Q. May TC bolts and/or DTI’s be reused?
   A. No. Once installed and fully tensioned or used for any type of testing, they must be discarded.

18. Q. Where should a DTI be installed, which way do the bumps face, and how do I determine if the bolt has adequate tension?
   A. The correct preferred position of a DTI is under the bolt head, with the DTI bumps bearing against the underside of the hardened bolt head.Alternate positions are possible, but only when reviewed and approved by the Engineer. DTI bumps must never bear against any soft steel or any turned component. For bolts to have adequate tension, the gaps on zinc-coated DTIs need to be compressed to 0.005” or less (and also need to be greater than 0). The manufacturer's installation procedure should be followed. For more information, obtain appropriate installation instructions from either DTI manufacturer (see Sheet 10 of 10 of Attachment No. 2), or contact the fastener specialist at the Division of Materials Engineering and Testing Services.
19. Q. Who establishes the job inspecting torque and how is it determined?
   A. The Contractor determines the value for inspection torque by testing 5 fasteners, in the presence of the Engineer, in accordance with Section 9(b)(3) of the RCSC Specification. One high and one low reading are discarded, and the remaining three readings are averaged. The Engineer will record the job torque, determine which bolts in the joint shall be inspected, and witness the Contractor performing the actual checking. The procedure shall be performed in accordance with Section 9(b)(4) of the RCSC Specification.

20. Q. Can a contractor partially install (“stuff”) some or all fasteners loosely in a joint with the intent of coming back in the near future and completing his tightening operation?
   A. No, absolutely not! The RCSC Specification [Section 8(A)] clearly prohibits this practice. Only as many fasteners as can be completely installed and tensioned during a work shift can be removed from the storage area. This rule helps prevent fasteners from losing their lubricant and rusting before the tightening operation and tension verification check has been completed. Occasionally an uneducated or unscrupulous contractor will attempt to do this so that he can speed up his operation. Wise inspectors of course prevent this practice and explain why it is a bad thing to do.

21. Q. Why must hot-dip galvanized faying surfaces be hand wire brushed?
   A. Hand wire brushing is required in order to assure that the galvanized surfaces will have sufficient friction between the plates in contact. Using power driven wire brushes can result in polishing of the surfaces, which would reduce the friction between the surfaces and the capacity of the connection.

22. Q. Why is the thread stickout limited to ¼ inch beyond the face of the nut?
   A. If the thread stickout exceeds ¼ inch, the length of full threads within the grip of the joint is very short, and any elongation that occurs in the bolt during tightening is limited to a very small portion of bolt threads within the grip. Excessive thread stickout reduces the ductile capacity of the fastener during extreme unusual combined tensile and shear loading that might take place during an earthquake. In addition, if thread stickout is extremely large, it is possible that the nut would “bottom out” in the transition zone of the threads during tightening and prior to the full tension of the bolt being achieved. In this case, there may be insufficient tension in the bolt although high torque readings may give a false indication otherwise.

23. Q. What level of inspection is required in order to assure that the bolts have been installed properly?
   A. All stages of bolt installation and tensioning must be witnessed in order to assure compliance with the specifications. It is the responsibility of the inspector witnessing high-strength bolting at the job site to thoroughly understand and enforce Sections 2, 3, and 8 of the RCSC Specification. Verifying that the required final torque has been achieved, without witnessing that the snugging and tensioning operations were
performed properly, does not guarantee that, after the joint has been completed, each of the fasteners have the minimum tension required
LIST OF SPECIFICATIONS AND REFERENCES FOR HIGH-STRENGTH BOLTING:


Note: By reference in the Caltrans Standard Specifications, this RCSC Specification is made a part of all Caltrans construction contracts. The use of high-strength bolts in structural steel connections must conform to requirements in this specification, unless otherwise stated in the contract Standard Specifications or Standard Special Provisions.

5. The following Specifications within the Annual Book of ASTM Standards, Volume 01.08, "Fasteners":
   - ASTM A325 or ASTM A325M, *Structural Bolts*.
   - ASTM A563 or ASTM A563M, *Nuts*.
   - ASTM F436 or F436M, *Hardened Washers*.
   - ASTM F959 or F959M, zinc coated *Direct Tension Indicators*.
   - ASTM F1852, *Twist off type TC Bolt Assemblies*.

6. The following National Standard titled *Fasteners for Use in Structural Applications*, ASME B18.2.6-1996, published by the American Society of Mechanical Engineers.


Approved Methods of Tensioning High-Strength Bolted Connections

Introduction

The Caltrans approved methods for tensioning of common high-strength bolt systems consists of two standard methods and two alternative methods. The two standard methods are known as the Turn-of-Nut method and the Calibrated Wrench method. The two standard methods alternative methods are known as the Twist Off-Type Tension Control (TC) bolts and the Direct Tension Indicator method. The basic steps for field testing, installation and performing final inspection of the standard methods are very similar to those of the alternative methods.

All fastener systems must pass the required pre-installation test, calibration testing and rotational capacity before being installed in a structure. These tests are performed at the job site by the Contractor and are witnessed by the Engineer. The faying (contact) surfaces of all joint plies must be clean and flat. In many instances, a thin coating of qualified paint or hot-dip galvanized zinc coating may be allowed on faying surfaces. The components to be assembled must fit properly such that the faying surfaces between plies in a joint must have full contact when bolts are installed at a snug condition only. All fasteners in a joint must first be tightened to a snug condition before the final tightening process can begin. In both the snugging and final tightening process, a systematic pattern must be used to tighten each joint, using a crisscross sequence to insure that bolts are evenly tensioned. The final tensioning of A325 fasteners in slip-critical bolted connection must have the following minimum tensions:

<table>
<thead>
<tr>
<th>Nominal Bolt Diameter (Inch)</th>
<th>Minimum Tension Values for A325 Fasteners (kips)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual Minimum*</td>
</tr>
<tr>
<td>1/2</td>
<td>12</td>
</tr>
<tr>
<td>5/8</td>
<td>19</td>
</tr>
<tr>
<td>3/4</td>
<td>28</td>
</tr>
<tr>
<td>7/8</td>
<td>39</td>
</tr>
<tr>
<td>1</td>
<td>51</td>
</tr>
<tr>
<td>1 - 1/8</td>
<td>56</td>
</tr>
<tr>
<td>1 - 1/4</td>
<td>71</td>
</tr>
<tr>
<td>1 - 3/8</td>
<td>85</td>
</tr>
<tr>
<td>1 - 1/2</td>
<td>103</td>
</tr>
</tbody>
</table>

* Tension values equal to 70 percent of specified minimum tensile strength, rounded to the nearest kip as specified in Table 4, titled Minimum Fastener Tension for Slip-Critical Connections and Connections Subject to Direct Tension, $T_{m}$, of the Research Council on Structural Connections (RCSC) Specification for installing A325 fasteners in slip-critical connections.

** Values are used for calibration and pre-installation testing of all A325 high-strength fastener systems.
Once all fasteners in a joint have been fully tensioned, the joint is inspected. This requires 1) a visual check to insure that plies are in full contact, and thread stickout is in the proper range and is uniform for all fasteners, and 2) the job inspecting torque is applied to 10% of all fasteners in each joint. Joints should always be inspected immediately after being completed. These same basic procedures are common for all of the approved fastener systems.

**Standard Methods for Installing High-Strength Bolts**

The following discussion gives specific information about the two standard methods, Turn-of-Nut and Calibrated Wrench, allowed by Caltrans for installing and checking high-strength bolts:

**Turn-of-Nut Method**

1. **First snug tighten all bolts:**
   When the turn-of-nut method is used, each bolt in a joint must be first brought to a snug-tight condition. At this point, all joint plies should be in firm contact and match marking is done.

2. **Match mark all bolts:**
   When the turn-of-nut tightening method is used to install high-strength bolts, match marking is an important mandatory part of the tightening operation. After snugging, the turned element of all fasteners and the outer plate in the joint are match marked with a felt marker or marking pencil as shown below so that the installer and inspector can see that the nuts have been turned a sufficient amount to adequately tension the fastener. The pictures below show the four initial marks made, and the final position of the marks after tightening has been completed.

Note: The two lines on the outer steel ply indicate the start (S) and finish (F) point of the turned element.
In a properly match-marked joint, four marks are made at the turned end of each fastener. These are:

a) **A mark on one corner of the nut.** In addition to this mark on one corner of the nut, the outside of the socket used to tighten the nut is usually also marked with a line on its exterior which will be visible during the tightening operation. This mark on the outside of the socket should overlay the hidden mark on the nut corner.

b) **A start line, S, put on the outer steel ply** after all bolts have been snug tightened, and which aligns with the corner mark on the nut.

c) **A radial line through the end of the bolt tail,** in line with the start line on the outer steel ply and the nut mark. This radial mark through the bolt tail is important, as it gives a clear indication whether the bolt head turned during tightening (i.e. was properly backed up and kept from rotating during the tightening operation).

d) **A finish line, F, on the outer steel ply** at the appropriate amount of either 1/3, 1/2 or 2/3 of a turn clockwise past the S mark. The location of this (F) mark will vary and depends on the length of the bolt being tightened.

3. **Final Tensioning of Fasteners:**
The final tightening of the bolt is done as follows:

The socket is positioned so that its exterior mark is aligned with the start (S) mark on the outer steel ply and the mark put on the corner of the nut. The nut is then turned a prescribed amount, depending on the bolt length as shown in Table 5 of the RCSC Specification, until the initial mark made on one corner of the nut lines up with the final mark, F, on the outer ply of the joint. While the nut is being turned, the bolt head (or component of the bolt that will remain stationary) is held with a back-up wrench. The radial mark through the end of the bolt tail should still be aligned with the start mark, S, on the outer ply. If not, this is a clear indication that the bolt head turned during tightening, and the bolt tension may be below the minimum required. This completes the tightening.

The final position of the nut has an allowable tolerance of several degrees with respect to the final mark, F, depending on the size and length of the high-strength bolt. The following are acceptable tolerances:

<table>
<thead>
<tr>
<th>Bolt Length</th>
<th>Specified Turn</th>
<th>Tolerances Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 4D )</td>
<td>1/3 turn (120°)</td>
<td>( \pm 30° )</td>
</tr>
<tr>
<td>over 4D but ( \leq 8D )</td>
<td>1/2 turn (180°)</td>
<td>( \pm 30° )</td>
</tr>
<tr>
<td>over 8 D but ( \leq 12D )</td>
<td>2/3 turn (240°)</td>
<td>( \pm 45° )</td>
</tr>
</tbody>
</table>

4. **Final Check:**
Each joint should be inspected as soon as all bolts in the joint have been tensioned. The job inspecting torque check should verify that the bolts in a connection, tightened by the turn of-nut method, are not below the required minimum tension. Loose bolts may indicate that the bolt heads were allowed to rotate during tightening or the plies of the joint were not in full contact after snug tightening was completed. Therefore, when installing several bolts in a single joint, it is best to snug bolts in at least two tightening stages, and to use a systematic, alternating
tightening pattern, starting near the middle of the joint. This process will insure even tension in all bolts when complete.

If the members being joined cannot be brought into firm contact by snugging all bolts, verify that the bolt is the correct length, and that the plies are not misaligned, warped, and do not have burrs and/or irregularities. If plies are misaligned and bolt holes do not line up, the cause of the misfit must be determined and corrected. Further tightening of bolts will generally not correct gaps between plies and around the bolts after they have been snugged, and may result in severely elongated bolts and/or distorted plates.

**Calibrated Wrench Method**

This tensioning method may be used only when the Contractor’s equipment and installation procedures are calibrated daily for each diameter, length, grade, and production lot of bolts.

Torque and/or impact wrenches shall also be recalibrated when significant difference is noted in the surface condition of the bolt or nut threads, or washers.

Calibrated wrenches used for installation shall be set to provide a bolt tension not less than five percent in excess of the minimum tension.

All bolts shall be installed with hardened washers under the turned element, and shall be brought to a snug condition prior to applying the final pretension. Snug tightening shall begin from the middle (or most rigid part) of the connection and progress to the free edges. The tightening operation should be performed such that a systematic (crisscross or alternating) pattern is followed and the same consistent pattern is used for both snugging and final tightening. In some cases, proper tensioning of the bolts may require multiple cycles of systematic partial tightening prior to achieving adequate and even pretension in all the bolts.

When using a torque wrench, the Contractor is required and the Engineer should verify that the torque used on bolts in the structure is consistent with the values determined during the calibration/pre-installation tests done at the beginning of the work shift. In addition, the length of bolt should be checked for compliance to thread stickout limits.

Using a suitable wrench with proper torque capacity for the desired bolt diameter and grade is very important. When the correct size of pneumatic impact wrenches are used, it should take the operator about 10 seconds (after snugging) to achieve the required minimum bolt tension. This condition may result if the time required to tighten a bolt to the minimum required tension is very short (4 seconds or less). It is undesirable to use a wrench which is too powerful for tensioning a particular size or grade of bolt because it can easily result in a fastener whose threaded shank is severely necked down and has been plastically stretched near ultimate capacity; this removes most all of the bolt’s residual capacity to stretch and deform plastically without breaking. Using too small, or a worn or broken impact wrench, on the other hand, will not produce the minimum bolt tension required at the recommended 10-second tightening period. Excessive hammering on nuts which results when attempting to tighten a bolt with an inadequate impact tool, (or too little air pressure or air volume) can distort nuts and damage any protective coating, and will still not provide sufficient bolt tension.
The following steps are typical ones used to properly test structural bolts when using a calibrated wrench:

1. The contractor should do calibration/pre-installation testing on a minimum of three bolts, nuts and washers for each diameter, length, grade, and production lot to be used for that day. Testing shall be performed in an appropriate model bolt tension calibrator, according to requirements in the RCSC Specification, Section 8 (d)(2). The contractor must order and use the proper length bolt for a particular joint thickness. Bolts from the same lot that are used in the structure must also be used for verification testing. Additional spacers with the proper center hole diameter must be used to adjust the grip in the bolt tension calibrator, so that two to three threads of stickout is flush with the face of the nut when the nut is finger-tight. Final stickout permitted is between flush and 1/4" past the face of the nut. Appropriate steps, as outlined in the Structural Bolting Handbook should be followed for testing short bolts.

If short bolts are required in the structure and cannot fit into a bolt tension-measuring device, direct tension indicators (DTIs) shall be used to verify adequate tension in the bolts. To determine the appropriate calibrated gap for a particular lot of DTIs, the contractor must furnish longer bolts of the same diameter and grade to be used in the structure, and use them in a bolt tension-measuring device along with DTIs. Once an appropriate calibrated DTI gap is established, the same lot of DTIs shall be used to determine torque or impact wrench setting for the short bolts installed in steel plate shimmed to the appropriate thickness to simulate the actual joint. The short high-strength bolts shall then be tensioned in a simulated joint to produce the same calibrated gap verified with DTIs from the same lot (Reference Direct Tension Indicator Method) and a torque value read at that gap. The average of the three torque values shall be the installation torque for that lot of short bolts and for that day.

2. First, the bolt must be brought to a snug condition. For the initial snugging, a spud wrench, impact wrench, or bar and socket may be used. The same tools used when installing high-strength bolts in the actual structure shall be used during installation testing.

3. Final tightening should follow one of the two following procedures:
   a. Procedure to be used with impact wrench:
      1) Tighten the bolt by turning the nut until the wrench “cuts out”. Verify that the tension achieved, as read on the bolt tension-measuring device, is at least 1.05 times the required bolt tension.

      2) Check the degree of turns on the nut to make sure it does not exceed the corresponding tolerance for the “turn-of-nut” rotation. If the amount the nut has been turned has exceeded the maximum rotation allowed, discard the assembly. A new assembly should be tested with the impact wrench torque value adjusted to correspond to the required bolt tension.
3) The high-strength bolt assembly shall be tested to ensure that the minimum tension is attainable by the installation crew and the tools being used, without exceeding the prescribed rotation.

b. Procedure to be used for torque wrench:
   1) Tighten the bolt by turning the nut until the tension on the bolt is at least 1.05 times the required bolt tension.
   2) Reading the dial on the torque wrench, measure the moving torque while turning the nut an additional 5 degrees in the tightening (clockwise) direction. This is the torque value that should be recorded.
   3) The average of the three values or the highest acceptable value should be used as the installation torque for this day.

**Alternative Methods for Installing High-Strength Bolts**

The following discussion gives specific information about the two alternative methods, Twist Off-Type Tension Control (TC) Fastener Assembly and Direct Tension Indicator, allowed by Caltrans for installing and checking high-strength bolts:

**Twist Off-Type Tension Control (TC) Fastener Assemblies**

All twist-off type tension control (TC) fastener assembly consists of a unique bolt having a splined end, a nut and a hardened washer. The head on the bolt is commonly domed or rounded, but may be manufactured with a hex shape. TC fastener assemblies are produced and shipped by the manufacturers as a precisely engineered and fully tested system. They must comply with requirements in the ASTM F1852 specification. Lubricant types and amounts and machining tolerances may be different from one lot to another, and consequently, the component parts may not be interchanged or altered in any way. Each assembly lot must be used only in the as-delivered, factory-lubricated condition. TC fasteners are installed using an electric wrench having a specially designed planetary chuck. This planetary chuck has dual sockets that engage both the nut and splined tail of the bolt at the same time and turn one relative to the other chuck until the splined tail on the end of the bolt breaks off.

When inspecting a TC fastener installation to ensure that a quality job is being done, a number of things must be checked: the initial job-site testing of the fasteners must be carefully observed and checked, the installation procedure required by the manufacturer must be reviewed, proper storage of the fastener assemblies out of the elements must be constantly checked, the tensioning operation must be carefully monitored while in progress, and the final tension of at least 10% of the fastener assemblies must be checked using a job inspecting torque. Just verifying at the end of the job that the splined end of each bolt has sheared off is not adequate. This only signifies that at some time during installation, the assembly was subjected to a torque adequate to cause the shearing of the splined tail, not that the final tension in each fastener is adequate.

As with other fastener assemblies, representative samples of TC fastener must be taken from each lot and pre-installation tests run at the beginning of the job. Successful completion of these pre-installation tests will to assure that 1) the installer knows the proper procedure to install the fasteners and follows the manufacturer’s instructions, 2) the actual equipment he is using to
install the fasteners works properly, and 3) the fasteners provide the minimum tension as specified in Section 8 (d)(3) of the RCSC Specification.

When observing pre-installation tests, the following should be verified:

1. A representative sample of not less than three bolts of each diameter, length, grade, and lot shall be installed and tensioned by the Contractor at the job site in a bolt tension calibrator. The Contractor’s installer shall demonstrate that each assembly develops a tension not less than five percent greater than the tension required by Table 4 of the RCSC Specification.

2. When testing a TC bolt having a domed head in a bolt tension meter, a flat bushing specifically made for testing the domed tension control bolts must be used under the domed head. These special bushings are not normally furnished as standard parts with bolt tension calibrators. A different size of bushing is required for each bolt diameter being tested and can be purchased through the manufacturer (such as Skidmore-Wilhelm) of the bolt tension calibrator.

3. The TC fastener assembly shall be tested using one flat hardened washer (furnished by the manufacturer of the TC fastener assembly), under the nut (turned element).

   Each TC fastener assembly shall first be snugged using the same effort and snugging equipment that will be used on the final structure. During the snugging operation, if the spline breaks off, the bolt shall be removed and the bolt tension at snug tight checked. If the tension at snug tight exceeds 50% of the minimum required tension load, the effort used to snug tighten the fastener should be reduced and new pre-installation tests run.

4. If when running the pre-installation tests, the TC bolts are too short to fit into a bolt tension-measuring device, direct tension indicators (DTIs) must be used to verify the proper tension. First a calibrated DTI gap needs to be determined using three bolts long enough to fit into a Skidmore, tightening each until a load of 1.05 times the minimum preload value has been attained, and then, using tapered feeler gages, determining an average gap value for the compressed DTIs. Once an average calibrated gap value has been determined for three DTIs, the same lot of DTIs shall be used in conjunction with short TC bolts in a simulated joint having the same grip as in the actual structure. When short TC bolts have been installed (tail has been snapped), the DTI gap must be equal or less than the calibrated value determined by using long bolts in a Skidmore bolt tension calibrator. This confirms that the fastener tension is equal to or greater than the minimum required.

   Rotational capacity testing is also presently required by Caltrans for this system and for this testing, conventional installation tools should be used (to prevent the splined end from being sheared off).

When tension control fastener assemblies are installed in a structure, the following procedure must be followed:
1. TC fastener systems must always be properly stored out of the weather and maintained in the original condition as supplied by the manufacturer, or else the fastener tension will change and problems will arise.

2. When assembling a TC-bolted connection as with other fastening systems, a TC fastener assembly must be installed in each of the holes of the connection.

3. The bolts shall be systematically snugged (preferably using a conventional tightening tool commonly used for a snugging operation – not an electric TC fastener installation tool) to bring all plies of the joint into firm contact and without yielding or fracturing the splined tails of the fasteners. If the TC fasteners are incorrectly installed and full tensioned in a single continuous operation, they will give a misleading indication to the inspector that all the fasteners are properly tightened. However some of the initially tensioned fasteners may not be. If the plies of the joint are not in firm contact after snugging bolts, then the cause needs to be determined and corrected.

4. Finally during the final tightening (tail snapping operation), each assembly is tightened following a systematic, crisscross pattern starting from the center of each joint.

After installation has been completed and there is any question about whether there is adequate tension in the TC fasteners, the following should be done:

- Uniform and proper thread stickout should be checked. After the spline has broken off, a partially threaded section (approximately 1/8") typically remains; these partial threads at the broken end of the TC bolt are not to be considered as part of the thread stickout. Therefore after installation, the actual length of the projecting bolt stub should extend at least 1/8" beyond the outer face of the nut to a maximum of 3/8".

- The contractor should determine a job inspecting torque value.

- A minimum of 10% of the TC fasteners must be checked using a torque wrench for adequate minimum preload.

**Direct Tension Indicators (DTIs)**

A direct tension indicator (DTI) is a special device used in conjunction with each high-strength bolt to insure proper tension in the bolt has been attained. DTIs have a number of evenly spaced bumps protruding on one side that are compressed against a hardened surface in a controlled manner. As the bolt is tightened, the bumps are crushed. When they reach a prescribed crushed height (0.005" for bridge and sign structures), the high-strength bolt has been sufficiently tensioned.

Basic steps for field testing of DTIs in a bolt tension calibrator (e.g. Skidmore) are as follows:
1. Test three DTIs of each diameter, grade and production lot, plus three sample bolts, nuts and washers. It is not a requirement that this test be conducted on each separate lot of bolts and nuts. Each DTI, along with sample fasteners, is called a “test assembly”.

2. Testing DTIs in a bolt tension calibrator requires the use a special flat bushing and flat hardened washer. The bushing available from the bolt tension calibrator manufacturer (Skidmore-Wilhelm) must be used under the nut (or turned element). DTIs are normally placed under the bolt head, with the bumps bearing directly against the underside of the bolt head (non-turned element).

3. Add spacers and washers under the nut, as necessary, to adjust thread stickout from zero to two threads beyond the face of nut, when the nut is finger-tight.

4. Testing or installing DTIs in a bolt tension calibrator is a two-person operation. While tightening the nut, the bolt head must be prevented from turning.

5. First snug the bolt with a DTI as will be done in the actual structure. In the snug condition, no gap on a DTI may be less than 0.015". Use a 0.015" feeler gage to check for gaps less than 0.015" at snug.

6. Then tighten the nut until the bolt tension as read on the bolt tension calibrator is equal to 1.05 times the minimum required bolt tension. Check how many gaps around the perimeter of the DTI the tapered feeler gage enters. It should enter 1/2 or more of the total number of gaps around the DTI.

7. Continue tightening the fastener until the number of gaps which a 0.005" feeler gage won’t enter equals or is greater than that shown in Column 4 of the table on Sheet 10 of 11 in Attachment 2 of BCM 170-2.0. The tension in the bolt as measured by the calibrator must be less than the minimum tensile strength of the bolt.

On the actual structure, verify that bolt heads are held stationary with a back-up wrench when nuts are being turned. In addition, check that all of the bolts in the connection are systematically snugged starting from the center of each joint, and the faying surfaces of all joint plies are in firm contact prior to performing the final tensioning of the bolts.

When installing a DTI, the protrusions shall always be positioned so that they bear against a hardened surface (normally the underside of the bolt head) that must be held stationary as the bolt is being tightened. Before bolts are permitted to be installed in the structure, a representative sample of at least three assemblies, of each diameter, grade, and lot shall be tested in a calibrated bolt tension-measuring device. The test assembly shall include a flat, hardened washer under the turned element. By doing the pre-installation test (also called field test in ASTM F959) the installation crew shall demonstrate that, using the same bolts, snugging and installation tools, and techniques to be used on the actual structure, and compressing the DTI protrusions to an average gap of 0.005", it will achieve a tension no less than 1.05 times the specified minimum bolt tension. This requirement is in Section 8 (d)(4) of the RCSC Specification.
When high-strength bolts are installed in the structure in conjunction with DTIs, the fasteners shall be installed in all holes of the connection and tightened starting from the center (most rigid part) of a joint in a systematic pattern, until all plies of the joint are in firm contact.

When an actual joint is being assembled, the fasteners should be checked to ensure they are uniformly snug. A snug tight condition is indicated by partial compression of the DTI bumps. After snugging bolts, any DTI which has been compressed such that any gap less than 0.015" shall be removed and replaced with a new indicator.

Once all fasteners in a joint have been snugged, the fasteners shall then be systematically tensioned, as was done during snuggling. In some cases, proper tensioning of the bolts may require multiple cycles of systematic partial tightening prior to achieving even final bolt tension in order to bring bumps in all DTIs to a uniform gap. When inspected after installation, the minimum number of gaps refusing a 0.005” tapered feeler gage shall be as follows: If all gaps have been reduced to 0 after installation has been completed, the DTI shall be removed and a new DTI and fastener installed.

DTIs should not be used when over-sized holes are present, unless approved by the Engineer and manufacturer of the DTI. If approved, special flat hardened washers must be used.

If a DTI cannot be placed under the bolt head (stationary element) due to unusual field conditions, contact the high-strength fastener specialist at the Caltrans Division of Materials Engineering and Testing Services (METS) for assistance. For DTIs approved for installation under the turned element, special hardened washers with a small inside diameter may be necessary, and can be obtained from the DTI manufacturer.

Attachment No. 1 contains answers to frequently asked questions regarding associated tools and equipment used in high-strength bolting.
COMMON QUESTIONS AND ANSWERS CONCERNING TOOLS USED IN HIGH-STRENGTH BOLTING

Bolt Tension Calibrators:
1. Q. What type of equipment should be used to perform torque and tension checks on high-strength fasteners?
   A. Skidmore-Wilhelm (models MS, M, or ML) or Norbar bolt tension calibrators are assigned to some ACM's to do quality assurance testing.

Typical bolt tension calibrator and steel case
The appropriate model Skidmore should be used, depending on the shortest length bolts to be tested (see chart below).

<table>
<thead>
<tr>
<th>Nominal Bolt Size,</th>
<th>Model of Bolt Tension Calibrator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
</tr>
<tr>
<td>1/2 – 13</td>
<td>2.25</td>
</tr>
<tr>
<td>5/8 – 11</td>
<td>2.50</td>
</tr>
<tr>
<td>3/4 – 10</td>
<td>2.75</td>
</tr>
<tr>
<td>7/8 – 9</td>
<td>3.00</td>
</tr>
<tr>
<td>1 – 8</td>
<td>3.000</td>
</tr>
<tr>
<td>1 1/8 – 7</td>
<td>4.750</td>
</tr>
<tr>
<td>1 1/4 – 7</td>
<td>5.000</td>
</tr>
<tr>
<td>1 3/8 – 6</td>
<td></td>
</tr>
<tr>
<td>1 1/2 – 6</td>
<td></td>
</tr>
<tr>
<td>Max. Tension Capacity</td>
<td>80K max.</td>
</tr>
<tr>
<td>Weight</td>
<td>65 lbs. +</td>
</tr>
</tbody>
</table>
There are also some older Norbar bolt tension calibrators available; check to make sure equipment has been calibrated within the past year, and is within the required accuracy limits.

2. Q. Are all of the necessary parts available with the basic bolt tension calibrators?
   A. Probably not. To test domed head TC bolts and all DTIs, a special set of flat bushings is required which is not normally furnished with the standard calibrator equipment. Flat bushings are readily available from the Skidmore-Wilhelm Mfg. Co. and are shown below.

### Special Flat Bushings Required to Test TC Bolts and DTIs

<table>
<thead>
<tr>
<th>Nominal Bolt Size, inch</th>
<th>Model of Bolt Tension Calibrator</th>
<th>M and ML Bushing #/Approximate Cost</th>
<th>MS Bushing #/Approximate Cost</th>
<th>H Bushing #/Approximate Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>MT-608</td>
<td>$15.00 ea.</td>
<td>MS-608 $30.00 ea.</td>
<td>HT-708 $20.00 ea.</td>
</tr>
<tr>
<td>5/8</td>
<td>MT-610</td>
<td>$15.00 ea.</td>
<td>MS-610 $30.00 ea.</td>
<td>HT-710 $20.00 ea.</td>
</tr>
<tr>
<td>3/4</td>
<td>MT-612</td>
<td>$15.00 ea.</td>
<td>MS-612 $30.00 ea.</td>
<td>HT-712 $20.00 ea.</td>
</tr>
<tr>
<td>7/8</td>
<td>MT-614</td>
<td>$15.00 ea.</td>
<td>MS-614 $30.00 ea.</td>
<td>HT-714 $20.00 ea.</td>
</tr>
<tr>
<td>1</td>
<td>MT-616</td>
<td>$15.00 ea.</td>
<td>MS-616 $30.00 ea.</td>
<td>HT-716 $20.00 ea.</td>
</tr>
<tr>
<td>1 1/8</td>
<td>MT-618</td>
<td>$20.00 ea.</td>
<td>MS-618 $35.00 ea.</td>
<td>HT-718 $20.00 ea.</td>
</tr>
<tr>
<td>1 1/4</td>
<td>MT-620</td>
<td>$20.00 ea.</td>
<td>MS-620 $35.00 ea.</td>
<td>HT-720 $20.00 ea.</td>
</tr>
<tr>
<td>1 3/8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1/2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The model MS Skidmore bolt calibrator was developed to test bolts which are shorter than can be tested in the Models M or ML calibrators. In Skidmore-Wilhelm’s development/design process, the front plates of the Model MS were made thinner. Skidmore-Wilhelm has pointed out that when testing TC bolts, the thinner MS plates will dish slightly when tensioning the fastener. This dishing may reduce the contact area between the nut face and washer, and may cause a slight increase in the torque required to rotate the nut. This may cause a reduction in tensile load read on the bolt calibrator dial at which the spline shears off. Skidmore recommends ordering and using the thicker plates for the MS model if the tension control fasteners are not meeting minimum tension requirements by 5 to 10%. The Skidmore-Wilhelm Mfg. Co. should be contacted immediately (216-481-4774) if use of their Model MS calibrator results in too low tension values when the spline shears off.

In addition to bushings, spacers of the proper length and inside diameter may also be required when testing long bolts to adjust thread stickout to between 0” (flush) and 1/4”.

3. Q. Should Caltrans provide the bolt tension calibrator for use on construction projects?
   A. No. The Contractor is to perform all pre-installation testing, rotational capacity testing, and inspection of completed joints at the job site, and shall provide all
necessary tools and appropriate calibrated equipment, including torque wrenches (dial or digital readout only), bolt tension calibrators, impact wrenches, sockets, and torque multipliers to do so. The Engineer is to witness preliminary calibration, testing, select fasteners to be inspected in a completed joint and witness joint inspection. Caltrans has Skidmore-Wilhelm bolt tension calibrators available for use by Caltrans employees doing quality assurance inspection.

4. Q. How often should the bolt tension calibrator be recalibrated and adjusted and who is qualified to do this?
   A. Recalibration and adjustments should be performed at a minimum annually, by a certified testing facility using equipment that is traceable to the National Institute of Standards and Technology at the Contractor’s expense. Required accuracy, after calibration is within ±2% of the actual load. The following is a list of acceptable laboratories that are qualified to recalibrate and repair bolt tension calibrators:

<table>
<thead>
<tr>
<th>Manufacturers* and Laboratory Test Facilities for Bolt Tension Calibrators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Almay Labs</td>
</tr>
<tr>
<td>1415 Newton St.</td>
</tr>
<tr>
<td>Los Angeles, CA 90021</td>
</tr>
<tr>
<td>Phone: (213) 746-1555</td>
</tr>
<tr>
<td>2) Technical Services Group</td>
</tr>
<tr>
<td>P.O. Box 250</td>
</tr>
<tr>
<td>Alameda, CA 94501</td>
</tr>
<tr>
<td>Phone: (510) 522-8326</td>
</tr>
<tr>
<td>3) Skidmore-Wilhelm *</td>
</tr>
<tr>
<td>Manufacturing Co.</td>
</tr>
<tr>
<td>442 South Green Rd.</td>
</tr>
<tr>
<td>Cleveland, OH 44121</td>
</tr>
<tr>
<td>Phone: (216) 481-4774</td>
</tr>
</tbody>
</table>

   ** Local representative and calibration/repair center for Norbar equipment

5. Q. Where can a field Engineer get more information about bolt tension calibrators?
   A. Information and literature can be attained directly from the manufacturers or their representatives (see the listing in Question 4 above).

**Torque Wrenches:**

1. Q. May the Contractor perform testing or installation of high-strength bolts with a “click-type” torque wrench?
   A. No. Either a dial or digital gauge torque wrench is required to accurately determine installation torque, perform RoCap tests, and determine job inspecting torque for inspection of a completed joint. When performing a RoCap test or determining proper job inspecting torque at the jobsite, the contractor cannot read the particular torque value at a given bolt tension when a click-type torque wrench is used. Also, generally
the accuracy of a click-type torque wrench is not adequate to meet Caltrans accuracy requirements.

Acceptable types of torque wrenches

2. Q. What is the “best practice” when using torque wrenches?
A. A torque wrench is properly used when the following concepts are followed:

- Proper installation procedures must be verified and torque values reestablished at least once each working day for each bolt diameter, length, and lot. A hardened washer must be used under the nut (turned end).

- Always use a proper size torque wrench with adequate torque capacity or use a smaller wrench in conjunction with a torque multiplier, when necessary. Never use a torque wrench that is too small for the job. If the torque limit of a wrench is exceeded, the wrench is generally ruined and cannot be repaired.

- Operating a large torque wrench is generally a two-person operation - one person to pull on the handle and one to read the dial. The person pulling should use a smooth motion. An extender handle of adequate length should be utilized to reduce effort required to turn nuts and to insure a smooth turning motion (A “jerky” motion generally results when the lever arm is too short). Difficulty attaining adequate tensile loads on large high-strength bolts (i.e., 1-1/8" to 1-1/2") generally indicates the need to use a torque multiplier in conjunction with a torque wrench.

- It is generally not good practice to use a torque wrench to undo a bolt. A torque wrench is a delicate instrument, and the mechanism of some is not designed to be loaded in the reverse (counter-clockwise) direction. It is much better to use an impact wrench or breaker bar for loosening or unloading tensioned fasteners.

- When performing RoCap tests, never use a torque wrench to perform the final portion of the test that requires that the bolt be rotated a specified large number of turns. This portion of the test may require a torque level that will severely overload a torque wrench normally used for routine fastener tensioning and cause irreparable damage.
A breaker bar or pneumatic wrench in combination with a torque multiplier should be used for this last phase of the RoCap test.

3. Q. Where can I obtain information about or purchase a satisfactory torque wrench?
   A. From one of the companies from the following chart:

<table>
<thead>
<tr>
<th>Torque Wrench Manufacturers* and Calibrator Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1)</strong> Proto*</td>
</tr>
<tr>
<td>14117 Industrial Park Blvd., N.E. Covington, GA 30209</td>
</tr>
<tr>
<td>Phone: (770) 787-3800</td>
</tr>
<tr>
<td><strong>4)</strong> Armstrong Tools*</td>
</tr>
<tr>
<td>5200 W. Armstrong Ave.</td>
</tr>
<tr>
<td>Chicago, Illinois 60646</td>
</tr>
<tr>
<td>Phone: (312) 763-3333</td>
</tr>
<tr>
<td><strong>2)</strong> Snap-On*</td>
</tr>
<tr>
<td>6632 Fig St., Unit B Arvada, CO 80004</td>
</tr>
<tr>
<td>Phone: (888) 762-7972</td>
</tr>
<tr>
<td><strong>5)</strong> Advanced Witness Series, Inc.</td>
</tr>
<tr>
<td>910 Bern Ct. #100 San Jose, CA 95112-1237</td>
</tr>
<tr>
<td>Phone: (408) 453-5070</td>
</tr>
<tr>
<td><strong>3)</strong> Mitutoyo*</td>
</tr>
<tr>
<td>16925 Gale Ave. City of Industry, CA 91745</td>
</tr>
<tr>
<td>Phone: (818) 961-9661</td>
</tr>
<tr>
<td><strong>6)</strong> Mountz, Inc.</td>
</tr>
<tr>
<td>1080 North 11th Street San Jose, CA 95112</td>
</tr>
<tr>
<td>Phone: (408) 292-2214</td>
</tr>
</tbody>
</table>

4. Q. How often should a torque wrench be recalibrated and adjusted?
   A. At least once a year. It must be recalibrated and adjusted more often if dropped/mishandled.

5. Q. Who is qualified to perform the recalibration and adjustments, and what information/certificates are required?
   A. A certified testing facility must have calibration equipment traceable to National Institute of Standardized Testing (NIST) standards and must perform calibration checks and any adjustments on equipment. If equipment cannot be adjusted so that its accuracy is within specifications, it is not permitted to be used.

6. Q. What accuracy is required for a torque wrench to be considered acceptable?
   A. Accuracy of torque wrenches shall be within 2 percent of the actual torque value, with a minimum of 4 verification readings evenly spaced over a range of 20 to 100% of full scale. If there are any questions about the accuracy of the contractor’s torque wrench, a copy of the latest calibration check after any adjustments were made should be required.

7. Q. What do the terms break torque and moving torque mean?
   A. Break Torque: The torque value required to initially start a nut in motion from a stationary position.
      Moving Torque: Torque measured while the nut is in motion.

8. Q. Does Caltrans provide torque wrenches?
   A. Yes, but only for Caltrans quality assurance testing or checking Contractor’s values, not for work that is required to be done by the Contractor.
9. Q. When using the calibrated wrench installation method, why is it necessary to determine an installation torque value for each lot of fasteners every day?  
A. Thread conditions (roughness, coating type and thickness, and pitch diameter), the type and amount of lubricant, and storage and weather conditions may be different for each lot of bolts. These variables can have a huge effect on the relationship between torque and tension, especially when using the calibrated wrench method to install high-strength fasteners. Therefore the RCSC Specification requires that certain installation procedures must be performed and appropriate installation torque values must be determined on a daily basis, using fastener samples from each lot of bolts to be installed in the structure.

**Calibrated Wrenches:**

1. Q. How often must a calibrated wrench be adjusted and checked to produce proper bolt tension?  
A. At a minimum, the tension value produced by a calibrated wrench must be checked daily at each job shift for each bolt diameter and length to insure the cutoff setting is correct. If a different lot of fasteners is used, or operators, length of air lines, tool being operated, or thread conditions on the fasteners change, the calibration of the wrench must be checked and perhaps recalibrated.

2. Q. Which types of calibrated wrenches are acceptable?  
A. Besides a dial or digital torque wrench, a pneumatic, hydraulic, or electric wrench with an adjustable control unit which can be set to positively shut off at the desired torque is acceptable. A standard impact wrench without a positive cutoff is not acceptable.

3. Q. What are some equipment variables that effect the final product?  
A. Compressor size and condition, the length, number, and size of air lines, air volume demand of other equipment being operated at same time, condition and size of pneumatic impact wrench, and adjustment settings all can affect torque output of an impact wrench.

4. Q. Why does an impact wrench need to be adjusted and checked so frequently?  
A. Experience has indicated that operator “feel”, condition and size of compressors, air lines, air tools, air pressure variations and the number of tools run simultaneously on a single manifold are all variables that account for differences of bolt tension at the
snug tight condition, as well as the final tension in the high-strength bolts. The influence of these numerous factors must be checked to insure consistent and accurate bolt tension.

5. Q. Why should it take approximately 10 seconds to fully tension A325 bolts?
   A. A wide variety of brands of calibrated impact wrenches with varying torque capacities are available and appropriate for various sizes of high-strength bolts. When using the correct size of impact wrench with A325 bolts, it takes about 10 seconds (after snugging) to achieve the minimum required bolt tension. Using too large of a calibrated wrench for a given size of bolt can result in the threaded shank of the bolt being elongated with the applied stress far exceeding the elastic limit (well into the plastic zone), resulting in very little remaining ductility. Using an impact wrench which is too small or worn will result in low fastener tension, wasted time and noise during installation, and excessive hammering on nut, causing damage to any protective coating.

**Torque Multipliers:**

1. Q. What is this tool and when is it used?
   A. The torque multiplier is a tool that amplifies a small input torque by gear reduction to produce a large output torque. It is commonly used in conjunction with a torque wrench, to reduce the tightening effort needed for testing, installing, and inspecting larger sizes of high-strength bolts. By using a multiplier, less tightening effort can be applied using smaller input wrenches and tools, and smoother and safer tightening operation results. This prevents accidents caused by dangerous but commonly used installation practices of overexertion on a short handled manual torque wrench, or hanging on the end of a long, heavy cheater handle. Also by using a multiplier, permanent damage to smaller torque wrenches which can easily be stressed above their minimum torque rating, can be avoided. An anti wind-up ratchet is a desirable optional feature available on many of the better multipliers.

   ![Acceptable types of torque multipliers](image)

2. Q. Are different sizes available?
   A. Yes. Multipliers are available with various multiplication factors and input and output drive sizes. (E.g., 1:4, 1:5, 1:10, 1:15, 1:25, 1:75, 1:100, etc.)

3. Q. Who manufactures and sells multipliers?
   A. Check the catalogues from following companies: Mountz, Norbar, Proto, Snap-On, and Advanced Witness Series, Inc. Phone numbers for these companies are included in the charts shown in Question 4 on Sheet 3 of 11, Attachment No. 2 of BCM 170-
2.0, and in Question 3 on Sheet 5 of 11, Attachment No. 2 of BCM 170-2.0. For further information contact Dan Thomas in the Division of Structure Construction Headquarters or the fastener specialist at the Division of Materials Engineering and Testing Services.

4. Q. How often does a multiplier need to be recalibrated?
   A. At least once a year. When a torque wrench is used in conjunction with a torque multiplier, the two should always be used together with a bolt tension calibrator to determine an accurate input torque/bolt tension relationship for installing and inspecting fasteners.

Electric Installation Tools with combo Spline/Nut Socket for Installing (TC) Bolts:

1. Q. Do all manufacturers of electric installation tools offer the same size of tool?
   A. No, not all electric tools (called Shear Wrench Tools) for installing TC fasteners have the same capacity. Normal electric installation tools require from 11 to 15 inches of working space. Some tools are designed with a right-angled drive for working in tight quarters and have a working clearance of about 7-1/2 inches. In addition, different manufacturers of electric installation tools and sockets for TC fasteners may produce spline sockets with slightly different internal dimensions. Variations in spline dimensions of TC bolts made by different fastener manufacturers and the actual thickness of zinc coating on the spline section may vary slightly. These conditions can prevent a tool socket from fitting onto the fastener spline. A tight socket clearance or heavy zinc coating on the spline may also prevent easy ejection of the broken spline from the inner socket.
2. Q. What variables can affect the satisfactory installation of a TC bolt assembly?
   A. This system is dependent on close manufacturing tolerances (bolt and nut thread dimensions, groove dimensions at tip), steel chemistry, amount and type of nut lubricant, and consistent heat treating all can affect the final bolt tension. Typical steps required with all other high-strength bolt operations, including proper joint fit, snug tightening, tensioning all fasteners evenly in an alternating pattern, are also required when installing TC bolts.

3. Q. Do you need to check the final TC bolt tension with a calibrated torque wrench when fastener installation has been completed?
   A. Yes. Like any normal high-strength bolted connection, joints can be improperly fit and TC bolts can be improperly installed. Plates in joints must flat, should have full bearing after snugging, and all fasteners in a joint must first be evenly snug tightened, and then fully tensioned in stages and in a patterned sequence, or else like any other fastener, some of the TC bolts initially tightened will be loose after the joint has been completed. As required with other tensioning methods, a job inspecting torque must be established and 10% of bolts in each connection (or a minimum of 2 bolts) should be checked for adequate tension immediately after tightening of a joint has been completed.

4. Q. How does one know if TC bolts have been tightened to at least the minimum required tension?
   A. By performing pre-installation tests on each lot, diameter, and length of fasteners, observing that proper installation procedures are followed, and inspecting 10% (or a minimum of 2) bolts in each joint using the appropriate job inspecting torque value.

5. Q. Should all TC bolts in a joint be taken to a snug condition?
   A. Yes. First, all TC fasteners should be first snugged in a connection without snapping off the splined tails before any final tightening is done. Use of a standard impact wrench, torque wrench, or spud wrench is recommended for the snugging operation. If the snugging operation is skipped, and instead, all TC fasteners are fully tensioned without first drawing all plies together, fasteners initially tightened may be loose. If the splined end of a TC bolt has been sheared off, it merely signifies that at some time during the tightening operation, the fastener has been subjected to sufficient torque to cause shearing of the spline. It does not necessarily mean that the final tension is adequate. An uninformed inspector who looks at a completed job may not be aware that just because the tails of all TC fasteners are broken, it does not necessarily mean that all TC fasteners have adequate tension.

**Tapered Feeler Gages Required for Measuring Gaps between Bumps on Direct Tension Indicators (DTIs):**

1. Q. Why do feeler gages need to be tapered in order to inspect for proper gap in an installed DTI?
   A. Feeler gages used for inspecting DTIs must be tapered and have narrow tips so that they can fit into each gap between closely spaced DTI bumps.
2. **Q.** Which thicknesses of tapered feeler gages are used for inspecting DTIs installed on bridge or sign structures: 0.015" or 0.005"?

   **A.** Two thicknesses of these special tapered feeler gages, 0.005" and 0.015", are commonly used for inspection. The Contractor should have them available and use them during pre-installation testing, installation, testing of short bolts, and determination of job inspecting torques. Caltrans inspectors should also have them handy. The 0.015" feeler gage can be used to inspect DTI gaps after snugging. The 0.005" tapered feeler gage is used to verify adequate DTI crushing during final tensioning for bridge and sign structures. After installation of a DTI is complete, the 0.005" feeler gage tip must be refused in at least 1/2 of the gaps, but all the bumps must not be fully compressed to a “0” gap. A whole set of 26 tapered feeler gages is also necessary when determining a “calibrated gap” for performing pre-installation tests and a job inspecting torque for short bolts (see pp 17 & 18 of the *Structural Bolting Handbook*).

3. **Q.** Where can I obtain tapered feeler gages?

   **A.** The 0.005" and 0.015" tapered feeler gages are available from either DTI manufacturer (see Question 5). Sets of tapered feeler gages (26 leaves) are available from Starrett (model 66T) [phone: 617-249-3551]; Mitutoyo (model 950-242); or McMaster-Carr [phone: 310-692-5911]. The widths of the tapered leaves may have to be trimmed down to match the taper and tip width of the DTI manufacture’s gages, so that they will fit between the DTI bumps.

4. **Q.** How many gaps must refuse the tapered feeler gage for the DTI to be acceptable?

   **A.** The following chart shows the number of gap refusals required for each size of A325 bolt to insure that the minimum tensile strength has been attained:

<table>
<thead>
<tr>
<th>Bolt Diameter, inch</th>
<th>Total Number of Gaps on DTI</th>
<th>1.05 x Minimum Bolt Tension, kips</th>
<th>Minimum Gap Refusals For Minimum Bolt Tensile Strength</th>
<th>Minimum Bolt Tensile Strength, kips</th>
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<tr>
<td>1/2</td>
<td>4</td>
<td>13</td>
<td>2</td>
<td>17</td>
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<td>4</td>
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</tr>
<tr>
<td>1 3/8</td>
<td>7</td>
<td>89</td>
<td>4</td>
<td>121</td>
</tr>
<tr>
<td>1 1/2</td>
<td>8</td>
<td>108</td>
<td>4</td>
<td>148</td>
</tr>
</tbody>
</table>
5. Q. What companies manufacture DTIs?
   A. In the United States, only the two following companies currently make DTIs:

   1. Applied Bolting Technology Products, Inc.  
      P.O. Box 255  
      Ludlow, Vermont 05149-0255  
      Telephone: 802-228-7390  
      800-552-1999  
      Facsimile: 802-228-7204

   2. TurnaSure LLC
      340 E. Maple Avenue, Suite 303  
      Langhorne, PA 19047
      Telephone: 215-750-1300  
      800-525-7193  
      Facsimile: 215-750-6300

Note: Both DTI manufacturers furnish free installation instructions and tapered feeler gages.
Structural Steel Working Drawings

Introduction
The procedure for review and approval of structural steel working drawings is a coordinated effort between Design and Construction personnel. The designer, with input from construction, has the primary responsibility for approval of the working drawings. In the case of projects designed by a Local Agency or Consultant the designer of record, in conjunction with Structure Design and the Design Oversight Engineer, has the primary responsibility for approval of the working drawings. However, the Shop Plan Clerk, in the Structure Design Documents Unit, will furnish the Local Agency Designer or Consultant with two copies of the working drawings.

Working Drawings
Attached is Memo to Designers 12-1 (Attachment No. 1) *Review of Working Drawings - Steel Structures*. The Memo to Designers, which is a cooperative effort of Design and Construction, covers the procedures required for review and approval of working drawings including responsibilities of the Structure Representative on a construction project. The procedure for submittal of plans and working drawings is for the Contractor (subcontractor or fabricator) to submit all documents directly to the Office of Structure Design, Documents Unit, Mail Station 9, 1801 30th Street, Sacramento 95816. The original submittals and any resubmittals shall be submitted to the Documents Unit. The Structure Representative should ensure that the contractor submits all documents to the Documents Unit in a timely manner.

The Documents Unit is responsible for administering the working drawing review and approval procedure during all phases of the approval procedure. The Documents Unit maintains a record of all working drawings submitted and distributes copies to the required individuals. This relieves the Structure Representative of the tedious administrative details required in distributing and coordinating the review and approval process.

The responsibility for checking working drawings is shared by the designer of record and the Structure Representative. The Structure Representative shall make all effort to coordinate directly with the designer. The working drawings shall not be returned to the Contractor until the designer of record has discussed and resolved all comments with the Structure Representative. The comments that are returned to the Contractor must be acceptable to both the Designer and the Structure Representative.

The Structure Representative shall ensure that the final working drawings are submitted by the Contractor to the Documents Units, in accordance with Section 55 of the Standard Specifications, prior to the acceptance of the contract. The Structure Representative can verify the submittal of the final working drawings by contacting the Documents Unit at (916) 227-8252.
REVIEW OF WORKING DRAWINGS – STEEL STRUCTURES

Procedure:

The instructions in this Memo apply to working drawings for bridges or other major structures. Working drawings for railings, signs, miscellaneous metal, and other minor items are for the use of field personnel and are not routinely reviewed by the designer. See Article 10 for review of projects designed by Local Agencies and Consultants.

To provide uniform treatment in checking steel working drawings, the following procedures shall be followed:

1. The responsibility for checking working drawings is shared by the designer, the Structure Representative and Transportation Laboratory. Working drawings shall not be returned to the contractor until the designer has discussed and resolved the details with the other reviewers. The comments returned to the contractor must be acceptable to all reviewers.

   A brief memo shall be written by the designer to document controversial decisions or when it is necessary to keep other involved parties informed. For example, a memo is required for any changes or clarification of details in the contract plans. A copy of the memo is to be sent to the Structure Representative and two copies are to be sent to the Transportation Laboratory.

2. When the initial drawings, between six and ten sets, are received, the Documents Unit will forward two sets to the Transportation Laboratory, one set with correspondence to the Structure Representative and the reminder with correspondence will be sent to the design section involved. If less than six sets are received, the Documents Unit shall immediately request the missing sets. The Documents Unit will make this distribution.

   In the event drawings are received for review involving prestressing systems, one of the sets will be forwarded to the Chairperson of the Prestressing Committee for check enroute to the design section involved.

3. The Transportation Laboratory will make the sheets as required and return one set to design.

4. The set of drawings sent to the design section will be the work and file set, that is, it will be marked as necessary in yellow to indicate the checking performed, and in red to indicate any changes required.

5. One of the two sets of drawings sent to the Transportation Laboratory will ultimately be returned to the Contractor. It should not be stamped until all details are resolved between the Structure Representative, the Transportation Laboratory and the Designer and compatible comments transferred to the sheet.

Supersedes Memo to Designers 12-1 dated January 1982
6. Subsequent submittals of working drawings will not be routed out to the Structure Representative or the Transportation Laboratory. If there are any significant changes, the Designer will contact both groups and discuss them before the distribution of prints is made.

7. The Documents Unit will keep the latest set of drawings on file and make them available to the Designer as necessary. When corrected or revised drawings are received, the initial prints will be marked with blue and returned to the design section. All superseded sheets may be disposed of unless a claim or change order is anticipated and there may be a need to reconstruct the history of the project.

8. Members of the structural steel committee may be consulted at any time to assist with technical questions concerning shop practices and procedures.

9. Special Procedure for Structures Carrying Railroads
   a. Specifications require an initial submittal of ten sets of drawings. If less than ten are received, the Documents Unit shall immediately request the missing sets.
   b. From two to four sets are sent to the railroad for their review, with a request that they be expedited.
   c. At the same time one set is sent to the Structure Representative, two to the Transportation Laboratory, and the remainder to the design section involved.
   d. The design section is not to return an “approved” or “disapproved” set until all comments, including the railroad’s are received.
   e. When the railroad comments are received, the design section will mark the plans accordingly, or resolve differences as necessary.
   f. The set returned to the Contractor will incorporate both State and Railroad comments.

10. Review of projects designed by Local Agencies and Consultants
    a. Review and oversight of projects involving structures, designed and developed by local agencies or private consultants, is the responsibility of Local Assistance or the Externally Financed Projects Branch.
    b. Occasionally, others may be requested to review technical specialty areas such as walls, railings, earth retaining systems or projects having complex seismic concerns.
    c. Coordination and all plan distribution activities during the design phase will be handled by the Local Assistance or Externally Financed Projects Branch.
    d. Coordination of shop plan submittals by consultants will require special handling by the branch
11. Stamping of Working Drawings

a. Initial Review

1. If they are correct on initial review, the checker shall stamp and date.

Checker shall initial one set of prints only (yelled check set). This set will be retained in

Approve
Pursuant to Section 5—1.02
Of the Standard Specifications

Jul 7 1989
State of California
Department of Transportation
Division of Structures

the job file by the Documents Unit.

2. If any corrections whatsoever are noted, the sheets in error shall be returned for correction. The sheets with corrections shall be stamped and dated:

Checker shall initial one set of prints only. This set will be retained in the job file by the

Prints Reviewed by
State Division of Structures and

Returned
Jul 7 1989
For Correction

Documents Unit.

b. Second or subsequent review.
1. If stamped “Returned for Correction” on subsequent review, prints will be handled in the same manner as prints for initial review.

If only a few minor corrections are made, all sheets needed for distribution must be marked with the same corrections and all stamped:

Checker shall initial one set of prints only (yellowed check set). This set will be retained in

APPROVED
PURSUANT TO SECTION 5—1.02
OF THE STANDARD SPECIFICATIONS

JUL 7 1989
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES

MINOR CORRECTIONS SHOWN IN RED

the job file by the Documents Unit.

12. Return to Contractor

After checking and the discussion with all reviewing agencies is completed, all copies of the Working Drawings shall be returned to the Documents Unit. One of the stamped copies will be sent to the Contractor, and additional copies will be requested as needed for rechecking or for distribution.

13. Distribution of Final Approved Drawings

a. Working drawing File – one print

b. Contractor – one print

c. Structure Representative – two prints (one for his use and one for Contractor’s Field Representative).

d. Transportation Laboratory – two prints (additional prints will be furnished where out-of-State
fabricators are involved).

e. Railroads – two prints for each Railroad company involved.

14. Final Disposition of Working Drawings

After completion of a project, the fabricator will furnish 35 mm film of working drawings to the Division of Structures as required by the specifications. These films are checked by the Documents Unit to verify that all required film has been received prior to sending them to file. The films are then filed in roll form by the Documents Unit.

After the films are received the file copies of Working Drawings will be sent to the responsible design section.

15. Guide for Checking Working Drawings

As a means of establishing uniform practice and avoiding omissions, but not as a substitute for common sense, the following outline is submitted as a general guide for checking Structural Steel Working Drawings:

a. Read the Standard Specifications and Special Provisions for the particular job. They may modify the usual procedure. Read the correspondence file; there may have been changes approved by the Office of Structure Construction since the contract was let. Call the Structure Representative to establish a working relationship, and to become familiar with any pending changes or special problems.

b. Changes from the contract plans or specifications, regardless of magnitude, should not be allowed unless they have been discussed and approved by the Structure Representative and Transportation Laboratory. Revisions may be satisfactory structurally but create administrative problems. Changes requiring Contract Change Orders as determined by the Structure Representative need special attention. These change orders could be grouped into two categories:

1. Those involving changes requested by the State and minor changes requested by the fabricator where there is no question on approval of the change order by both parties. The working drawings can be approved but the note “Contract Change Order to be processed” added to each detail sheet involved.

2. Those involving controversial changes requested by the fabricator. These should be returned to the fabricator with the note “Request must be made by the Contractor to the Resident Engineer for Contract Change Order.” The fabricator may ask that the working drawings be held by design pending such negotiation. Design should not hold any plans without such a request.

c. Review the Contractor’s erection procedure to be sure that it will satisfy the assumption for
continuity made in design. If the design assumptions are not met, the contractor must submit calculations for revised cambers and stresses. He may be required to increase plate thicknesses or change types of steel.

d. Check to see that all material shown in the working drawings conforms to the size, thickness and steel type shown on the contractor plans or with the requirements of an approved erection procedure.

e. The amount and method of camber should conform to the contract plans or with values computed to accommodate an approved erection procedure.

f. Check the size of all welds. If a welding sequence or procedure other than that shown is proposed, it should be reviewed by the Transportation Laboratory.

g. Check the direction of rolling of plates where specific orientation is required, and the location of butt splices and details of connections not dimensioned on the plans.

h. In general, check only those items listed above. For example, do not routinely make a detailed check of dimensions or the bill of materials.

Philip C Warriner

Guy D. Mancarti

RCA:jgf
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NOTES:

1. * DESIGNATES THE MEMO WAS ISSUED AS A BRIDGE CONSTRUCTION BULLETIN (BCB). All other memos were issued as a BRIDGE CONSTRUCTION MEMO (BCM).

2. EFFECTIVE 10-28-22 ALL MEMOS FOR SECTION 180-0.0 WERE DELETED AND/OR REPLACED BY A NEW BCM AS SPECIFIED.