Chapter 8: Precast Concrete

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8-1 Introduction

While most concrete structures are designed to be cast-in-place (CIP), some projects may require specific members to be fabricated off-site. These members are referred to as precast (PC) concrete members. PC concrete members are cast and cured at a precast facility in a controlled environment. Once fabrication is complete, the members are transported to the construction site, where they are installed in their permanent locations.

Contract Specifications, Section 90-4, *Concrete – Precast Concrete,* and Section 51-4*, Concrete Structures – Precast Concrete Members,* contain the requirements for fabricating, handling, and erecting precast concrete members. Precast prestressed (PC PS) concrete piles have additional requirements, including those for fabrication and construction, under Section 49-2.04, *Piling – Driven Piling – Precast Prestressed Concrete Piling*.

8-2 Advantages of PC Concrete Members

The use of PC concrete is chosen during the design phase for several reasons. The following are key advantages of utilizing PC concrete members:

1. Minimize or eliminate falsework – Most PC concrete members can be erected with minimal to no use of falsework. Falsework for CIP concrete construction may have unacceptable impacts to traffic and sensitive environments, or may be difficult to install due to obstructions or conflicts. These issues can be significantly minimized or avoided entirely by using PC members.
2. Parallel construction activities – Precasting allows the fabrication of concrete members to be partially or fully off the critical path, allowing these activities to occur simultaneously with other on-site activities. In contrast, CIP concrete construction is very linear, where one activity must be completed before the next begins. Precasting, however, facilitates the parallel progression of significant bridge work off-site, minimizing delays and improving overall project efficiency.

Other advantages to using PC concrete members include improved quality control, elimination of risk of weather-related impacts, and increased safety and efficiency.

Box culverts, drain inlets, piles, columns, deck panels (discussed in Chapter 7, *Bridge Deck Construction*), slabs, and girders are examples of common precast concrete members. PC PS concrete members are a specific type of precast concrete, as their fabrication includes prestressing steel. Figure 8-1 shows the fabrication of a PC PS concrete pile. PC PS concrete girders are the most frequently precast concrete members used in bridge construction.

Figure 8-1. PC PS Concrete Pile Fabrication

8-3 Preparation and Fabrication

8-3.01 Quality Control

Contract Specifications, Section 90-4.01D(1), *Concrete – Precast Concrete – General – Quality Assurance – General,* categorizes various types of PC concrete members into four tiers. In general, Tier 1 is designated for bridge members, Tier 2 for earth retaining systems and sound walls, Tier 3 for drainage, and Tier 4 for other members not included in the previous tiers. Refer to the aforementioned specification for complete tier classification of specific PC concrete members. Figures 8-2 through 8-7 show examples of various Tier 1 PC concrete members.

Figure 8-2. Round PC PS Concrete Piles

Figure 8-3. Square PC PS Concrete Piles

Figure 8-4. PC PS Concrete Panels

Figure 8-5. PC Concrete Abutment

Figure 8-6. PC Concrete Column

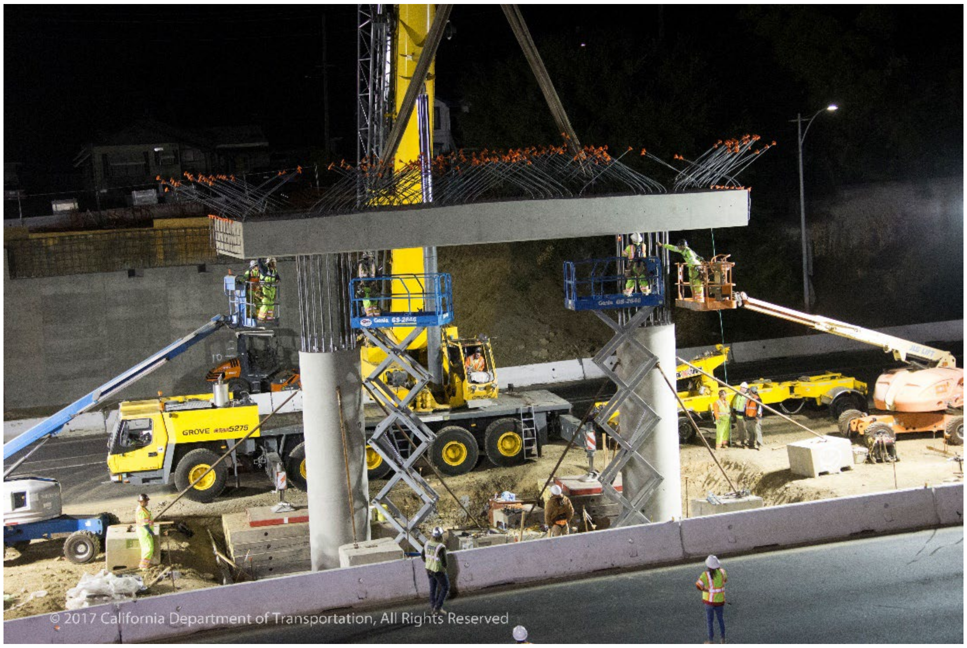

Figure 8-7. PC Concrete Bent

The level of the quality control (QC) required depends on the tier classification of the PC concrete members as detailed in *Contract Specifications,* Section 90-4.01D(2), *Concrete – Precast Concrete – General – Quality Assurance – Quality Control*. Tiers 1 and 2 have the most rigorous requirements. For example, PC concrete members in these tiers must be fabricated at a plant that is on the Department's Authorized Facility Audit List for Structural Precast Concrete. This ensures that the fabricator is capable of adhering to the required QC standards, and that Materials Engineering and Testing Services (METS) is familiar with the plant's processes. Should any issues arise during fabrication, they can be addressed before the members are transported to the jobsite.

Moreover, for Tier 1 and 2 members, the Contractor must submit a Precast Concrete Quality Control Plan (PCQCP) prior to the Quality Control Meeting, which the Quality Control Manager of the plant must attend. Consult with your METS Representative (METS Rep) to get the latest information on the facility where the precast members are being fabricated at and to request assistance in reviewing the PCQCP.

The efficiency of a casting yard relies on its ability to cycle work crews and casting beds quickly. To facilitate this, high-early-strength concrete mixes and steam curing are commonly used to accelerate the removal of PC concrete members from their casting beds. However, these methods can result in excessively high temperatures within the curing concrete, potentially compromising the integrity of the members. For this reason, there are limits on the temperatures that the concrete is allowed to reach, thus the requirement for a temperature monitoring and recording plan in the PCQCP.

Tiers 3 and 4 do not require METS involvement and can be released on site by the Resident Engineer (RE) or Structure Representative (SR) based on a signed certificate of compliance (COC).

Repairs to damaged PC concrete members must be authorized by Structure Construction (SC), the Bridge Design (BD) Project Engineer, and METS.

8-3.02 Submittals

For the fabrication and erection of PC concrete members, the Contractor must submit various submittals for the Department's review and authorization. The following is a list of required submittals, with necessary information and key considerations to be aware of while performing a review. These submittals must be authorized before the associated activity can begin:

1. Shop Drawings
   a. Include METS and the BD Project Engineer in the review process.
   b. Verify layout, dimensions, material, embeds, compliance with concrete specification requirements, and requirements for specific PC concrete members per *Contract Specifications*, Section 51-4.01C(2), *Concrete Structures – Precast Concrete Members – General – Submittals – Shop Drawings*.
   c. Confirm inclusion of epoxy-coated bar reinforcement or prestressing stands, if required.
   d. For PC PS girders, check inclusion of anticipated deflections and calculations per *Contract Specifications*, Section 51-4.01C(2)(b), *Concrete Structures – Precast Concrete Members – General – Submittals – Shop Drawings – Girders.*
2. Concrete Mix Design
   a. Review in accordance with applicable subsections of *Contract Specifications*, Section 90, *Concrete*, including Section 90-4.02, *Concrete – Precast Concrete – Materials.*
   b. Unless specified otherwise, self-consolidating concrete (SCC) may be used to cast PC concrete members in accordance with *Contract Specifications*, Section 90-5, *Concrete – Self-Consolidating Concrete*.
   c. For box culverts, *Contract Specifications*, Section 51-4.02D(5), *Concrete Structures – Precast Concrete Members – Materials – Fabricating Precast Concrete Members – Box Culverts,* allows dry cast methods for fabrication. Refer to ASTM C1837, *Standard Specification for Production of Dry Cast Concrete Used for Manufacturing Pipe, Box, and Precast Structures*, for guidance on dry cast concrete.
   d. Include METS in the review process.

3. Precast Concrete Quality Control Plan (PCQCP) (Tiers 1 and 2)
    a. Required for each PC concrete plant.
    b. Ensure all information required in *Contract Specifications*, Section 90-4.01C(3), *Concrete – Precast Concrete – General – Submittals – Precast Concrete Quality Control Plan,* is included.
    c. Include METS in the review process.
    d. Must be submitted prior to PC concrete QC meeting.
4. Erection Work Plan
    a. Required for PC PS concrete girders and deck panels.
    b. Verify plan is signed and sealed by a licensed engineer in the State of California.
    c. Review and analyze details for transporting, unloading, staging, lifting, erecting, and temporary bracing.

Provide copies of all submittals relevant to precasting, such as the PCQCP, mix designs, shop drawings, and schedules, to METS for their concurrent review. METS and SC should meet to review and resolve their comments together prior to discussing the comments with the Contractor and fabricator. Provide METS with copies of all authorized submittals to be used for inspection purposes.

In addition to the above, the below submittals may be required during and after fabrication:

1. QC Test Results (Tiers 1 and 2)
    a. Submitted by the Contractor via the Data Interchange for Materials Engineering (DIME) database.
2. Certificates of Compliance (all Tiers) for:
    a. Cementitious material – Signed by the PC concrete product manufacturer.
    b. Curing compound
    c. Each PC concrete member
        i. Tier 1 and 2 – signed by QC manager (QCM)
        ii. Tier 3 – signed by QC inspector
        iii. Tier 4 – prepared by manufacturer.
3. Daily Production Log (Tiers 1 and 2)
    a. Must include daily temperature data for Tier 1 PC concrete members.
4. PC Concrete Report (Tiers 1 and 2).

8-3.03 Precast Concrete Quality Control Meeting

Fabrication and delivery of PC Concrete members requires the coordination and cooperation of at least the following parties:

1. The Contractor and the PC concrete QCM
2. A representative from the PC fabricator plant
3. The RE and/or SR
4. METS.

All parties must collaborate to ensure the timely inspection, release, and delivery of PC concrete members to the project.

Contract Specification, Section 90-4.01D(2)(b), *Concrete – Precast Concrete – General – Quality Assurance – Quality Control – Quality Control Meeting,* requires a PC QC meeting to be held after the Contractor submits their PCQCP. The purpose of this meeting is to ensure all parties are aligned with the PC concrete scope of work and the contract requirements.

While the Contractor and RE/SR are primarily responsible for contract administration, the PC fabricator and METS handle most of the material inspections. For this reason, the METS Rep typically leads this meeting.

The METS Rep will likely address the following topics during the PC QC meeting:

1. Roles and Responsibilities – Clarify the expectations of the Contractor, QCM, QC inspector(s) (QCI), RE/SR, METS Rep, and the METS inspector.
2. PCQCP – Review the requirements of the plan and address deficiencies of the submitted PCQCP.
3. Reporting – Discuss the reporting requirements of the QCI and QCM.
4. Non-conforming Work – Discuss the process for reporting and handling non-conforming work.
5. Job-specific Details – Highlight design details and contract requirements unique to the project.

In addition to the fabrication-related items listed above, it is recommended to discuss the process of delivering the PC concrete members to the jobsite. Due to the size and weight of members that are typically transported, delivery can involve several logistical, technical, and safety-related challenges. Mitigation of these challenges may require extensive coordination with external project stakeholders including California Highway Patrol (CHP), adjacent municipalities, and the Department's Permitting Office.

Discuss the PC QC meeting with the METS Rep in advance so they can confirm their availability as well as prepare the relevant agenda and discussion topics.

8-3.04 Quality Assurance

As with most material fabricated off-site and shipped to the construction site, METS provides quality assurance inspection at the site of fabrication (PC concrete fabrication facility). Conforming material is tagged and released by METS, prior to being shipped to the jobsite.

Review the Contractor's submitted Form CEM-3101, *Notice of Material to be Used*, to see which facility will be producing PC concrete members and verify that they are on the Department's Authorized Facility Audit List for Structural Precast Concrete. Although facilities on the Authorized Facility Audit List have been authorized to fabricate PC concrete members on Caltrans projects, high personnel turnover or other factors may impact a fabricator's efficiency, consistency, and quality. Contact your METS Rep to discuss their level of confidence in the chosen facility. This will also open the lines of communication with METS before receiving any mandatory submittals which they will aid in reviewing.

The SR may request to schedule a PC fabricator site visit with the METS Rep. This will provide an opportunity to become familiar with the facility's operations and QC.

METS documents their source inspections of PC concrete member fabrication by recording relevant activities and observations on a Form TL-6033, *Precast Concrete Inspection Report*. The form includes checkboxes to document the status of the facility audit, authorized materials, submittals, and pouring activities the report covers. Figure 8-8 is a sample cover page of a TL-6033. METS provides copies of the TL-6033 to the RE and SR. Upon completion of final inspection, METS places release tags, TL-0624, *Inspection Release Tag* ("orange tag"), on each of the PC concrete members that are authorized for delivery.

If METS determines a PC concrete member does not comply with the contract requirements but still meets its intended function, METS may instead attach a TL-0625, *Materials Suitability Tag* ("blue tag"). In such cases, the METS Rep will have already informed the RE and SR of the non-compliance, and the SR should have coordinated with the BD Project Engineer to determine how to proceed with accommodating and incorporating the non-compliant member. An example of this situation is if a PC concrete member does not meet specified camber requirements.

Refer to METS Office of Quality Assurance and Source Inspection (QASI) Manual[1], Sections 51-F, *Concrete Structures – Precast Concrete Members*, through 51-J, *Concrete Structures – Precast Concrete Box Culverts,* for further clarification regarding METS' role and expectations in the inspection and release of PC concrete members and other materials incorporated into construction projects.

[1] Caltrans internal use only

STATE OF CALIFORNIA • CALIFORNIA STATE TRANSPORTATION AGENCY

DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
MATERIALS ENGINEERING AND TESTING SERVICES
OFFICE OF QUALITY ASSURANCE AND SOURCE INSPECTION

Contract #: [redacted]
EFIS #: [redacted]
Vendor #: [redacted]

PRECAST CONCRETE INSPECTION REPORT

Resident Engineer: [redacted]
Project Name: [redacted]
Prime Contractor: [redacted]
Precast Firm: [redacted]
Quality Control Contact: [redacted]

Date Inspected: 10/10/2023
OQASI Arrival Time: 0630
OQASI Departure Time: 1600
Location: [redacted], CA
Quality Control Present: ☒Yes ☐No

Bid Item: 103
Contract Quantity: 31
Type of PC Member: Precast Prestressed Concrete Box Girder (100'-110')

Caltrans PC Audit: ☒Yes ☐No **Exp. Date:** Expires 6/2024
Authorized Shop Drawings: ☒Yes ☐No **Date:** 9/29/2023
Authorized Mix Design: ☒Yes ☐No **Date:** 10/2/2023 (Mix Design # S9.8-25FA)
Authorized Strand: ☒Yes ☐No **Date:** 6/29/2023*, 9/12/2023 (*EA# [redacted])
Authorized PCQCP: ☒Yes ☐No **Date:** 6/28/2023
EPD has been authorized: ☐Yes ☒No ☐N/A **If Yes, mill name/location(s):**

☐ **Pre-Fabrication** ☒ **Pre-Pour** ☒ **Pour** ☒ **Post-Pour** ☐ **Final Release**

Summary of Items Observed: Caltrans Quality Assurance Inspector [redacted] (QA), arrived on site at [redacted] in response to a submitted Inspection Request to observe various fabrication operations on precast prestressed concrete box girders for the [redacted]. On arrival, QA with [redacted] (QCM), [redacted](QC), and [redacted] (Plant Engineer).

<u>Post-Pour Operations for Box Girder SB2.2 (2 of 11) (Cast 10-9-23)</u>:

QC reported to QA that overnight breaks for 10/9/2023 Casting averaged 5470 psi meeting stripping strength requirements (5000 psi stripping requirement per drawing 1.1 of the approved plans). QC dataloggers recorded a high internal temperature of 152.0 and 136.4 degrees. QA datalogger recorded a high internal temperature of 149.0. Data provided by QCM showed no rise in temperature above 40 degrees per hour and that bed enclosure was maintained above 60 degrees until cut down. QA performed random post-pour dimensional checks, finding no issues. QA visual inspection of bottom surface found surface to be smooth with no obvious irregularities. QC performed post pour dimensional inspection and found zero tolerance issues. QA witnessed QCM perform camber measurements with QCM recording 1" camber. Drawing 2.1 lists anticipated mid-span camber at 1". Box girder was moved to patching area with cleanup not underway as of yet. No other post-pour observations to report.

<u>Strand Stressing and Pre-Pour Operations for Box Girder SB2.2 (3 OF 11) (Cast 10-10-23)</u>:

Stressing began at 0904 and was completed at 0930 hours. Ambient temperature at time of stressing was recorded as 64 degrees. QA/QC monitored initial and final tensioning thru completion and verified that the

TL-6033, Precast Concrete Inspection Report (06/01/2023 PH) Page 1 of 4

Routing: 1. Contract File 2. Branch Senior, Resident Engineer, MR 3. Structure Representative (if applicable)

Figure 8-8. Sample Form TL-6033, *Precast Concrete Inspection Report*

8-3.05 Pre-Installation Inspection

Although PC concrete members are released by METS before delivery, it is critical for SC staff to thoroughly inspect members as they arrive to the jobsite. Verify that the delivered members have been released by METS by collecting the TL-0624 orange tags and ensuring they correspond to the delivered material. Measure controlling dimensions and deflection (camber) to confirm they align with the project plans and calculations. Visually inspect damage-prone areas including the ends of girders, embed locations, dunnage supports, and adjacent any repairs made prior to release. Confirm that PC concrete members are handled exclusively at the designated pick points outlined in the authorized erection work plan, as seen in Figure 8-9. Inspect for any handling damage and check that members are properly stored on-site to prevent potential damage. If necessary, coordinate with the Contractor to add additional support at the bearing points.

Figure 8-9. PC Concrete Handled at Pick Points

Inspect the quality of the concrete surfaces for any cracks, spalls, honeycombing, or other defects. Note any areas requiring repair, as these should be addressed before PC concrete members are installed. All repairs made must be in accordance with the authorized repair procedures. Only patching material listed for its intended use on the Department's Authorized Materials List (AML), Precast Concrete Cementitious Based Repair Material is allowed for patching PC concrete members.

Exposed spacers and positioning reinforcement are typical defects for box culverts. Although these issues are not grounds for rejection per *Contract Specifications*, Section 51-4.02D(5), *Concrete Structures – Precast Concrete Members – Materials – Fabricating Precast Concrete Members – Box Culverts,* coordinate with the Contractor to implement appropriate repairs, as these may contribute to future corrosion issues.

8-4 Precast Prestressed Concrete Girders and Slabs

8-4.01 Deflection/Camber

As mentioned in Chapter 7, PC PS concrete girder and slabs exhibit time-dependent behavior after being stressed in the casting bed and before deck concrete placement. Prestressing is performed under an unbalanced condition, as the prestressing force is designed to account for the full weight of the structure. However, the deck, diaphragms, barrier rail, and deck furnishings (e.g., fencing, sidewalks, etc.) are not yet in place when girders are initially installed. As a result, the member experiences upward deflection after release of prestressing strands due to the eccentricity of the strand profile. This upward deflection is sometimes referred to as “camber” and intentionally designed to counteract the downward deflection induced by the design load demands. Do not confuse this with the bridge camber indicated in the project plans, which is the amount of downward deflection of the girders anticipated as a result of the additional dead load applied, along with long term creep, once bridge construction is complete.

The Contractor’s shop drawings must account for this time-dependent behavior, ensuring the girder or slab erection and deck concrete placement are scheduled appropriately. The BD Project Engineer must review the schedule and verify that the camber calculations noted in the shop drawings for the PC PS concrete member span are appropriate. If the anticipated time between fabrication and installation is changed significantly – such as early fabrication or construction delays – the amount of bridge camber may need to be reevaluated. Effects of prestressing loss, creep, and shrinkage should be considered when reevaluating. Discuss this with the BD Project Engineer if schedule delays become an issue.

If excessive camber is observed before girder or slab installation, collaborate with the BD Project Engineer to evaluate and address the impact of the camber on the final structure. It may be necessary to adjust bridge elements. *Contract Specifications*, Section 51-4.03B, *Concrete Structures – Precast Concrete Members – Construction – Girders, Box Girders, and Double T Girders,* outlines the restrictions for making adjustments to accommodate excessive camber.

Minimum permanent vertical clearances must be maintained, along with the final bridge deck profile characteristics. This is typically achieved by adjusting the height of the haunch, which is the concrete buildup between top of girder and bottom of deck. Project plans typically specify the minimum superstructure depth (measured from the top of deck to the bottom of girder), so the thickness of haunch should vary along the bridge length based on the vertical profile, cross slope, camber, and dead load deflection.

Unless otherwise specified on the project plans, set the minimum haunch thickness based on constructability considerations. For example, if the precast deck panels are used as deck forms, a minimum haunch thickness of ½ inch might be needed for bedding strips under the deck panel. In any case, the top flange of girder must not encroach into the bridge deck.

Avoid introducing an additional vertical curve, or “hump”, to the final profile while planning adjustments. Consider factors such as bridge skew, orientation of the bridge deck finishing machine, and camber height to ensure proper bar reinforcement clearances.

Section 5.3.9, *Deflection and Camber*, of Bridge Design Memo*,* BDM 5.3*, Precast Prestressed Girders*, provides a detailed discussion on PC PS girder camber and explores potential methods to address camber related issues.

8-4.02 Bearing Pads

PC PS concrete girders and slabs installed on bridge spans are typically supported at their ends by permanent elastomeric bearing pads which are installed on abutment seats or bents. METS tests and releases elastomeric bearing pads by lot. When delivered to the jobsite, the pads must be accompanied by certified test results and COCs. Confirm that the lot number(s) of the pads matches the lot number(s) noted on the COC. Verify also that the type of elastomeric pad delivered – nearly always steel-reinforced – matches the type and dimensions specified in the project plans.

Bearing pads play a critical role in the stability of PC PS concrete members when installed in their final location. Confirm that they are at the correct orientation and slope when placed on abutment seats. Even a small misalignment can compromise the stability of the PC PS member. Bearing pads for PC PS girders are typically level. For voided slabs, bearing pads may need to match the bridge superelevation, as specified in the project plans.

The project plans may specify the placement of galvanized sheet metal on the bearing pads, with the top of pads coated with silicone grease. This can create potential issues for the installation of PC PS concrete girders, as it introduces a risk of girders sliding. Make the Contractor aware of this potential risk so that they can take precautions during girder installation. Additionally, verify that temporary bracing is installed promptly per the authorized erection work plan to minimize this risk.

8-4.03 Girder Stability

As previously noted, the Contractor must submit an erection work plan for the Department’s review and authorization. This plan must detail the procedures for unloading, lifting, erecting, and temporarily bracing the girders. During girder picking and installation, verify that the work complies with the authorized erection work plan to prevent any potential failures in the field. Be aware that even if it appears the Contractor is following their plan, there remains a risk for incidents and mishaps to occur.

It is important for the licensed engineer who developed the erection work plan to evaluate not only the in-place stability of girders but also for the stability during the picking and placement processes. For the incident in Figure 8-10, it was determined that the girder required longitudinal stabilizers to prevent lateral bending during picking.

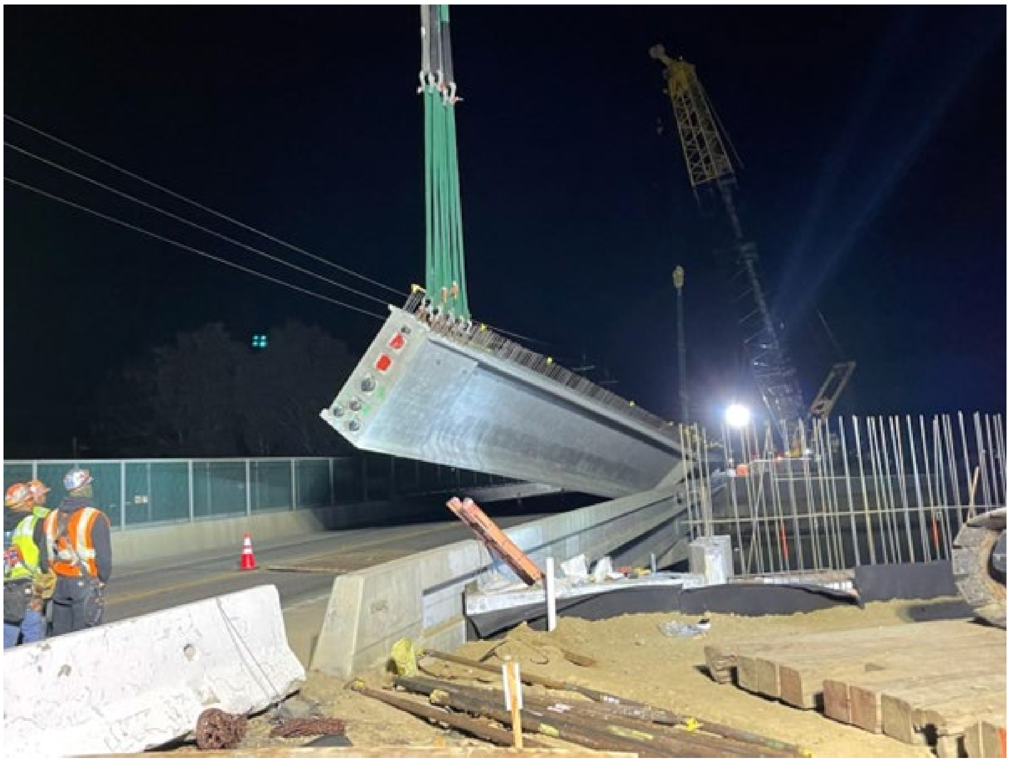

Figure 8-10. PC PS Girder Failure During Picking

Confirm girders are stable while each is being placed and when they are in their final position. Typically, girders are temporarily braced against each other to provide lateral support. Therefore, the erection work plan must specify how the Contractor intends to stabilize the first girder before installation of subsequent girders. Figures 8-11 and 8-12 are example details of PC PS concrete girder bracing, and Figure 8-13 is a picture illustrating temporary girder bracing that has been installed between girders. The Precast/Prestressed Concrete Institute (PCI) has published *Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders*, which provides guidance for assessing the stability of precast members during various phases of installation, including during transport and seating; note that this publication is available for download from the "Free Resources" tab.

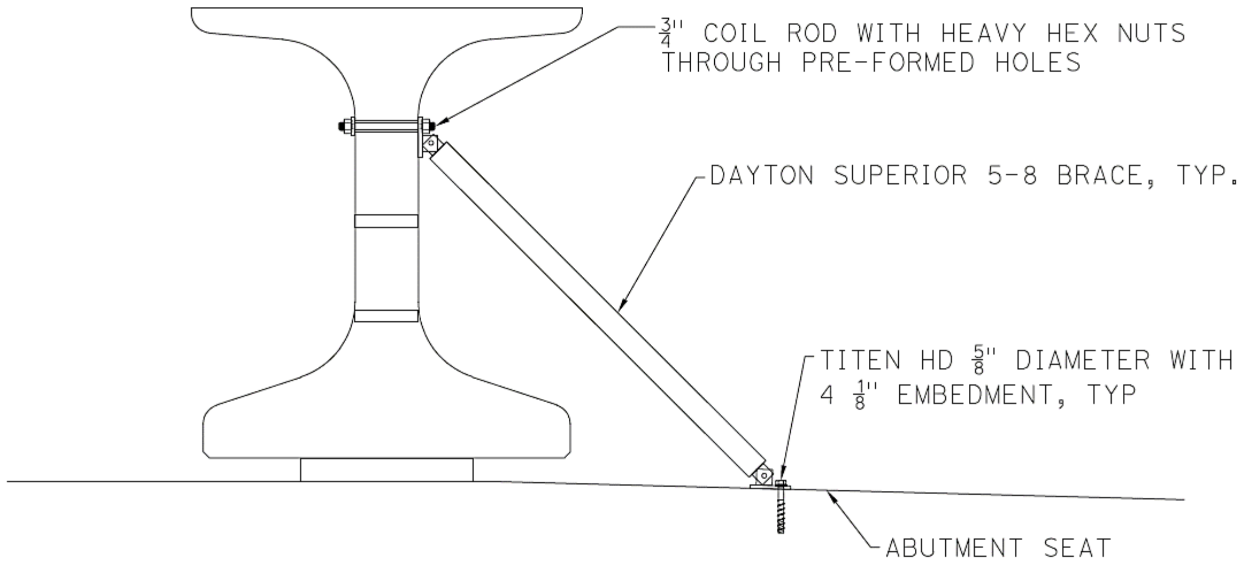

Figure 8-11. PC PS Concrete Girder Bracing Detail – 1st Girder

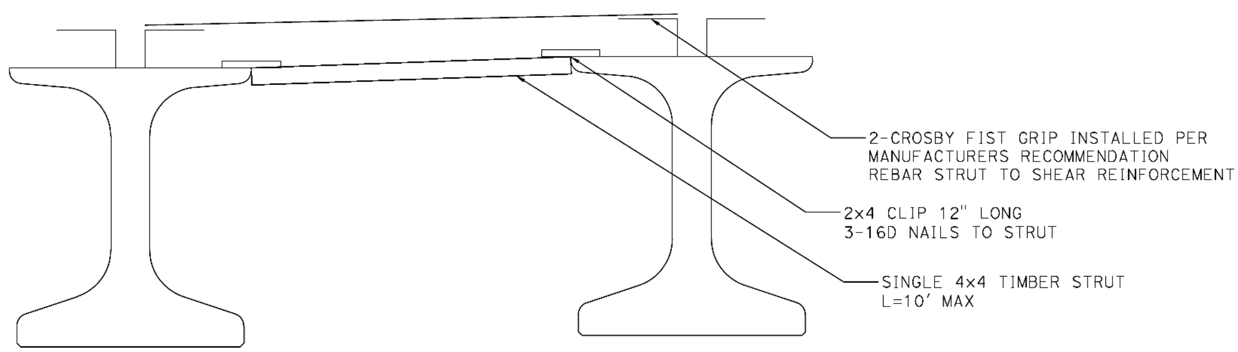

Figure 8-12. PC PS Concrete Girder Temporary Bracing Detail – Remaining Girders

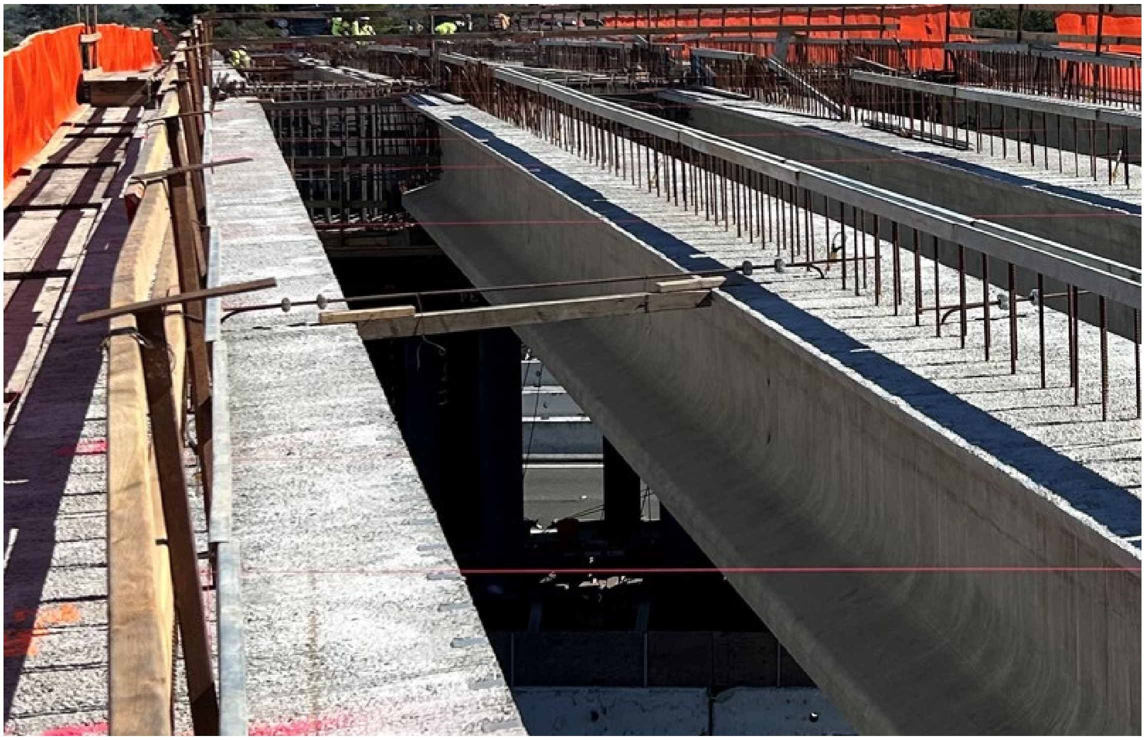

Figure 8-13. PC PS Girder Temporary Bracing Between Members

8-4.04 Bar Reinforcement

During source inspection, METS inspects bar reinforcement for PC concrete members at the PC facility before concrete placement. For PC concrete girders, project plans typically specify stirrups to be cast straight so that they can be bent in the field after the girder installation. Be aware that impalement protection, discussed in Chapter 7, must be in place once the girders are installed and access is in place. The PC concrete girders shown in Figure 8-14 had impalement protection in place prior to being installed.

Refer to Section 4-4.02, *Material and Fabrication Verification* of Chapter 4, *Reinforcement*, for guidance regarding field bending of bar reinforcement, including minimum required bend diameter and tail length as specified in the *Building Code Requirements for Structural Concrete* (ACI 318) published by American Concrete Institute (ACI). Bar reinforcement must not be damaged after being field bent.

Figure 8-14. Bar Reinforcement Impalement Protection

When reviewing the project plans and shop drawings, take note if the exposed reinforcement is to be epoxy-coated. Only epoxy-coated reinforcement complying with ASTM A775/A775M, *Standard Specification for Epoxy-Coated Steel Reinforcing Bars*, which is colored green, is permitted to be field bent. The Contractor must repair any damage to the epoxy coating in accordance with ASTM A775/A775M. Unbent epoxy-coated stirrups from installed PC concrete girders are shown in Figure 8-15. Figure 8-16 shows these stirrups after bending.

Figure 8-15. Unbent Epoxy-Coated Bar Reinforcement Stirrups

Figure 8-16. Bending of Epoxy-Coated Bar Reinforcement Stirrups

8-4.05 Girder Splicing

For bridges requiring very long full-length PC PS concrete girders or project sites with restrictive access routes, the project may specify fabrication of shorter PC concrete segments to be spliced together during installation. Post-tensioning the spliced segments may also be specified to achieve structural continuity. Adjoining surfaces of closure joints must have been fabricated with roughened vertical surfaces if shear keys were not specified. Check that post-tensioned ducts cast in the PC concrete segments extend sufficiently so that they can effectively connect to the ducts of the adjoining segment. Refer to Section 5.3.13, *Spliced Precast Prestressed Girders*, of previously referenced BDM 5.3 for additional information.

8-4.06 Forms and Cast-In-Place Concrete

The underside of PC concrete girder bridge decks are exposed, requiring that their forms be removed. The exception is if stay-in-place forms, such as precast concrete deck panels (PDP) or permanent steel deck forms (PSDF), are specified. PSDF may also be allowed if proposed by the Contractor and authorized by the Department. Refer to Chapter 7 for further details regarding bridge deck forms for PC concrete girder bridges.

The Contractor may choose to install deck overhang formwork brackets onto the exterior girders before girders are placed in their final location, as seen on the girder in Figure 8-17. This work is easy to accomplish while girders are still on the ground. Verify that formwork brackets are installed per all authorized shop drawings before girder placement. The authorized shop drawings for the PC concrete member will indicate any required inserts cast into the member for attaching formwork brackets. These inserts must correspond with details provided in the authorized shop drawings for the overhang formwork brackets and meet manufacturer requirements for spacing, depth, and edge distance.

Figure 8-17. Overhang Formwork Brackets Before Girder Installation

Project plans typically indicate the superstructure depth at girder supports (such as abutment and/or bent cap), and, in some cases, at mid-span. The mid-span depth would be based on the anticipated girder camber/deflection. Deck thickness is also shown on project plans. Figure 8-18 is an example detail showing deck thickness and structure depth at the bearing centerline, which aligns with the centerline of the girder. While the haunch thickness can be calculated using this information, it varies along its width due to the deck cross slope. As mentioned in Section 8-4.01, the superstructure depth may be adjusted from the plan dimension to account for deviations in the anticipated girder camber, provided that the changes comply with *Contract Specifications*, Section 51-4.03B with abutment or bent cap seat elevations adjusted accordingly.

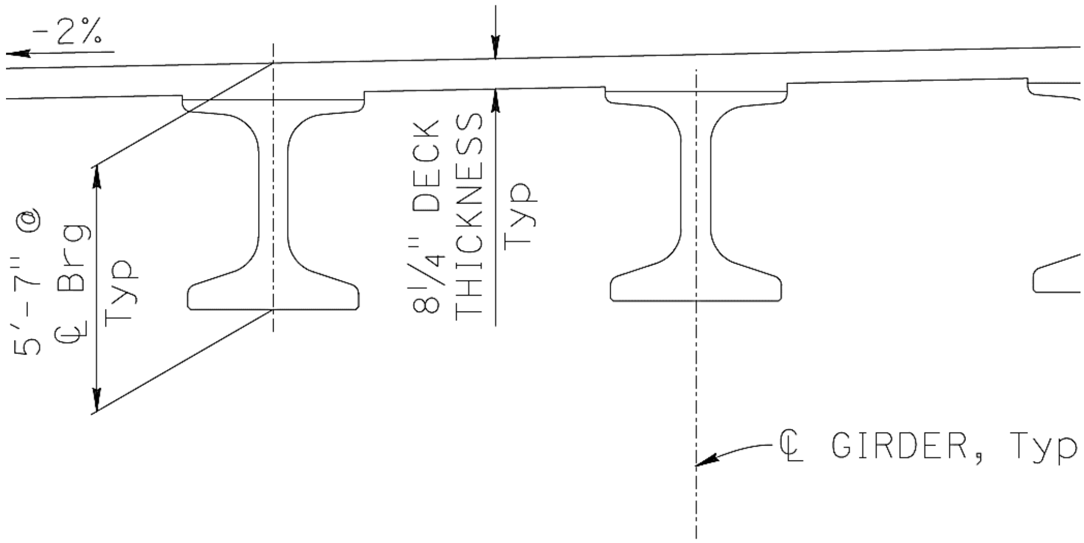

Figure 8-18. Structure Depth and Deck Thickness Detail

Contract Specifications, Section 51-1.03D(2), *Concrete Structures – General – Construction – Placing Concrete – Concrete Bridge Decks and Diaphragms,* requires intermediate diaphragms be cast prior to the deck for bridges with simple span PC concrete girders. Check that the project plans show a construction joint at the intermediate diaphragm/deck interface to reflect this requirement. If no joint is shown, consult with the BD Project Engineer to clarify the intent. Verify also that connection hardware from PC concrete girder to intermediate diaphragm, typically sets of bolts inserted into the PC concrete girder, are properly installed. Figure 8-19 provides an example detail of an intermediate diaphragm showing callouts for both the construction joint and the connection bolts.

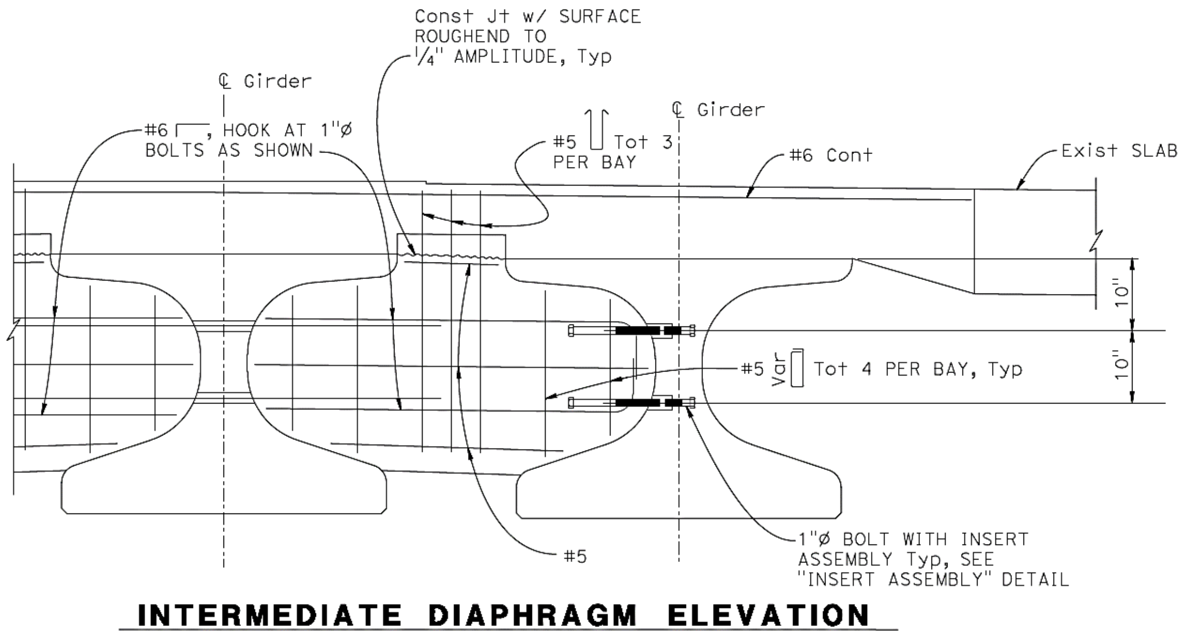

Figure 8-19. Intermediate Diaphragm Detail

8-5 Accelerated Bridge Construction

The need to reduce construction related impacts contributed to the development of Accelerated Bridge Construction (ABC). ABC is a project delivery method that utilizes innovative bridge design and construction techniques, which may deviate from traditional methods, to reduce construction schedule, minimize traffic disruptions, and lessen other potential impacts. One advantage of using PC concrete members, as discussed in Section 8-2, is the ability to fabricate concrete members off-site while on-site activities progress simultaneously. This benefit aligns closely with the ABC concept, and thus the reason why PC concrete members are commonly incorporated in ABC projects.

The use of PC concrete members alone does not necessarily qualify a project as an ABC project if it also incorporates more traditional bridge design and construction techniques. Review the contract specifications and project plan sheets to verify the project you are working on is an official ABC project by locating the logo shown in Figure 8-20:

Ct® Caltrans®
ACCELERATED BRIDGE CONSTRUCTION

Figure 8-20. Caltrans ABC Logo

If the project is an ABC project, review the Department's Accelerated Bridge Construction (ABC) Manual[1] (note that the ABC Manual uses the term "precast element" instead of "precast member"). The manual contains various checklists that SC staff should utilize when administering ABC projects.

In addition to consulting the BD Project Engineer, contact the SC Falsework Engineer[1] for ABC-related project questions and issues. The SC Falsework Engineer serves as the ABC specialist for SC. For any sampling and testing requirements, coordinate with the METS Rep as needed.

While PC PS concrete girders and piles have long been common PC concrete applications in bridge construction, ABC projects use a more extensive range of PC concrete members, such as columns, pier caps, abutments, deck panels, and wing walls. The ABC Manual refers to these items as Prefabricated Bridge Elements (PBEs).

8-5.01 Ultra-High Performance Concrete

ABC may incorporate the use of specialty material like Ultra-High Performance Concrete (UHPC) to shorten on-site bridge construction time. UHPC is a cementitious composite of finely ground constituents combined with a superplasticizer and approximately 2 percent steel fibers. It can be designed to achieve concrete strengths in excess of 9,000 psi in just 10 hours, making it ideal for creating strong structural connections between PC members in the tight work windows typical of ABC projects. However, UHPC is more temperamental than regular concrete. Work closely with the METS Rep to ensure the work is compliant with contract requirements. The Department maintains an AML for UHPC products that are authorized for use on Caltrans' projects.

UHPC is not commonly required and, as such, is not included in the current *Standard Specifications*. If it is required for a particular project, the relevant requirements will be provided in the project-specific *Special Provisions*.

UHPC may be specified for various bridge elements, including the following:

1. PC Member Connections
    a. Closure joints
    b. Grouted keyways (see Figures 8-21 and 8-22)
    c. Grouted duct splices
    d. Pocket connections
    e. Socket connections
2. Link Slabs
3. Bridge Deck Overlays.

[1] Caltrans internal use only

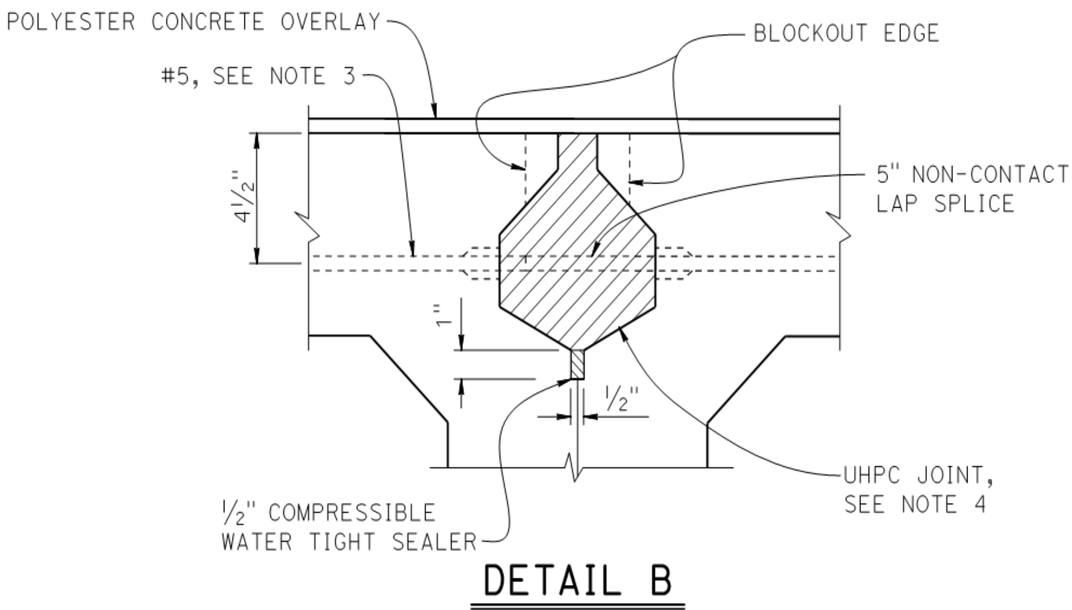

Figure 8-21. UHPC Grouted Keyway Detail

Figure 8-22. Grouted Keyway Filled With UHPC

The Contractor is typically required to submit a UHPC work plan for the Department to review and authorize, perform a full-scale mockup of UHPC placement (a mockup workplan may be required), and in some cases perform a full-scale preassembly of the completed PC PS girders at the fabricator's facility to verify fit. Mockups should be performed under the same conditions that the actual UHPC placement will be performed in, including atmospheric conditions, and carried out by the Contractor's field staff who will be performing the work on-site. This ensures that the Contractor is familiar with construction of UHPC, understands UHPC material requirements and limitations, and can properly complete the work. Note that wooden mockups may not accurately replicate surface temperatures.

Although the Contractor may request the UHPC mockup requirement be waived, it is not recommended. Exceptions may be taken if the Contractor has recently and successfully performed a similar UHPC pour using the same UHPC material in a comparable environment, and with the same crew.

The below is a list of lessons learned and critical items for SC staff to be aware of when working with UHPC:

1. Material quantity and expiration – Confirm the Contractor has the correct amount of material ordered and available for the project, including the amounts associated with required mock-ups, samples, head-cups, joint tolerances, construction losses and required over-pour, and that the material on site is not expired.
2. UHPC manufacturer's representative – A representative from UHPC material supplier must attend the UHPC preconstruction meeting and be on site during UHPC pours. The representative will be responsible for any required adjustments during the batching process to achieve the required material properties.
3. Testing facility preparation – The testing facility, whether mobile or at a permanent location, must be prepared to process QC samples promptly. In some cases, QC cylinder breaks may need to be performed within 1-3 hours of preparation.
4. Transportation to testing facility – Transportation of samples must be performed carefully. Verify that samples are securely handled by a designated person and delivered to the testing facility.
5. Pre-wet saturated surface dry (SSD) condition – Typical UHPC specifications require the joint be pre-wet for at least 2 hours, with the surfaces interfacing with UHPC being dry immediately prior to UHPC placement. Obtaining and maintaining SSD condition until the pour is one of the most important factors for achieving a good bond at the interface (see Figure 8-23).

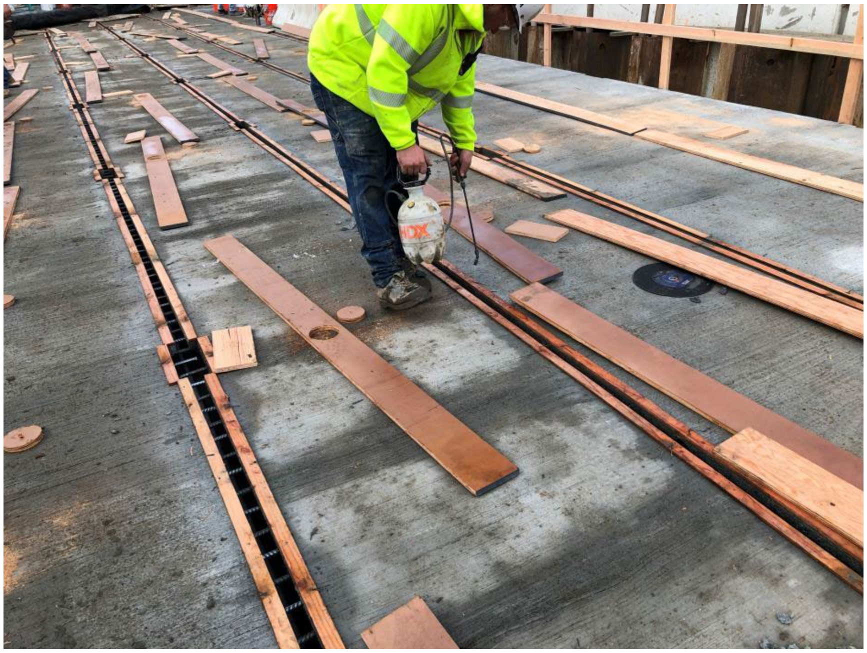

Figure 8-23. Laborer Maintaining Saturated Surface Dry Conditions

6. Material conveyance – The Contractor should develop a method to transport UHPC from the mixer to the pour location. Manual transport, such as laborers carrying 5-gallon buckets across a job site, can be physically demanding and dangerous. The Contractor's plan should include back-up measures appropriate for the selected method of placement, whether they be additional labor or standby buggies/carts.
7. Creating and maintaining head – Structures with a cross slope or longitudinal slope require tight, sealed joints at top and bottom to prevent leakage. Also, it is essential to maintain proper head – keep the level of the UHPC pour high – at intermittent locations. The Contractor's selected method of maintaining constant positive head throughout the placing operation will dictate how much additional material should be ordered and accounted for.
8. Curing –The Contractor uses time-temperature prequalification, to establish the theoretical compressive strength based on heat input over time, otherwise known as strength-maturity relationship. In the case of an ABC project, proper heat curing is very important, particularly if the specifications require an applied curing temperature to achieve rapid cure. This also includes the cylinders being cured in the same fashion as the bridge to produce accurate opening age breaks.
9. Redundancy – Due to the nature of UHPC as a material, along with the rigid time constraints associated with ABC construction, it is critical that all elements of the proposed UHPC placement and curing plans are assessed for potential failure modes and the appropriate back-up plans developed and agreed upon ahead of the production operation.