

Chapter 4: Overhang & Barrier Upgrades

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4-1 Why Are Barriers Upgraded or Replaced?

Caltrans maintains an extensive inventory of bridges. In the Department's continuing efforts to maintain public safety and the increasing size and weight of vehicles, there are several reasons to upgrade or replace a barrier on a bridge. The bridge could be undergoing a widening project to improve traffic capacity, or a maintenance project scoped to replace and upgrade outdated barriers in poor condition to extend the facility's service life. A barrier may simply need to be replaced due to damage from traffic or environmental causes. Some barriers may even need to be replaced to accommodate the addition of a sound wall. It is important to note that any barrier that is replaced or upgraded will need to be updated to current safety standards. Caltrans has adopted the Federal Highway Administration (FHWA) recommendation to follow guidelines outlined in the *Manual of Assessing Safety Hardware (MASH)* for all barrier systems.

4-2 Contract Requirements for Overhang and Barrier Upgrades

The following sections will help illustrate the various contract documents associated with a project involving a barrier upgrade or repair.

4-2.01 Project Plans and Special Provisions

The most common sources of information for any project are the contract plans sheets, standard plans, and special provisions. Plan sheets with information on barrier work may include "Layout", "General Plan", "Staged Construction", "Abutment Layout", "Abutment Details", "Typical Section", and "Architectural Details", along with sheets specific to barriers and railing. These sheets contain information such as the limits and type of barrier to be removed, as well as the new system it will be replaced with. Any project scoped to replace a barrier with a new system may also include details on how to increase the strength of the edge of deck to support the heavier system and larger impact loads. It should be noted that the contract will specify limits of bridge removal from the edge of deck, along with existing reinforcement, which must be preserved.

4-2.02 Standard Specifications

In Chapter 1, *Introduction*, several sections of the *Standard Specifications (SS)* that describe requirements for common rehabilitation activities were discussed, including:

1. **Section 5-1.37, *Control of Work – Maintenance and Protection***, describes requirements for placing heavy loads on bridges.

2. **Section 7-1.04, *Legal Relations and Responsibility to the Public – Public Safety***, describes requirements for operations reducing vertical and horizontal clearances.
3. **Section 14, *Environmental Stewardship***, describes requirements relating to environmental compliance and resource management.
4. **Section 16-2.02, *Temporary Facilities – Temporary Pedestrian Facilities***, describes requirements for constructing temporary pedestrian facilities with protective covering, used during construction
5. **Section 48, *Temporary Structures***, describes requirements for building temporary structures used during construction.
6. **Section 60, *Existing Structures***, describes requirements for protecting the remaining portion of the existing structure. Notably, subsection 60-2.02, *Bridge Removal*, describes the following:
 - a. The removal operation for each Bridge No./Structure named in a table within the special provisions.
 - b. Requirements for bridge stability during all stages of bridge removal.
 - c. Submittal requirements for bridge removal, as well as inspection requirements for the Contractor’s registered engineer during the bridge removal operation.
 - d. Requirements for bridge removal over and/or adjacent to roadways and railroads.

In addition to the SS sections described above, the following describes the contract requirements specific to barrier construction:

1. **Section 83, *Railings and Barriers***, describes the materials and construction requirements for building various types of barriers. The construction requirements include the type of forming allowed (extruded, slip-form, or cast-in-place-with-fixed-forms), curing requirements, finishing requirements, and material requirements such as concrete. This section refers to Section 51, *Concrete Structures*, Section 52, *Reinforcement*, Section 75, *Miscellaneous Metals*, and Section 90, *Concrete*, to describe general concrete, reinforcement, and miscellaneous metal work requirements. The requirements described in this section will be explained in more detail later in this chapter when field inspection of barrier construction is discussed.

4-2.03 Standard Plans

In the following sections, several types of concrete barriers detailed in standard plans and contract requirements will be reviewed and discussed.

4-2.03A Concrete Barrier Type 60 Series

These types of barriers are used on both the roadway and on bridges. Type 60 series concrete barriers (often referred to as Type 60 barrier) are commonly placed in the median and serve to separate opposing traffic; see Figure 4-1 for an illustration.



Figure 4-1. Type 60 Barrier Rail (with Architectural Treatment) Placed in the Median

The Type 60 barrier details are provided in Standard Plan A76A through A76I. When constructing barriers on bridges, it is important to realize that any item installed on the bridge must allow for bridge movement at the bridge joints. Notes on standard plan sheets will describe details that must be provided for barriers to accommodate bridge movement. For example, see Figure 4-2 below for notes 1 and 2 on Standard Plan A76A, *Concrete Barrier Type 60M*, which describes construction details that must be provided at the transition between the structure and the roadway. See Figure 4-3 below for transition details on Sheet A76AB, *Concrete Barrier Type 60M Details*, of the *Standard Plans*, to accommodate bridge movement.

NOTES:

1. See Standard Plans A76AB and A76AC for details of Concrete Barrier Type 60M end anchors, connection to structures and transitions to Concrete Barrier Type 50 and Concrete Barrier Type 60MS.
2. See Standard Plan A76C for Concrete Barrier Type 60M transitions at bridge column and sign pedestals.
3. Where glare screen is required on Concrete Barrier Type 60M, use Concrete Barrier Type 60MG.
4. Where roadbed offset is greater than 1 1/2", see Concrete Barrier Type 60MC.
5. See Project Plans for barrier delineation locations.
6. Reinforcing stirrup not required for roadbed offsets less than 1'-0".
7. For roadbed surfaces offset greater than 1 1/2" and less than or equal to 3", no reinforcement required. For roadbed surfaces offset greater than 3" and less than or equal to 8", use two #4 Reinf at 3" above the lower roadbed surface. For roadbed surfaces offset greater than 8" and less than or equal to 12", use two #4 Reinf at 3" above the lower roadbed surface and two #4 Reinf at 8" above the lower roadbed surface. For roadbed surfaces offset greater than 12" and less than or equal to 36", use two #4 Reinf at 3" above the lower roadbed surface and two #4 Reinf at every 8" increment vertical spacing above the first two #4 Reinf.

Figure 4-2. Standard Plan A76A Note 1 and 2 Referencing Details for Concrete Barrier Transition for Type 60 Barrier

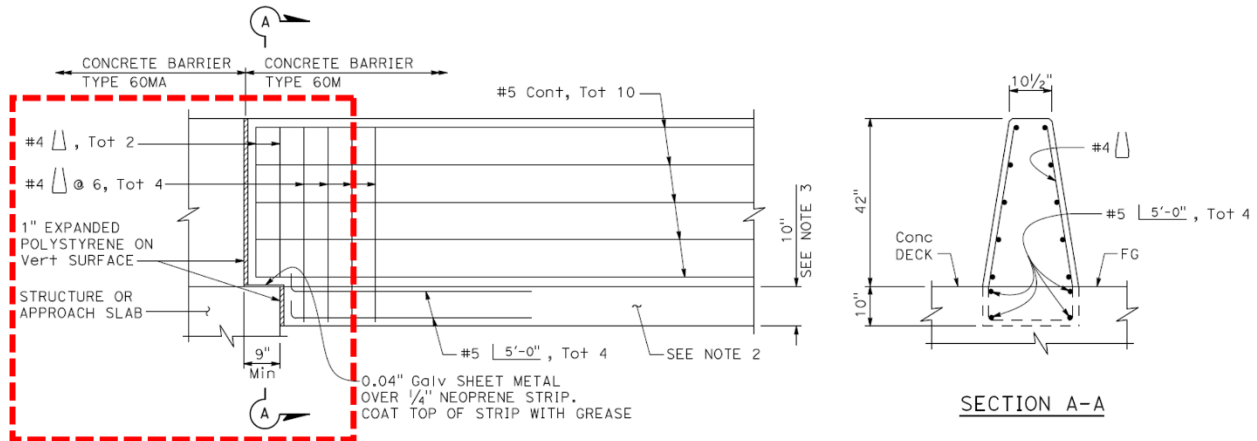


Figure 4-3. Standard Plan A76AB Showing the Transition Details to Allow for Bridge Movement

4-2.03B Bridge Concrete Barriers

These types of concrete barriers are only placed on structures such as bridges and retaining walls, typically at the edge of deck (EOD); see Figure 4-4.



Figure 4-4. Bridge Concrete Barrier at the Edge of Deck

The bridge concrete barrier shown on the standard plan supports many kinds of variations and features; these features might include the addition of electroliers, pull boxes, chain-link railing, or a sidewalk. Figure 4-5 shows an example of a bridge concrete barrier plan sheet (Standard Plan B11-79, *Concrete Barrier Type 836 Details No. 1*), with common features.

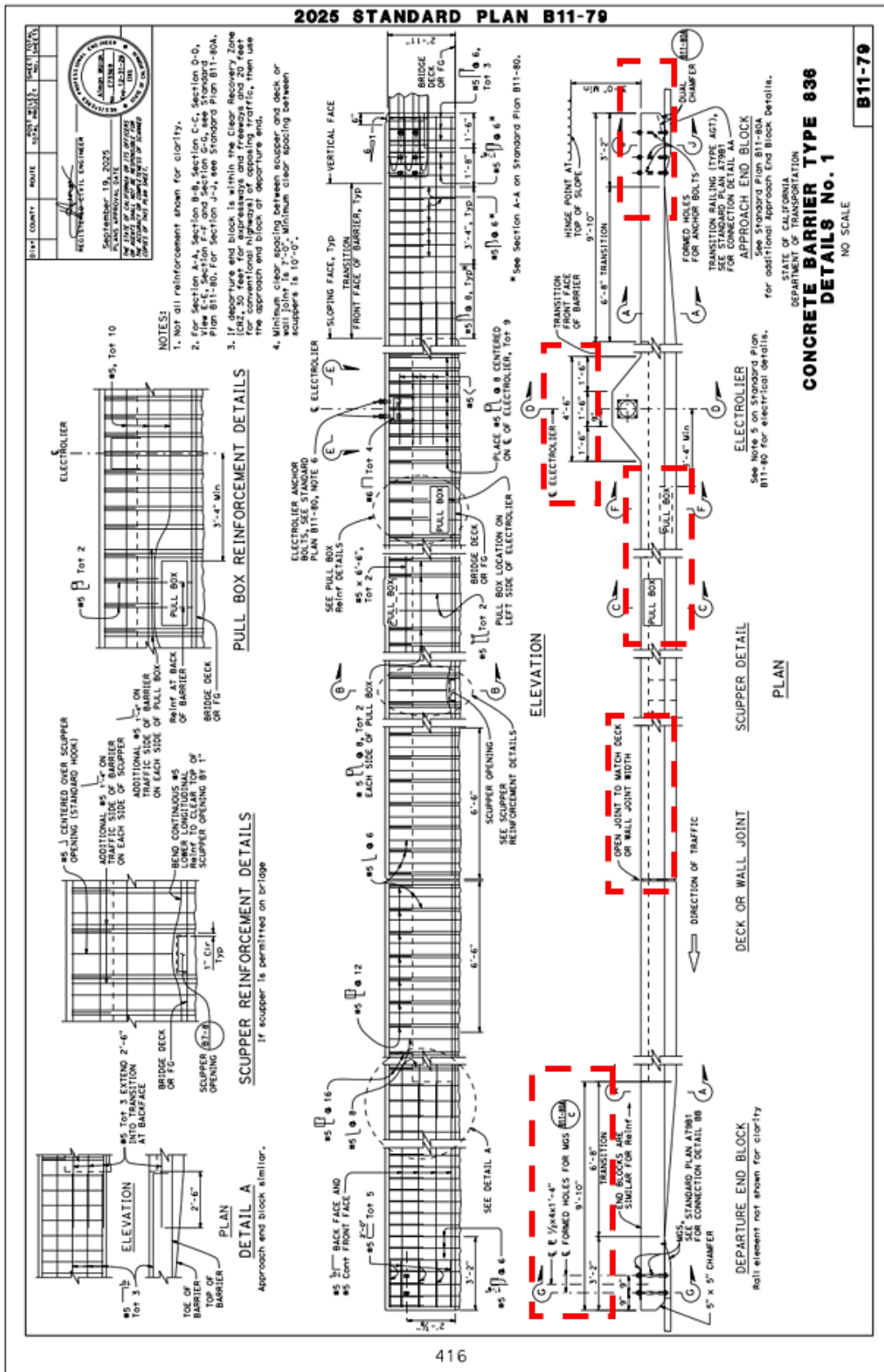


Figure 4-5. Standard Plan B11-79 Showing Transition, Joints, Electrolier, and Pull Box Details

The details shown in Figure 4-5, (from Standard Plan B11-79) are depicted in the barrier Figures 4-6, 4-7, 4-8, and 4-9 provided below:



Figure 4-6. Bridge Barrier with Transition to Metal Beam Guard Rail



Figure 4-7. Bridge Barrier with Electrolier Pedestal



Figure 4-8. Bridge Barrier Expansion Joints



Figure 4-9. Bridge Barrier Pull Box

Additionally, the contract plans might modify standard bridge concrete barriers by adding features such as architectural details, sound walls, and sign structure pedestals. See Figure 4-10 and 4-11 for an example of a barrier that was modified to include architectural details.

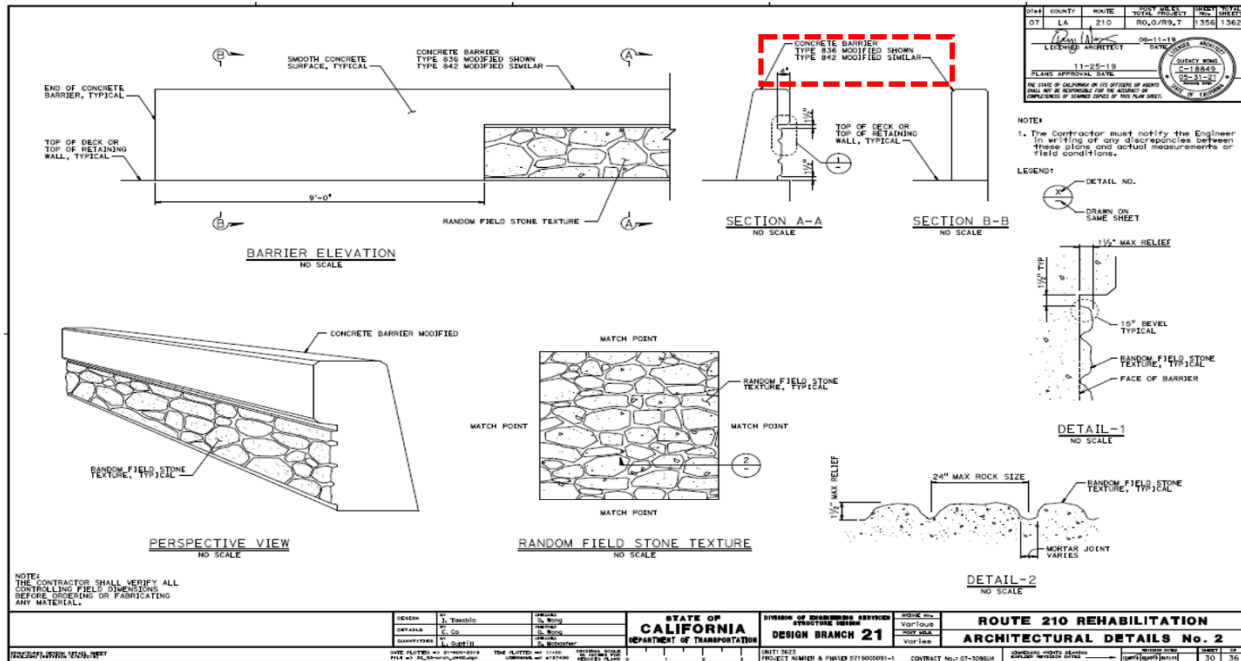


Figure 4-10. Contract Plan Showing Barrier Type 836 Modified to Add Architectural Details



Figure 4-11. Bridge Concrete Barrier Modified with Random Field Architectural Treatment

When standard concrete bridge barriers are modified to support a sound wall, provisions are typically provided in the contract plans to detail this modification of the barrier. A side-by-side illustration of a standard Type 842 barrier and a modified version of the same for sound wall support is depicted in Figure 4-12. The flat deck surface on the edge of deck side of the rail is a useful feature when forming- see Section 4-3.04, *Reinforcing Bar Placement and Forming of the Barrier*, for additional information.

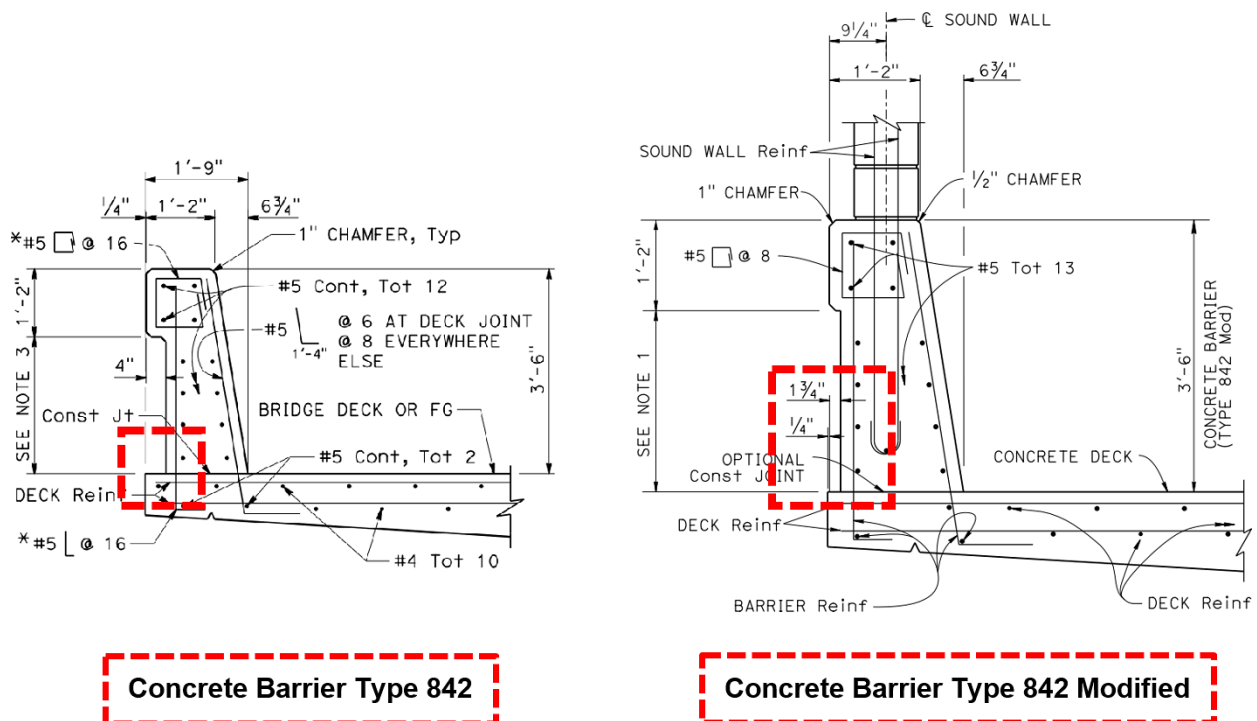


Figure 4-12. Standard 842 Barrier and Modified 842 Barrier

When constructing bridge concrete barriers, the standard plans provide construction details that are commonly required on most projects; a few of those details are described below:

1. **Details to construct joints in barrier and utilities to match bridge deck joint:**
As mentioned previously in Section 4-2.03A, *Concrete Barrier Type 60 Series*, when constructing barriers on bridge EOD or on retaining wall, it is important to realize that any item installed on the bridge must allow for bridge movement at the bridge joints. See Figure 4-13 and corresponding Figure 4-14 that illustrate joints in the bridge deck or retaining walls extending through the barrier.

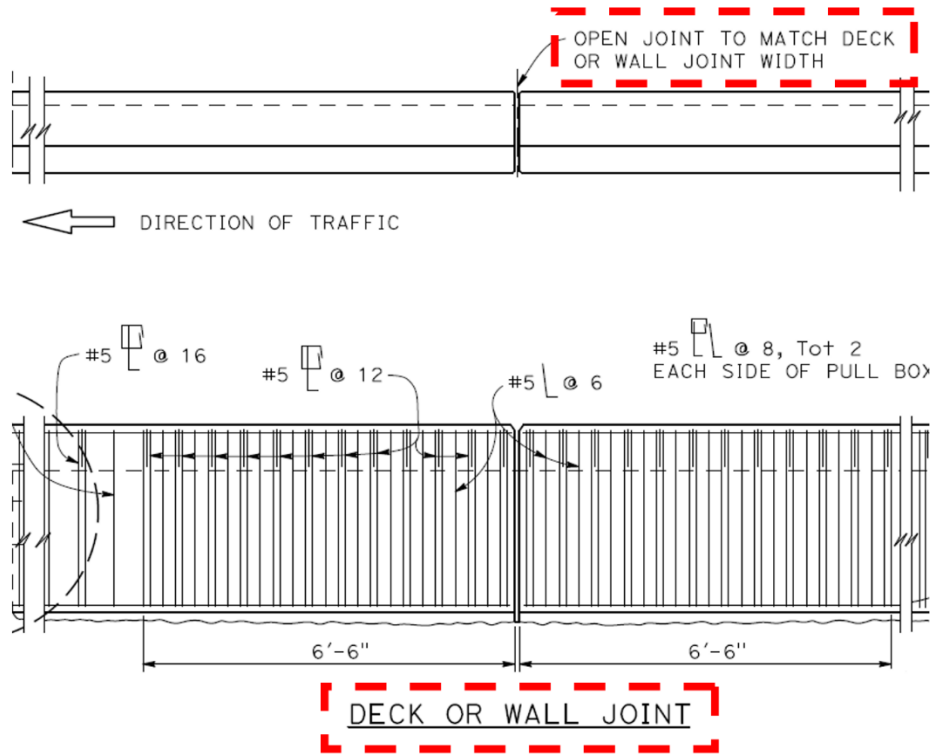


Figure 4-13. Standard Plan Detail Showing Type 836 Barrier Joint Matching Wall/Bridge Joint



Figure 4-14. Deck Joint Extending through the Barrier

It should also be noted that various items might be installed inside or on top of the concrete barrier, such as utilities, bicycle railing, or chain link fence. As expected, all these items also need to be able to accommodate bridge movement. As an example, see Figure 4-15 and the corresponding Figure 4-16 that shows a utility duct expansion joint detail that must be used at a bridge joint when an electrical conduit is installed in the barrier.

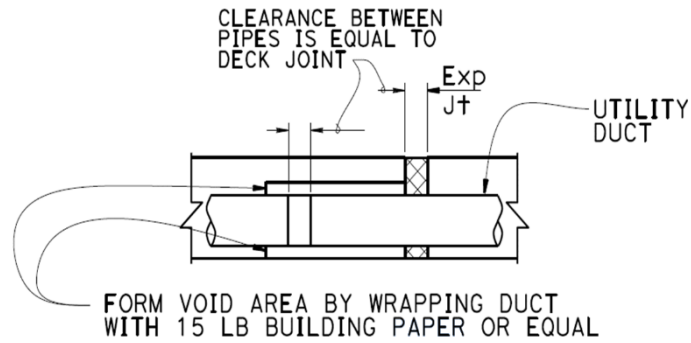


Figure 4-15. Utility Duct Expansion Joint Detail

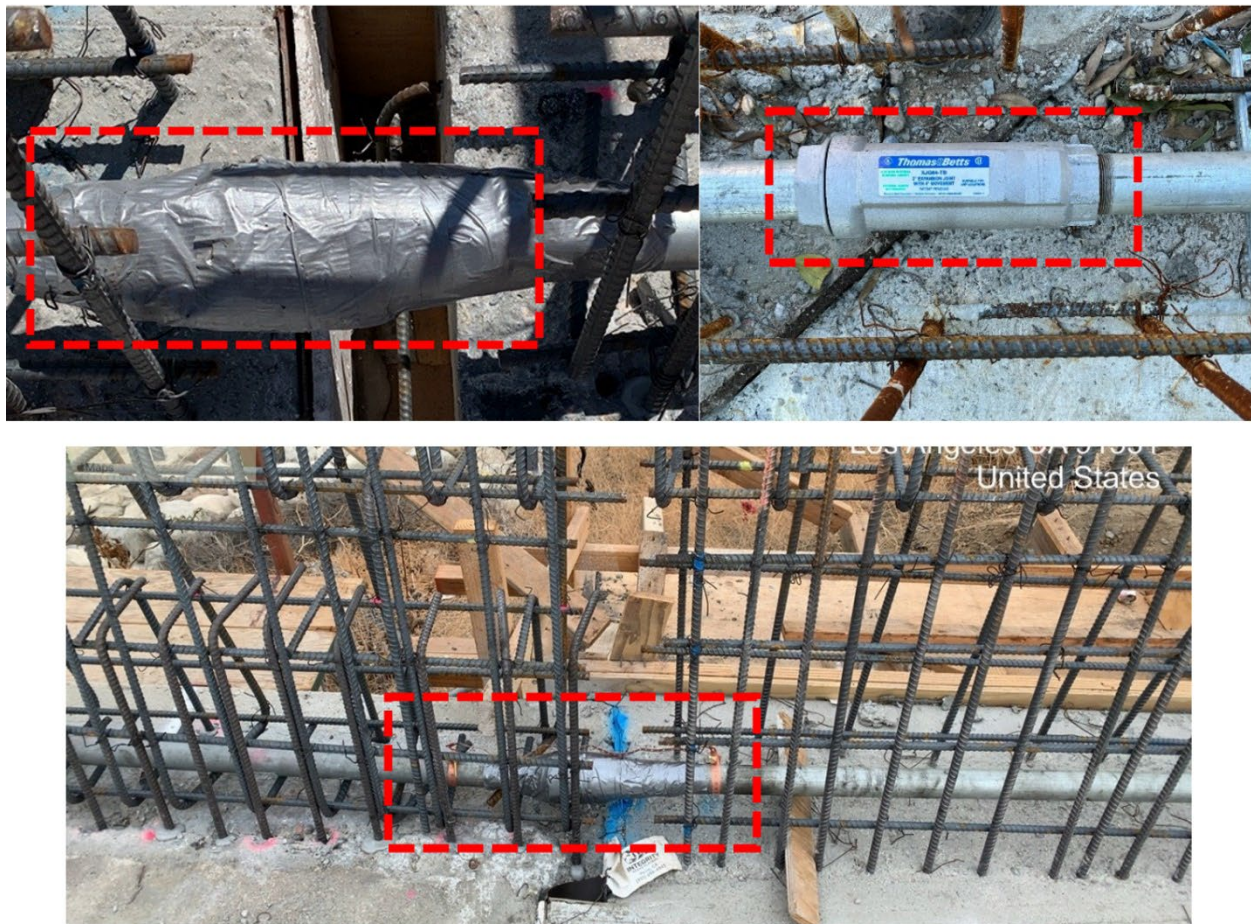


Figure 4-16. Utility Duct Expansion Joint Photograph

- Details to prevent water and debris from entering joints** – When constructing a barrier, the standard plans provide several details to prevent water and debris from entering joints. Water can result in the corrosion of metal objects. If debris can enter joints, dirt might hinder the free movement of structural elements, which might result in additional stress to the structure and premature failure of the structural elements. Also, if water can enter joints, it might accumulate behind the retaining wall, creating hydrostatic pressure and possibly overloading the structure. Figure 4-17 and Figure 4-18 show example details provided in the *Standard Plans* to prevent debris or water from entering the joints; note that these details may differ slightly compared to the current standard plans.

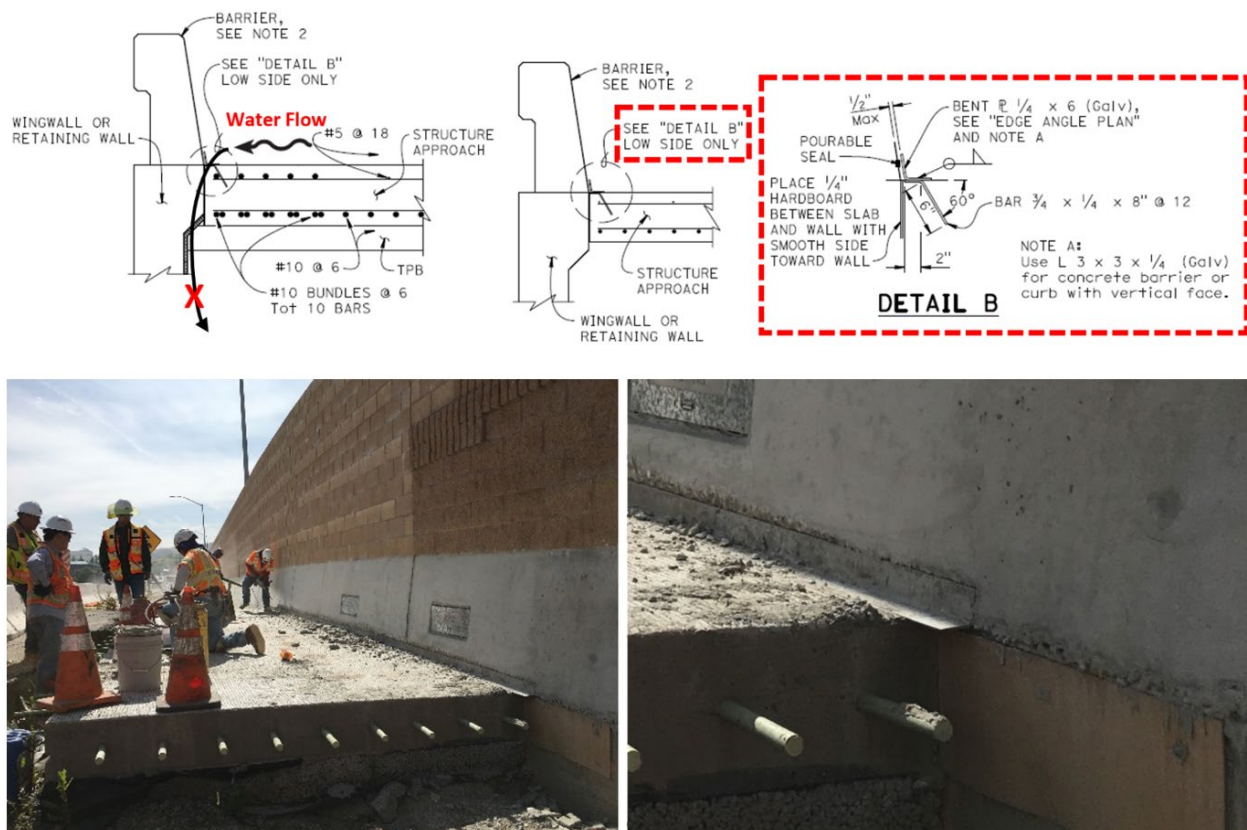


Figure 4-17. Angle Iron Provided at the Low-Side to Prevent Water Flow into Approach Slab Joint

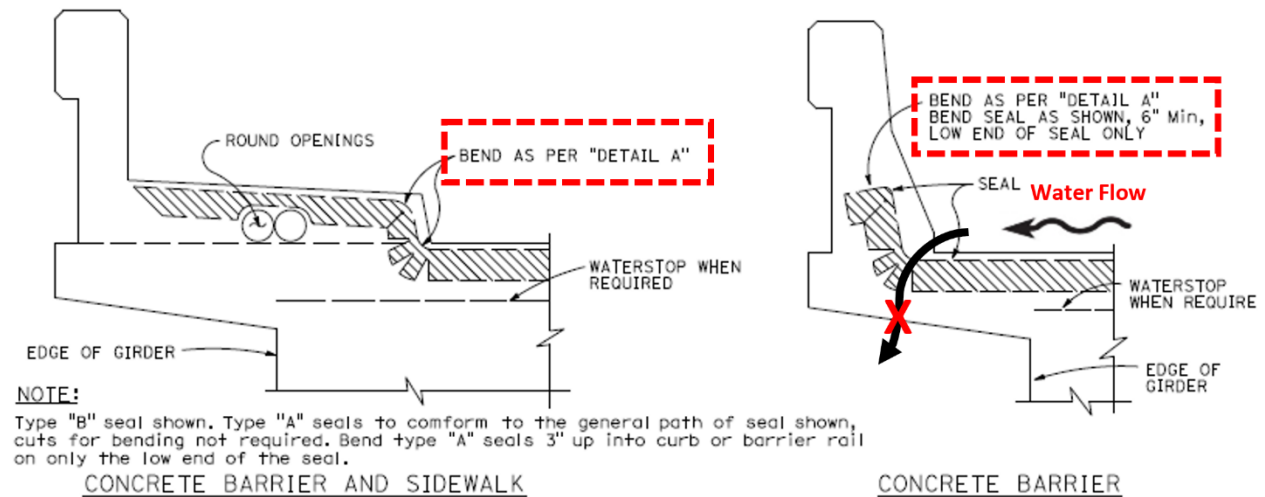


Figure 4-18. Joint Seals Are Bent Up at the Low-Side of the Deck into the Barrier to Prevent Water Flow into the Joint

It should be noted that not all details for preventing water from entering joints are shown in the standard plans; contract plans often have additional details for the same purpose. As an example, see Figure 4-19 for a sample detail that was provided in a contract plan. When installing joint seals or water stops, care must be taken to not damage existing utilities; the illustration of the utilities in the sidewalk in Figure 4-18 depicts this situation well. Refer to the following sections of this manual for additional information:

- Section 2-3.01, *General Practice and Considerations*
- Section 2-3.02, *Type A & AL Poured Seals*
- Section 2-3.03, *Type B-Compression Seals.*

- NOTES:**
1. FOR COMPLETE RIGHT OF WAY AND ACCURATE ACCESS DATA, SEE RIGHT OF WAY RECORD MAPS AT DISTRICT OFFICE.
 2. SEE STRUCTURE PLANS FOR ARCHITECTURAL DETAILS.
 3. WATERSTOP IN THE EXPANSION JOINT SHALL BE EXTENDED 6 IN INTO CONCRETE BARRIER.

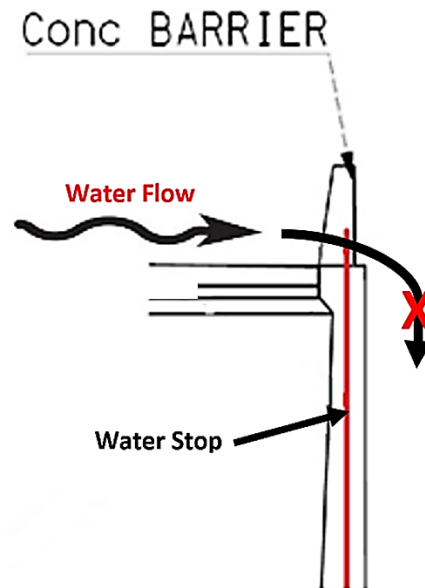


Figure 4-19. Water Stop Described and Illustrated in Contract Plans

Figure 4-20 illustrates what may happen due to a failed or incorrectly placed water stop.



Figure 4-20. Water Pouring out of Joint Due to Defective Water Stop

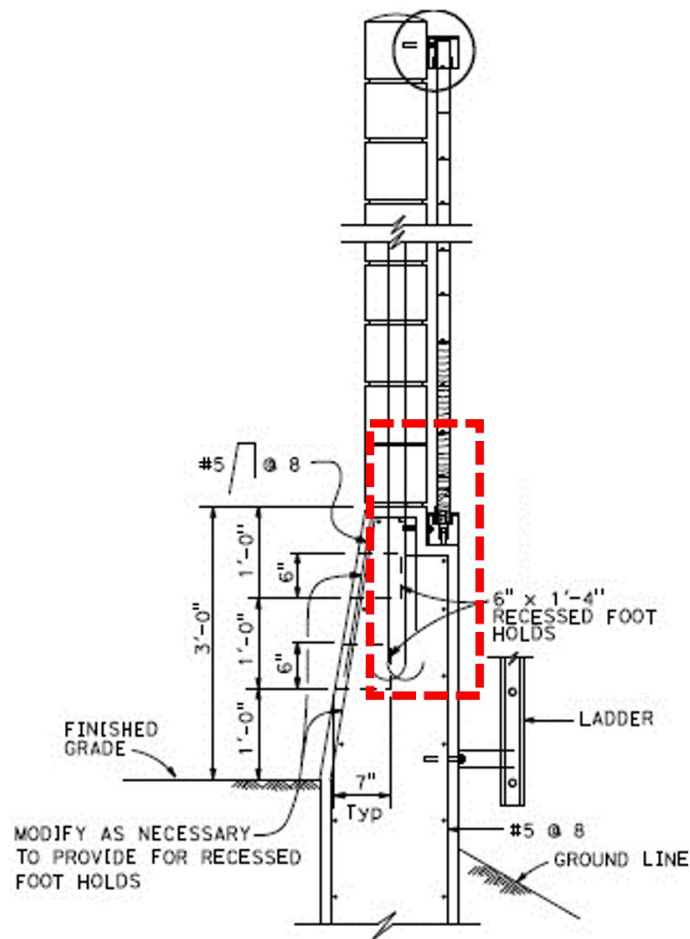


Figure 4-22. Example of Modification to Barrier Shape and Rebar Due to Installation of Access Door

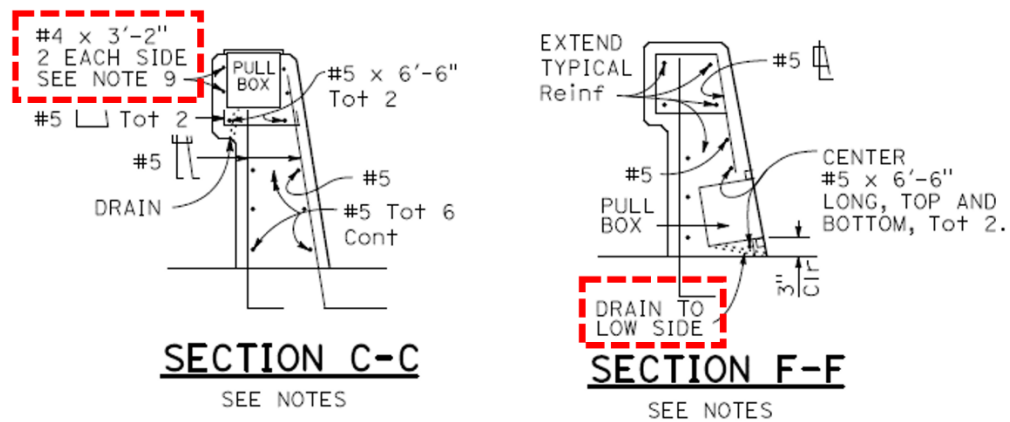


Figure 4-23. Examples of Barrier Modifications: Installation of Drain and Additional Rebar for Pull Box Placement

4-2.04 Safety Requirements

Each Caltrans project will have a project Code of Safe Practices (COSP) in which anticipated activities and associated safety concerns are listed. Barriers provide fall protection for Caltrans personnel, the Contractor's employees, and the public.

Pending completion of a barrier rail, a temporary system must be put into place to protect people, as illustrated in Figure 4-24. On rehabilitation projects, the Contractor must submit a fall protection plan to be reviewed and authorized before an existing barrier is removed.

Cal/OSHA [Construction Safety Orders](#), § 1620, *Design and Construction of Railings*, provides requirements for temporary railings. If temporary railings are not feasible, the plan can allow alternative methods such as controlled access zones (see Cal/OSHA § 1671.2, *Controlled Access Zones and Safety Monitoring Systems*, for more details). The most important component of any fall protection zone plan is the identification of the Safety Monitor. This person's role is to guard the zone and restrict access; they shall not have any other task assigned while performing their watch.



Figure 4-24. Temporary Fall Protection

4-3 Barrier Upgrade Project Administration and Field Inspection

In the previous section of this chapter, contract requirements for the construction of barriers were discussed. In this section, the typical construction sequence of barrier replacement will be discussed and the activities that SC staff perform during the construction process to verify the Contractor's compliance with the project requirements will be described. SC has developed [Bridge Construction Memos](#) (BCMs) that align with the *Standard Specifications* and provide guidance to SC staff. These BCMs are contained in the *Bridge Construction Records and Procedures (BCR&P) Manual*.

4-3.01 Temporary Structure and Bridge Removal

The Contractor's authorized bridge removal work plan submittal serves as the plan the Contractor must follow when removing a bridge or portions of a bridge. SC staff inspecting bridge removal must have a copy of the authorized submittal during the removal operation. SC staff need to review the submittal before the removal operation begins, to verify Contractor compliance with the same. SC staff should always verify that the latest version of the removal plan is being used.

Before the Contractor begins the bridge removal operation, SC staff shall verify the bridge removal limits for that shift. If the authorized bridge removal submittal requires the installation of temporary supports to achieve stability, refer to *Contract Specifications* Section 48-3.01C(2), *Temporary Structures – Temporary Supports – General – Submittals – Shop Drawings*, for submittal requirements of the temporary support. The remaining structure must be stable at all times during the bridge removal operation. Both the temporary support submittal and the bridge removal submittal need to be authorized before the bridge removal operation begins.

In addition to providing stability for existing structures, temporary structures may also be utilized to provide a protective cover for people, property, and the environment by catching falling debris. Per *Standard Specifications* Section 48-3.02B, *Temporary Structures – Temporary Supports – Materials – Design Criteria*, temporary supports made for protective covers must meet the requirements of sections 48-2.02B(3), *Temporary Structures – Falsework – Materials – Design Criteria – Stresses, Loadings, and Deflections*, and 48-2.02B(4), *Temporary Structures – Falsework – Materials – Design Criteria – Special Locations*.

After bridge removal, temporary structures might also be required to support forming and to create a walkway. BCM D-4, *SC Field Review of the Temporary Structures (Falsework)*, establishes the procedure for field review of the temporary structures. See Figure 4-25 for a temporary protective structure over an environmentally sensitive area (ESA). Protective covers over ESA, traffic, or railroad property must also be constructed before starting removal activities.



Figure 4-25. Temporary Protective Structure Used for Forming Support and Walkway

4-3.02 Surveying and Grading

Surveying and grading are required for constructing a barrier. The objective of surveying and grading is to have smooth profile lines for the finished barrier. SC staff need to ensure the transition from the bridge barrier to the adjacent roadway barrier has a smooth profile. See *Standard Specifications* Section 83-3.01D(2)(b), *Railings and Barriers – Concrete Barriers – General – Quality Assurance – Quality Control – Barrier Smoothness*, for barrier grading requirements.

According to *Standard Specifications* Section 83-3.03A(3), *Railings and Barriers – Concrete Barriers – Construction – General – Adjusting Barrier Height*, for concrete barriers constructed on existing pavement or an existing structure, adjustment to the height of the barrier is performed to compensate for irregularities in the existing grade. The following is an overview of how a concrete barrier constructed on a recently completed bridge may be adjusted to provide a visually smooth profile to the traveling public. The barrier height may need to be adjusted to compensate for the bridge camber, dead load deflections, and construction inconsistencies. Surveying the new bridge deck should be done after the superstructure construction has been completed and the falsework has been released. When surveying a long bridge deck, intervals of 10 feet are commonly used and a profile of the bridge deck is plotted; noting the areas that may be low/high, resulting in an undulating bridge deck. Some short bridges can be “sighted” down the barrier forms to identify any low points. It is important to note that it is only allowable to raise the barrier forms by shimming the base to provide a visually smooth barrier, while maintaining minimum barrier heights for safety concerns. When administering barrier construction projects, [BCM 83-3](#), *Railings and Barriers – Concrete Barriers*, establishes the process that must be followed by SC staff.

4-3.03 Drill and Bond Dowels and Anchor Bolts

When shown on the contract plans, drilling and bonding of rebar into the existing bridge deck may be used to connect the new barrier to the bridge. Drilling and bonding of anchor bolts may be used for attaching various items, such as a column cover steel plate on the barrier (see Figure 4-26). The following *Standard Specifications* sections, all contained within the common path of 51-1.03E, *Concrete Structures – General – Construction – Miscellaneous Construction*, describe the requirements for drilling and bonding of dowels:

- 51-1.03E(3), *Drill and Bond Dowels*
- 51-1.03E(4), *Drill and Grout Dowels*
- 51-1.03E(5), *Drill and Bond Dowel – Chemical Adhesive.*



Figure 4-26. Column Protection Steel Cover Plate Installed with Drill and Bond

During overhang and barrier replacement, drill and bond operations may be used to construct the overhang and the barrier. Examples of drill and bond for overhang construction may include drilling and bonding of rebar into the exterior stem to replace any damaged deck rebar during existing overhang removal or as additional rebar for construction of the new overhang; see Figure 4-27.

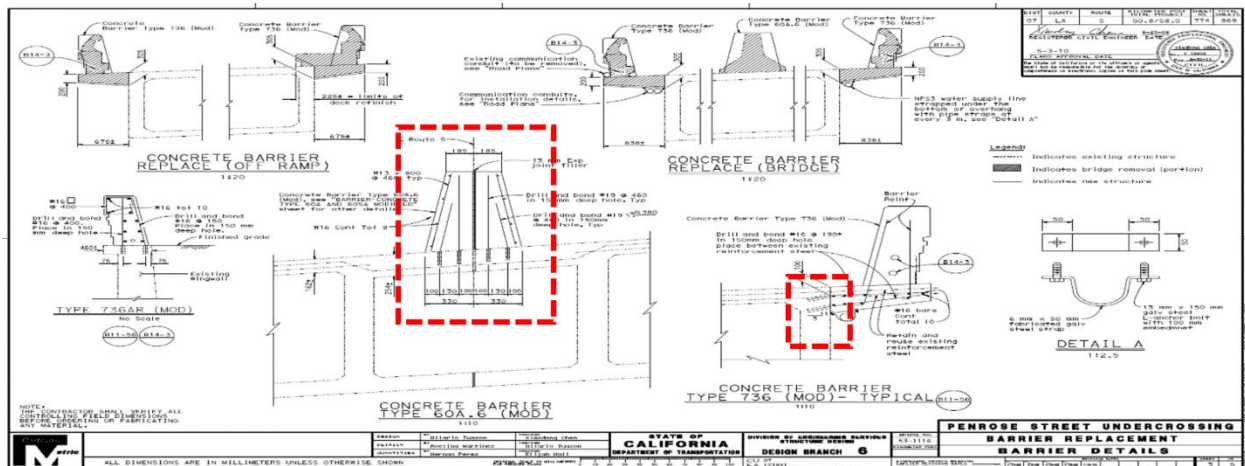


Figure 4-27. Drill and Bond Used for Construction of Barrier and Overhang

BCM 51-1.03E, *Concrete Structures – General – Miscellaneous Construction*, provides further explanation of the process that SC staff must follow when inspecting bonding material. When installing drill and bond dowels or expansion anchors, the strength of the installed dowels can be affected by the condition of the concrete. Cracked, chipped, and spalled concrete might not have enough strength to support the design load on a dowel. Additionally, damage to the drilled hole might prevent proper confinement of the bonding material and allow for the bonding material to drain out. A dirty concrete surface will also adversely affect the proper bonding of the dowel. During inspection of the drill and bond dowel operation, SC staff must perform the following:

1. Verify that loose, chipped, and spalled concrete is removed and that the holes are drilled into sound concrete.
2. Verify holes are drilled true to the dimensions shown on the contract plans. Over-drilling can result in a through hole that would allow for the bonding material to drain. Verify that holes are drilled to the depth shown in the contract plans. Commonly, contractors wrap tape on the drill bit to mark the desired depth of the hole, or they use drill stops, as illustrated in Figure 4-28.



Figure 4-28. Use of Tape Around Drill Bit or Drill Stop to Achieve the Desired Hole Depth

3. Verify the diameter of the drilled hole is the correct size. For drill and bond dowels, SS 51-1.03E(3) states that holes for bonded dowels must be 1/2 inch larger than the nominal dowel diameter, as shown in the contract plans. The size of the hole can be verified by reading the drill bit size on the shank; see Figure 4-29. The required hole diameter varies depending on the type of bonding product used; note the hole size required for drill and grout dowels in SS 51-1.03E(4), or drill and bond with chemical adhesive in SS 51-1.03E(5).



Figure 4-29. Drill Diameter Size Marking on The Shank of Drill Bit

4. Verify holes are drilled per locations shown in the contract plans; this will allow for proper edge distance and center-to-center spacing. Consult with the Designer if existing rebar interferes with the hole locations.
5. After drilling, verify that the holes are dry and clean. A clean hole is often achieved by a combination of blowing compressed air into the hole and brushing; it is important to read and comply with the manufacturer's instructions for the specific product used. Similarly, the dowels need to be inspected to verify that they are clean and free of any oil or residue that might prevent proper bonding.
6. After placing the bonding material and inserting the dowel into the hole, verify that the hole is filled up and that the level of bonding material does not change with time. The level of bonding material remaining constant is a good indication that the drilled hole is a blind hole and not a through hole. Through holes are sometimes inadvertently created due to over-drilling or the existence of voids in the concrete (such as in a voided slab or a utility). Any change in the level of the bonding material must be investigated and appropriate corrective action taken.

After installing the dowel into the hole, SC staff need to verify that the dowels are left undisturbed for the correct duration, depending on the bonding material used and in accordance with the following guidance:

- Per SS 51-1.03E(3), drill and bond dowels require 3 hours or until the dowels can be supported by the concrete.
- Per SS 51-1.03E(4), drill and grout dowels require the grout to be cured for 3 days or until the dowels are encased in concrete.
- Per SS 51-1.03E(5), drill and bond dowels (chemical adhesive) require a minimum duration per manufacturer's recommendation.

Hitting or “sounding” each dowel with a hammer after the required set time is a quick and easy way to determine if the dowel and the epoxy/grout material have formed a good bond. You should hear a strong ping when striking the dowel with a hammer. A hollow or dead sound means the dowel is most likely not properly bonded or set. As outlined in the specifications, the Contractor needs to replace a defective dowel.

SC staff must verify that the Contractor’s proposed bonding material is on the Materials Engineering and Testing Services [Authorized Material Lists](#) (AML). If epoxy is used to bond dowels, conform with requirements outlined in *Standard Specifications* Section 51-1.03E(5) introduced previously, and guidance in [BCM 95-1](#), *Epoxy – General*. SC staff must also verify the Contractor follows the manufacturer’s directions for the epoxy application.

4-3.04 Reinforcing Bar Placement and Forming of the Barrier

Field inspection of reinforcing bar (rebar) placement and concrete forming during a barrier replacement is generally the same as for any other type of concrete structure. As such, routine inspection duty for rebar placement and forming is not repeated here, and only activities specific to the barrier rebar placement are discussed. For general information and routine inspection activity, please refer to the Caltrans *Concrete Technology Manual* and BCM 52-1, *Reinforcement – General*, and BCM 52-6, *Reinforcement – Splicing*, of the *BCR&P Manual*.

On bridge rehabilitation projects, the contract plans typically note portions of the existing rebar to be preserved during bridge removal operations. Existing rebars that are to be incorporated into the new construction must be protected in place and verified that they are clean, undamaged, and free of loose concrete or debris. Occasionally, during the removal process, a portion of existing concrete may be chipped or damaged beyond the removal limit shown in the contract plans. Additionally, the original structure may not have been built exactly per plan and structurally critical rebar may not be exactly where they are expected to be. These two occurrences, separately or combined, can expose elements that were not anticipated, and can potentially separate or compromise load-bearing elements from the structure, weakening it in ways not contemplated during the design phase. Bridge Design must be consulted if concrete bonded to load-carrying rebar is damaged; see Figure 4-30 for an example.

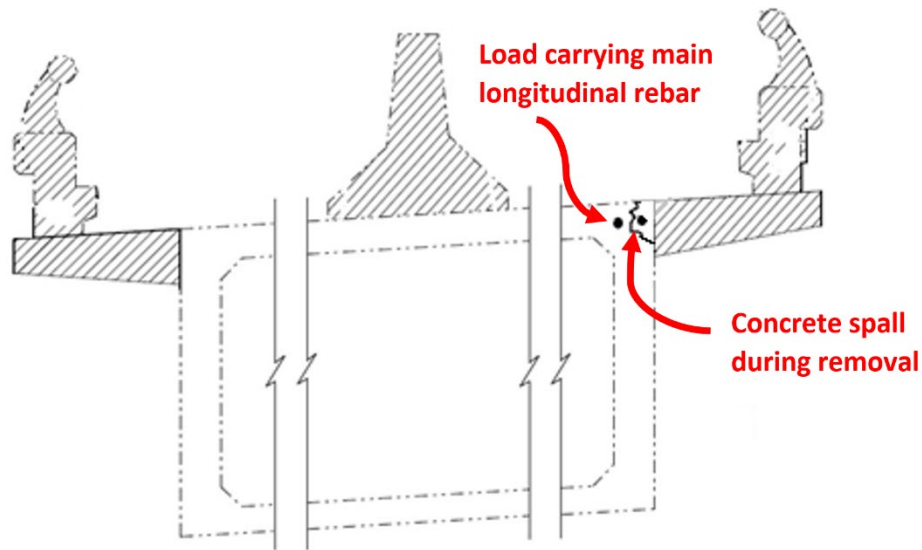


Figure 4-30. Bridge Cross Section and the Main Longitudinal Rebar Needing to Remain in Place

For new overhangs, the inspection of the barrier rebar, including the placement, size, and length of the rebar, must start at the time of overhang construction. It should be noted that a portion of the vertical rebar placed in the barrier are installed at the time of the construction of the overhang. During overhang and barrier inspection, the rebar layout must be verified to see if it accommodates all modifications to the barrier. For example, modification to the barrier for the installation of soundwalls or electroliers will affect the barrier rebars embedded into the overhang; see Figure 4-31.

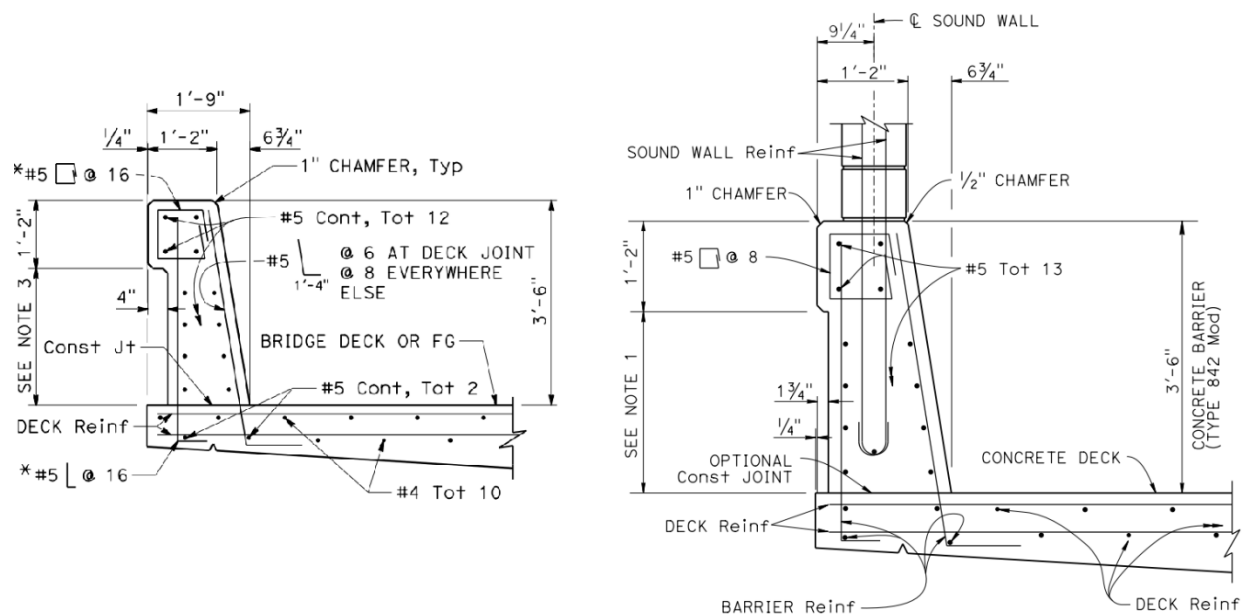


Figure 4-31. Type 842 Barrier (Standard) vs Modified (Supporting Soundwall)

For construction of new barriers, cast-in-place-with-fixed-forms method (CIP-FF) is required for all barriers except the Type 60 barrier. See Figure 4-32 for an example of CIP-FF barrier forming. When CIP-FF is used, *Standard Specifications* Section 83-3.03A(6)(b), *Railings and Barriers – Concrete Barriers – Construction – General – Barrier Construction Methods – Cast-In-Place-with-Fixed-Forms Method*, prohibits the use of PC mortar blocks (referred to as “dobies” in the field) to support the reinforcing steel on the traffic side of barriers.



Figure 4-32. CIP-FF Forming: No PC Mortar Block Is Attached to Traffic Side Rebar

For barrier Type 60 series, the specifications allow extrusion or slip form method in addition to the CIP-FF. See Figure 4-33 for an example of slip forming. For concrete barriers constructed using extrusion or slip form methods, SC staff must verify the following:

- The horizontal reinforcing bars are placed continuously, and the reinforcement does not deviate more than 1 inch from the positions shown.
- The means and methods used by the Contractor provide the required minimum rebar clearances shown in the contract plans.
- In freeze and thaw areas, the reinforcing steel is epoxy-coated.



Figure 4-33. Example of Slip-forming

An item of interest when forming concrete barriers at the edge of bridge decks, such as the concrete barrier Type 842 illustrated in Figure 4-12, is the flat area of the deck between the EOD and indented face of the rail. For the standard Type 842 rail, this indentation creates a 4-inch-wide ledge, which is useful to support the barrier forms. See Figure 4-34 for a modified concrete barrier, with a similar indentation that creates a supporting surface.

In cases where this indentation is missing, forming and finishing the barrier rail may pose some challenges. An example would be a Type 842 modified concrete barrier to support a sound wall on top of a retaining wall; see illustration in Figure 4-35.



Figure 4-34. Support at Edge of Bridge Deck that Was Utilized During Barrier Forming

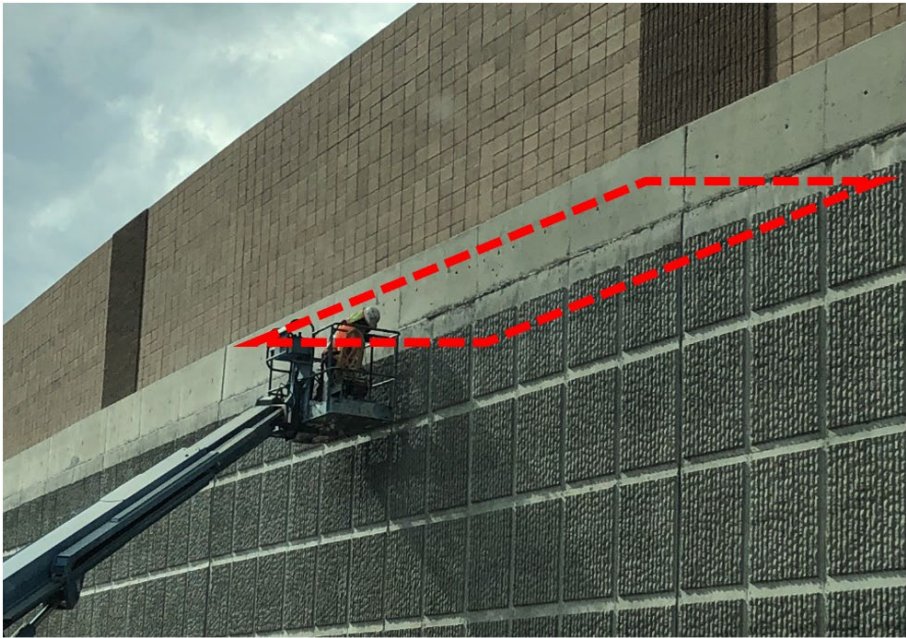


Figure 4-35. Barrier Constructed Without Form Support Requiring Extensive Finish Work

Vertical rebars of the barrier pose an impalement risk to the workers and the public. SC staff need to verify that proper impalement protection is provided. Commonly, wood members that are 2 by 4 inches are used to cover the top of the rebar, as illustrated in Figure 4-36. Other methods of impalement protection can also be used.

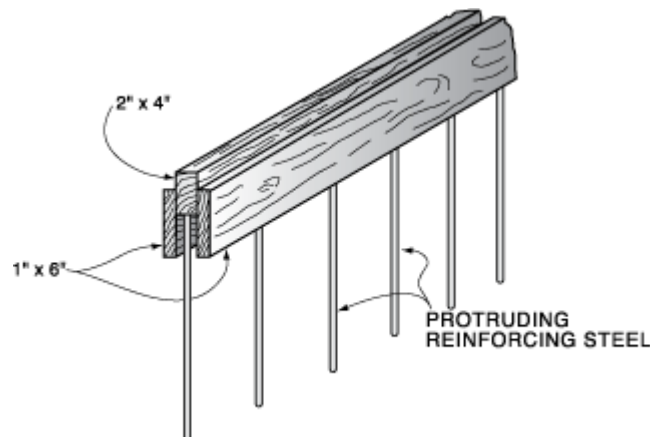


Figure 4-36. Impalement Protection for Barrier Rebar

4-3.05 District-Assigned Items/Miscellaneous Items

Assistance from a Resident Engineer (RE) may be sought for inspection of a utility and to verify that all required hardware for the utility is correctly installed. Before closing of the barrier forms, it should be verified that all embedded hardware is installed securely. The traffic side of barriers is a highly visible surface to the traveling public and proper placement of hardware, such as pull boxes, provides pleasing aesthetics.

4-3.06 Sound Walls

For barriers with sound walls to be constructed on top, pay special attention to rebar placement in the barriers (e.g., not having the appropriate clearance to the rebar), inconsistent concrete masonry unit (CMU) block spacing, or insufficient CMU block edge distance to the face of the barrier. Commonly, inspectors create templates of the concrete CMU blocks using cardboard or plywood. Inspectors would then use the CMU block template to quickly verify rebar placement and appropriate rebar clearances inside the CMU blocks. It is very important that CMU rebar placement is verified before barrier concrete placement. See Figure 4-37 for an example of CMU block template used for verifying proper rebar placement and clearance.

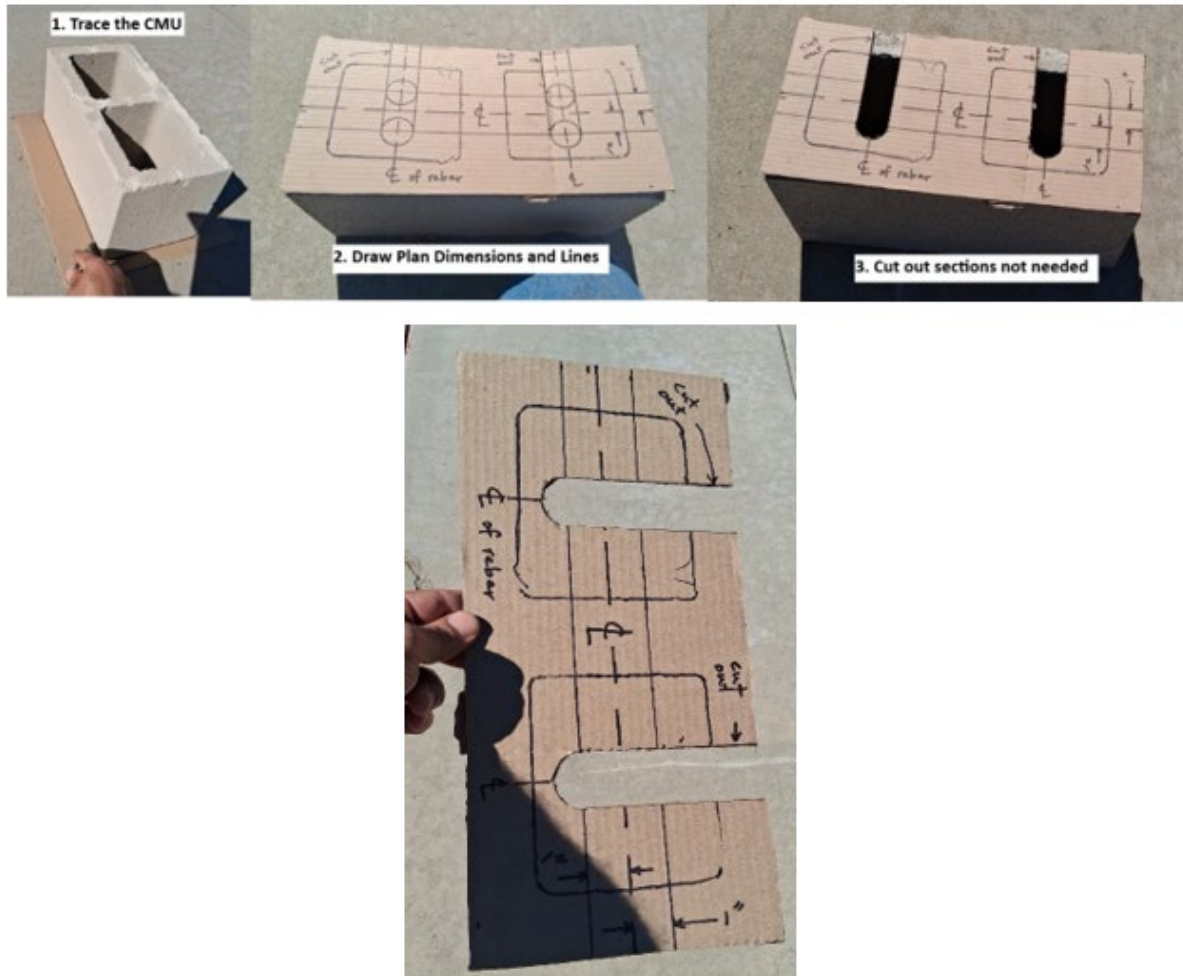


Figure 4-37. Photo of CMU Block Template

4-3.07 Pour/Cure/Finishing

As stated previously, depending on the type of barrier, the CIP-FF method or extrusion/slip form method may be used. Construction using CIP-FF is a common method for many types of concrete structures and will not be covered here. Slip forming is a construction method in which concrete is poured into a continuously moving form. It allows for continuous cast-in-place "flawless" (i.e., no joints) concrete structures, which have superior performance characteristics compared to piecewise construction using discrete form elements. Slip forming is a more economical method of construction when it is used for long sections of a barrier. A proper concrete slump is required to maintain a balance between the workability of the concrete to take the formed shape and to minimize deformation. The equipment used for extrusion or slip-form construction is bulky, requiring room to operate. *Standard Specifications* Section 83-3.03A(6)(a), *Railings and Barriers – Concrete Barriers – Construction – General – Barrier*

Construction Methods – General, allows extrusion or slip form construction for Type 60 series only. Type 60 barrier is commonly installed for long lengths using a consistent cross-sectional shape, and there is often space available in the roadway median to operate the required machinery.

To verify that the slip form construction method for a barrier is acceptable, the Contractor may be required to submit evidence of successful operation of the slip form method or other equipment, as outlined in *Standard Specifications* Section 83-3.03A(6)(c)(ii), *Railings and Barriers – Concrete Barriers – Construction – General – Barrier Construction Methods – Extrusion or Slip form Method – Placing Concrete*. Basic inspection activities for a concrete pour (such as verifying mix design number, monitoring temperature, checking slump, etc.) using slip forming are the same as the traditional CIP-FF construction, and will not be discussed here. Shortly after the concrete is poured, SC staff must install permanent reference elevations as described in [BCM C-13](#), *Permanent Reference Elevations*, into the fresh concrete.

After the placement of concrete, the method of curing and finishing for slip forming is significantly different from CIP-FF; see *Standard Specifications* Section 83-3.03A(7), *Railing and Barriers – Finishing*. In slip forming, before the start of curing, it must be verified that the concrete finish is free of surface pits larger than 1 inch in diameter and that the Contractor applies soft brush finishing before application of curing. Accordingly, for a Type 60 barrier, Class 1 surface finish is not required since slip forming is frequently used. For the Type 60 barrier, curing compound is applied after initial finishing, and a final light abrasive finishing is applied after 7 days. For barriers other than Type 60, CIP-FF is the only type of construction allowed.

For barriers other than Type 60, finishing work can be done after curing; the curing can be done either by forms-in-place or by using a curing compound. Note the unique curing requirements found in *Standard Specifications* Section 83-3.03A(8), *Curing*. After curing is complete, the inspector must verify that the Contractor can provide a Class 1 surface finish. Note that any alternative method of surface finishing must be authorized. BCM 51-1.03F(1-4), *Concrete Structures – General – Finishing Concrete*, establishes the process for inspection of concrete finishing. The [Reinforced Concrete Construction Manual](#) Section 5-13, *Concrete – Concrete Surface Finish*, discusses Class 1 finishing and whip blasting.

4-3.08 Outputs

During construction of any project, SC staff are required to collect and maintain certain project records and to submit certain records to SC Headquarters during the construction and upon completion of the project. [BCM C-6](#), *Required Documents to be Submitted During Construction*, describes the process and the documents to be sent to SC Headquarters. For barrier replacement construction, SC staff are required to complete as-built project plans that include permanent reference elevations.