Chapter 6: Bridge Removal Elements

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6-1 Barrier Rail and Edge of Deck

Partial bridge removal includes barrier rail removal and edge of deck (EOD) removal. A barrier rail upgrade to modern safety standards requires the removal of the existing barrier rail and sometimes the EOD, if the new rail is wider than the existing barrier rail and in cases of sliver widenings. EOD bridge removal most often occurs when widening a bridge. With a widening, the existing transverse reinforcement is typically used to splice to new reinforcement in the new deck. This is achieved by removing a portion of the deck concrete while preserving existing reinforcing steel.

In barrier rail and EOD removal operations, the *Contract Specifications*, Section 60-2.01C, *Existing Structures – Structure Removal – General – Construction*, limits the striking energy of impact hammers to 1,200 ft-lb per blow. This maximum energy limitation attempts to preserve the existing concrete that is to remain in place. The required 1-inch-deep relief saw cut also attempts to preserve the existing concrete. Unfortunately, neither requirement guarantees the desired preservation. A good understanding of the means and methods of breaking concrete effectively and efficiently with skillful operation of the hammer, coupled with competent supervision and field engineering, leads to good results.

Accommodating public traffic while widening a bridge is common and usually necessary for public convenience. Re-striping the traffic lanes to temporarily reduce lane widths and/or shoulders is often necessary to provide room for a temporary barrier system and access to the work. On most projects, space is limited so the temporary barriers must be anchored to the bridge deck as there is no space for temporary barrier displacement if vehicular impact occurs. Gawk screens (Figure 6-1) are often used; they provide some worker protection and reduce excessive queuing in the traffic lane.

Where an adjacent traffic lane is necessary to facilitate the work, traffic requirements often dictate off-peak traffic demand and the working hours. In many urban locations this requires night-time lane closures. Night work comes with additional safety concerns and equipment, including placement of light plants at locations where the glare doesn't impact traffic. Workers are required to wear the appropriate reflective garments and the work window must provide additional time to set up and take down the lane closure with the required equipment.

Edge of deck removal requires a 1-inch-deep saw cut made along the length of the bridge at the removal location. Storm Water Pollution Prevention Program (SWPPP) and environmental concerns require that the concrete slurry generated from the saw cutting operation be vacuumed up as the cutting proceeds. If less than the entire cantilevered portion of the bridge overhang is removed, then a second saw cut is required on the underside of the overhang. This second saw cut can be more difficult to perform and is sometimes accomplished with a smaller dry cut saw.

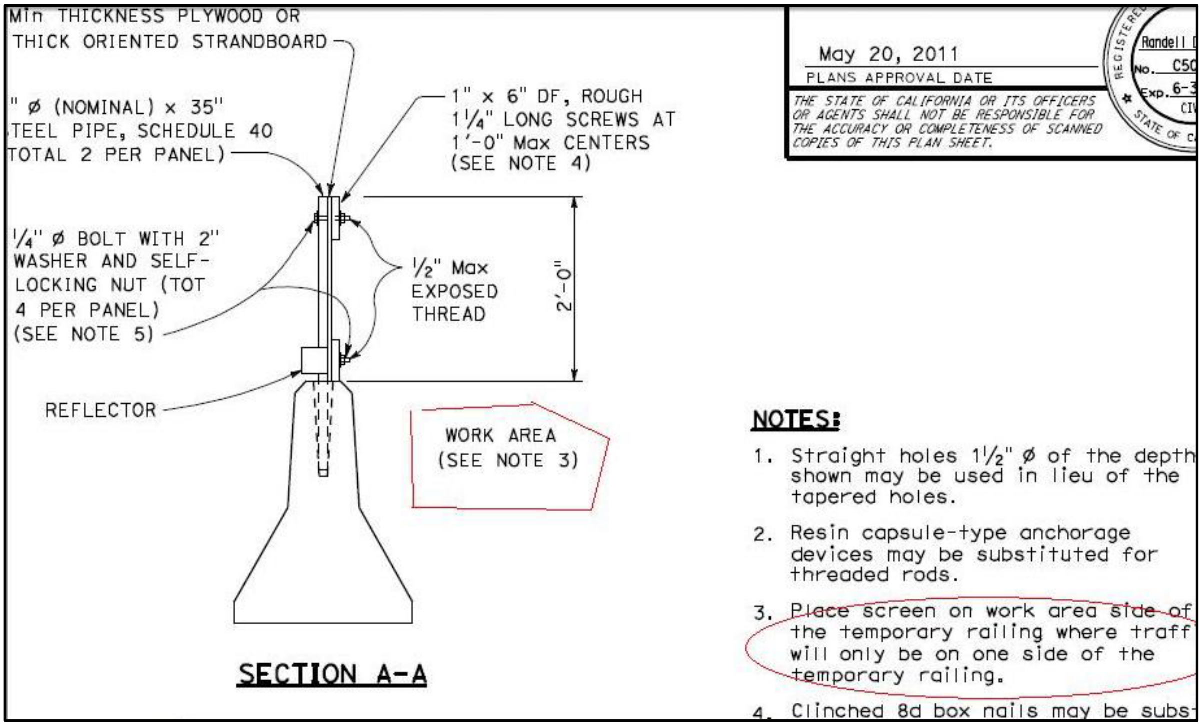

Figure 6-1. Gawk Screen Example

Where it is possible for debris to free fall below the structure, protective covers must be installed. Protective covers are required over traffic, railroad property, water, or other environmentally sensitive locations.

The *Contract Specifications*, Section 60-2.02C(2), *Existing Structures – Structure Removal – Bridge Removal – Construction – Protective Covers,* states: “At locations where only bridge railing is removed, protective covers must extend from the face of the exterior girder or at least 2 feet inside of the railing to be removed to at least 4 feet beyond the outside face of the railing.”

Figure 6-2. Rail Replacement Protective Cover, Sacramento

This specification assumes a typical situation of a standard bridge rail and does not mention that a portion of the deck may also need to be removed. Sometimes a widening requires removal of the entire bridge deck overhang, back to the face of the exterior girder. At other times, a bridge rail is replaced without removing any portion of the bridge deck. And sometimes the removal is somewhere in between. Figure 6-2 shows a protective cover installed for a bridge rail replacement. It served the situation well, but the reader can see that, unless the plywood was more than 6 feet wide, it did not meet the specified requirements, as the minimum distance of 2 feet inside of the rail is not met. The specification anticipated some separation between the soffit and the plywood cover, which can occur when a girder mounted overhang bracket is installed to support a protective cover.

Figure 6-3. Custom Debris Box used for Edge of Deck Removal

6-1.01 Bridge Rail Removal Work Plan

A bridge removal work plan for bridge rails will vary depending upon the reason for removal and the type of rail. Common reasons include upgraded rail replacement or bridge widening. Preservation of elements not to be removed is essential. The contract *Special Provisions* for protecting existing elements often include:

1. Authorization of a written plan
2. Maximum energy limits on hydraulic hammers
3. Partial relief saw cuts to limit spalling
4. Professional monitoring of the bridge removal process.

Bridge rail removal is often performed behind temporary barriers, or with traffic detoured. The method of debris management increases in importance when removal is over traffic, waterways, or other sensitive locations. Field engineering is to ensure compliance with the authorized written plan and, more importantly, that the removal operation is effective in meeting the desired results.

Figure 6-4. Asbestos Shim Removal

Figure 6-5. Commercial Suspended Debris Box

Figure 6-6. Suspended Debris Containment Platform

Sometimes a custom debris box suspended from a crane is used when removing the bridge rail. A debris box is, at times, used for the Contractor's convenience even when a protective cover is not required. A debris box needs to be evaluated for the requirements of a protective cover, which depends on the construction and configuration of the box. A debris box suspended by a crane is prohibited where the load is suspended over traffic or over a railroad where the railroad requires a protective cover. However, a box might meet the intent of the specification over an environmentally sensitive area where there is no prohibition to suspended loads. When the Contractor opts to use a debris box, the size of the debris box, the load demand, and the capacity would all require evaluation. Typical debris boxes are illustrated in Figure 6-3 and 6-5.

Cranes and bucket devices, as well as any debris platform, will have load limits that may require intermittent debris removal to prevent overloading. Debris falling to the ground may require protecting paved surfaces or buried utilities. See Figure 6-6 for an illustration of a debris containment platform, and Figure 6-7 for an illustration of general bridge barrier removal.

Older metal railings are sometimes supported on asbestos shims (shown in Figure 6-4) or have lead paint, which require special removal procedures. Bridge rails sometimes contain conduits for utilities that need to be addressed in advance of removal.

Hazards to be considered for bridge rail removal operations include:

1. Noise restrictions
2. Ear and eye protection
3. Air quality concerns including demolition generated airborne contaminates
4. Fall protection
5. Traffic management
6. Debris platform limitations
7. Falling debris and site access control.

Some other safety considerations are:

- Lack of preliminary engineering survey by a competent person which could result in an unforeseen failure or a Cal/OSHA citation. Bridge rails may contain lead paint, asbestos containing materials, embedded electrical conduits, and the EOD presents an ever-present fall hazard. The preliminary engineering survey and the bridge removal work plan seek to identify and mitigate these hazards.
- Demolition activities can be an attractive nuisance. Bystander access should be discouraged, and screening used where appropriate. Controlled access is necessary everywhere, but particularly in urban areas and on high profile bridges.

Figure 6-7. Barrier Rail Removal, Dry Creek

6-2 Deck

Not all bridges are candidates for complete concrete deck removal and replacement, as many structures were post tensioned after the deck was placed, and girder damage may occur if the dead load of the deck is removed. However, steel girders, most precast concrete girders, and conventionally reinforced concrete box girder bridges may be suitable for complete deck replacement. Occasionally, temporary shoring or lateral restraints may be necessary. Care is required to protect the integrity of the bridge girders and diaphragms while the deck is being removed. A full-length saw cut may be used to prepare a portion of deck for removal as illustrated in Figure 6-8.

Figure 6-8. Sawing Deck for Removal, Yellow Creek

Steel girder and most precast concrete girder bridges can have the deck removed as the first stage of a complete bridge removal; see illustration in Figure 6-12. Debris platforms supported on the bottom flanges of the girders can be an effective containment option. Demolition equipment can be operated on the bridge deck and backed off as work progresses. Removal of a concrete deck from a steel girder bridge without shear studs or shear clips can be relatively clean if saw cut full-depth and then lifted off with an excavator with a slab removal attachment or bucket and thumb; this is illustrated in Figures 6-9 and 6-10. The slurry from water-cooled saw cutting and general debris requires containment.

Figure 6-9. Slab Removal Attachment on Excavator

Figure 6-10. Slab Removal with Bucket and Thumb on Excavator, Spanish Creek

Precautions need to be taken when using heavy demolition equipment adjacent to steel girders that are to be preserved. Girders need to be protected from damage including nicks, gouges, and cuts.

Bridge deck removal sometimes precedes complete bridge removal to ease removal of girders, to salvage bridge girders, or if concrete/asphalt surfacing is an environmental concern. See Figure 6-11 for an illustration of a slab deck removal.

Figure 6-11. Slab Deck Removal, Simmerly Slough

Figure 6-12. Bridge Deck Removal from Steel Girders, Acid Flat

Partial depth deck removal in the field as part of deck rehabilitation or along the edge of deck for rail work has the added concern of protecting the deck which is to remain in place. This usually requires relief saw cuts to limit spalling and handheld pneumatic hammers to minimize damage. Sawcutting, combined with removal of a specific portion of deck or bridge overhang, is often preparatory for a bridge widening. In that case, the existing rebar would be retained to facilitate joining the new and old bridge decks, as illustrated in Figure 6-13.

Figure 6-13. Sawcut Line and Reinforcement Preservation for Widening, Sacramento

Partial deck removal includes removing top surface cover by milling, grinding, or hydro blasting. It is the goal in these operations to preserve the concrete and reinforcing steel left in place. Constant monitoring of the depth of removal and soundness of the deck left in place is necessary. The as-built project plans may indicate a concrete cover of 2 inches over the existing reinforcement, but actual construction tolerance varies.

Partial deck removal is often part of deck joint repairs, including replacement of expansion joints or joint seals. Partial deck removal over steel girders to accommodate installation of shear studs is frequently part of a strengthening plan, as illustrated in Figure 6-16.

Figure 6-14. Unsound Concrete Removed for Repair After Asphalt Surfacing Removal

Partial deck removal includes removal of unsound concrete, as shown in Figure 6-14 above. Unsound deck concrete is usually identified by the field engineer and marked for replacement. The most common sounding device is a steel chain, but a hammer can also be used.

Figure 6-15. Coring Drainage Hole Through Deck

Grinding off the wearing surface of a bridge deck can sometimes cause temporary drainage issues. If the bridge deck is returned to traffic prior to installing a new wearing surface, a temporary drainage hole might be necessary; see Figure 6-15.

Figure 6-16. Installing Shear Studs on Steel Girders after Partial Removal of Concrete Bridge Deck

6-3 Girders

A common practice with steel girders is to remove the deck and salvage the girders. With modest spans, the entire girder can be removed at once. Long spans may require temporary supports and cutting the girders into convenient lengths before removal, an example of which is shown in Figure 6-17. Steel girders often have lead paint that may require abatement prior to flame cutting. Girders can also be cut with a hydraulic shear mounted on an excavator. Individual steel girders might have a stability issue once diaphragms are removed which should be addressed in the bridge removal work plan.

Figure 6-17. Excavator Mounted Hydraulic Shear Removing Steel Girder, Hamilton Branch

Concrete girders, including box girders, have been removed using the peck-and-sag method, where girders are weakened with a hydraulic hammer and allowed to sag to the ground. Often the peck-and-sag approach begins with substantial deck removal that eliminates the deck acting as a compression flange. The excavator is usually operated from the superstructure when removing portions of the deck, and from the ground when pecking at the girders. See Figure 6-18 for an illustration of girder removal.

Figure 6-18. Girder Removal, Imperial Ave, Imperial County

The nature and stability of the structure will often control the demolition sequence. For example, the location of a hinge will usually dictate that the long span in the hinged span be demolished first. Some structures, such as a multi-span arch bridge with three-pinned arches can progressively collapse; once a girder fails, the entire structure can be unstable and collapse. This illustrates the level of care and attention required in both developing the bridge removal work plan, as well as the execution in the field, to ensure a safe and controlled removal.

Girders demolished over a traveled way require some method to protect the structural section of the highway. A common protective cover is 2 feet of fill placed on top of the paved surface. Girders over water may require a trestle as a protective cover.

Figure 6-19. Wire Saw Cutting Concrete Girder Supported by a Crane

6-4 Bent Caps

Concrete bent caps that can be reached from the ground are usually removed with a hydraulic hammer mounted on an excavator. However, there are other techniques that can be employed, including diamond wire sawing in difficult to access areas or where there are other restrictions preventing the use of an excavator with a hydraulic hammer. See Figure 6-19 for an illustration of a wire saw, and Figure 6-20 for an illustration of bent cap removal.

Figure 6-20. Bent Cap Removal, Salsipuedes Creek

6-5 Bents and Columns

The typical removal sequence for bents and columns is from the top down with a hydraulic hammer mounted to an excavator. Caution is warranted, particularly in older bridges, where for safety reasons the column or bent should be considered pinned at the bottom due to a lack of tension steel tying the column or pier to the foundation. Wooden piles lacked any tension ties, as did early steel piles. Even if there is nominal tension steel on the as-built project plans, there is always the possibility that the connection has corroded, rendering it ineffective. Often, such a column can be pulled over, while at other times some additional weakening of the column's base is necessary for a controlled layover; see Figure 6-22 for an illustration. Figure 6-21 illustrates pier rotation after demolition of an arch, while Figure 6-23 illustrates weakening pile extensions in preparation for bridge removal.

Figure 6-21. Pier Rotation After One Span of 4-Span Arch was Demolished

Figure 6-22. Column Removal by Pushover after Weakening Base, Mulholland Drive, Los Angeles

Figure 6-23. Weakening Pile Extensions for Span by Span Removal, Simmerly Slough

6-6 Abutments

Usually by the time abutments are being removed, most of the “difficult” aspects of bridge removal are completed. However, abutments can also have their challenges. There have been instances where it was a necessity to protect property or environmentally sensitive areas adjacent to an abutment. Wildfires can also pose a threat in dry areas near the abutment, and care needs to be taken to prevent fires and to be prepared in the event of a fire caused by flame cutting. Further, abutments can be adjacent to historical buildings or utilities that require special consideration. Abutment removal in stage construction may require shoring to support the narrower abutment left in place. Figures 6-24, 6-25, and 6-26 illustrate various aspects of abutment removal.

Figure 6-24. Abutment Removal, Dry Creek

Figure 6-25. Partial Abutment Removal with Shoring and Temporary Support, Greenwood Creek

Figure 6-26. Wingwall Removal, Hat Creek

6-7 Footings

The *Contract Specifications*, Section 60-2.01C, *Existing Structures – Structure Removal – General – Construction,* requires that piling, piers, abutments, footings, and pedestals be removed to 1 foot below the ground line or 3 feet below finished grade, whichever is lower. The project specific PLACs (permits, licenses, agreements and certifications), *Special Provisions*, or plans may require otherwise, as a complete removal is sometimes necessary to install a new structure in its place. There may also be environmental or other conditions, which may require deeper removal.

6-8 Pilings

Typically the piles are left in place after footing removal, and the requirement to remove 1 foot below ground line or 3 feet below finished grade is satisfied. However, pilings can be completely removed with a vibratory hammer or a crane and core barrel. Concrete piles are generally more difficult to remove than steel piles; an operator might break the skin friction by first driving the pile deeper, and then extracting with a vibratory hammer or by jetting. See Figure 6-27 for an illustration of pile removal below grade. Removing piles from a waterway to three or more feet below grade can be more difficult than complete removal, and verification of partial removal in a waterway is always difficult.

Figure 6-27. Piling Removal Below Grade, Simmerly Slough

6-9 Special Locations

Waterways are locations that require special attention since access and environmental restrictions almost always make bridge removal more difficult and time consuming. Depending on the environmental restrictions, removal operations might be preceded by a water diversion or building of an isolation cofferdam. Trestles are often used to support a containment installation. Silt curtains, gravel pads, turbidity monitoring, and divers have been employed to remove, monitor, and verify bridge removal.

Some removal operations can be considered special bridge removal due to the existing conditions. See Figure 6-28 for an example of a partially collapsed bridge, which required special removal. Though not common, at times the safest, most environmentally sound, and economical method of removal is blasting. Two examples are the old Bay Bridge piers in the San Francisco Bay and the I-5 steel truss bridge across Shasta Lake.

Figure 6-28. Special Bridge Removal at a Partially Collapsed Bridge, Pfeiffer Canyon