State of California
Department of Transportation
Division of Engineering Services

Bridge Removal Manual

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Structure Construction
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Acknowledgements

The 2023 Bridge Removal Manual is the culmination of decades of experience and guidance in the removal or demolition of bridges. After the Loma Prieta earthquake in 1989, followed by the Northridge earthquake in 1994, there was a program of rapid removal, repair, and replacement of earthquake damaged bridges which highlighted the need for field staff guidance on how to administer the bridge removal contractual requirements, including railroad regulations. This need led the development of various Bridge Construction Bulletins to communicate guidelines for the consistent statewide administration of bridge removal work. Although the various Bridge Construction Bulletins were great guidelines and served their purpose, they were temporary in nature, so the need for a formal Bridge Removal Manual was recognized.

The effort to draft a new Bridge Removal Manual began in earnest in 2019 by the Temporary Structures Technical Team in Structure Construction Office A under the leadership of team sponsor, Steve Harvey, P.E., and later Bryan Bet, P.E. Steve Harvey recruited long-time Structure Representative, Gary Pelfrey, P.E., out of retirement to help write the initial draft of the manual. Gary and Steve's combined experience was invaluable in developing a manual that communicates the essentials of bridge removal. Principal author Richard Yates, P.E., worked with Gary Pelfrey, Jim Nicholls, P.E., and Høgni Setberg, P.E., to develop the topics and edit the manual. The principal development team is grateful to all the Temporary Structures Technical Team members and Area Construction Managers who took the time to provide valuable and insightful comments. These reviewers include Kari Forbes, S.E., Raman Guraya, P.E., Eric Urmeneta, P.E., and Justin Wood, P.E., from the technical team, as well as managers Tony English, P.E., Andy Gill, P.E., Tom Grey, P.E., and David Tenorio, P.E. Special thank you to Senior Bridge Engineers Roy Auer, P.E., Parvin Sebti, P.E., and Glen Wheeler, P.E., for reviewing and commenting on the manual as well.

Thanks to Cheryl Poulin, P.E., Roy Auer, Marty Cook, Barbora Rejmanek, and the Structures IQA branch for their review and editing to help maintain a professional and consistent presentation and for providing the tools and recommendations necessary to publish this manual.

Signed,

RICHARD FOLEY
Deputy Division Chief
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Chapter 1: Introduction

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1-1 Purpose and Scope

The *Bridge Removal Manual* has been issued by the Department of Transportation's Division of Engineering Services (DES), Structure Construction (SC). The intended purpose is to provide an educational resource and administrative support to the SC staff who are in responsible charge of bridge removal on State highway projects. Proper use of the *Bridge Removal Manual* requires a thorough understanding of the principles of civil engineering design and construction, and familiarity with the relevant *Contract Specifications*. The *Falsework Manual* is referenced several times and is an indispensable resource when considering stability, temporary supports, or protective covers during bridge removal operations.

The scope of this manual is to provide a resource for typical bridge removal on State highway projects and is not intended to cover all possible bridge removal scenarios. While the clear majority of Caltrans' projects with bridge removal can benefit from the use of this manual, there are many unique bridges and removal methods that this manual does not cover. Engineering judgment will be required to determine the applicability of this manual to a specific bridge removal project.

1-2 Statement of Structure Construction Policy

Structure Construction (SC) policy is to remove bridges (or portions thereof) in a safe, controlled manner that protects the public, workers, and the environment. This is accomplished through a thorough review and authorization process of the bridge removal work plan and verifying that the authorized plan is properly implemented during field removal activities.

1-3 Contract Specifications and References

Some of the key requirements for bridge removal can be found in the following *Contract Specifications* and references:

1. Caltrans *Contract Specifications*:
    a. Section 5, *Control of Work:*
        i. Section 5-1.02, *Control of Work – Contract Components*: Item 1.7 – *Supplemental Project Information*, includes permits and agreements negotiated by the State that are part of the contract and can include work and restrictions that can have a major impact on bridge removal.
    b. Section 7, *Legal Relations and Responsibility to the Public:*
        i. Notice of responsibility to the public including a section on Cal/OSHA requirements.

c. Section 12, *Temporary Traffic Control*:

   i. The requirements for temporary access routes for pedestrians which must be maintained, are found in this section.

d. Section 13, *Water Pollution Control:*

   i. Demolition as used in the context of Section 13 includes all bridge removal activities specified elsewhere in the contract documents. The goal is to handle and control all manner of waste as close as possible to its source. This includes concrete slurry and general debris control. The purpose is to keep all waste from entering the waters of the State. The specific emphasis is placed upon stormwater runoff and exposures over and adjacent to the waters of the State. In some instances, specific methods are prescribed to deal with debris, e.g., the use of a vacuum to remove concrete slurry immediately after it is produced. Good housekeeping is an important element of both pollution control and job site safety.

e. Section 14, *Environmental Stewardship:*

   i. Since the majority of bridges are either habitat for biological resources or are adjacent to such habitat, environmental stewardship is a significant consideration in bridge removal.

f. Section 16, *Temporary Facilities:*

   i. The requirements for temporary facilities used to move pedestrians through the work site can be found in this section.

g. Section 48, *Temporary Structures:*

   i. Section 48 is referenced in Section 60-2.01A, *Existing Structures – Structure Removal – General*, where temporary covers, supports, and bracing are required for bridge removal work. Therefore, Section 48 requirements for engineering calculations, plans, and review are applicable to bridge removal work.

h. Section 60, *Existing Structures:*

   i. Section 60 addresses bridge removal, including partial bridge removal. This section includes most of the bridge removal requirements including submittal requirements, quality assurance, materials, protective covers, preliminary work, and the requirements for the Contractor's engineer.

2. Project *Special Provisions*:

   a. The project *Special Provisions* will contain contract specific requirements and restrictions above and beyond what is in the *Standard Specifications* and will frequently include requirements outlined in the project permits and agreements. A careful review of the *Special Provisions* is necessary to ensure

all requirements from the project permits and agreements are incorporated and adhered to.

3. *Information Handout*:
    a. The *Information Handout* contains the project specific permits and agreements including railroad agreements, environmental permits, asbestos report, and lead report when applicable.

1-4 Contractual Relationships

The Contractor is responsible for developing and implementing the bridge removal work plan. The Structure Representative is responsible for reviewing and authorizing the bridge removal work plan and verifying that the Contractor follows the authorized plan. The Contractor's engineer that signed and sealed the bridge removal work plan is the engineer in responsible charge of the bridge removal work.

1-5 Cal/OSHA Demolition References

There are many specific Cal/OSHA regulations covering demolition and those references will not be covered in this section specifically. Rather, this section highlights some areas of importance regulated by Cal/OSHA in relation to demolition. The primary hazards associated with demolition are:

1. Structure collapse
2. Falls from elevated work areas
3. Exposure to noise and hazardous air contaminants, including crystalline silica, lead paint, and asbestos
4. Falling debris
5. Impalement
6. Heavy construction equipment and traffic.

1-6 Definitions

ACM – Asbestos containing material. The Environmental Protection Agency (EPA) ruled that bridges are considered as structures that fall within the category of "facility" as outlined in Title 40, § 61.141, *Definitions*, of the Code of Federal Regulations. The EPA further stated that the National Emission Standards for Hazardous Air Pollutants require bridge concrete to be sampled for the presence of asbestos before demolition to determine whether the concrete (suspect material) is ACM.

As-builts – Historical record of a bridge's design and modifications implemented during construction or maintenance.

Authorized reviewer – The Structure Representative or their delegated assistant in responsible charge of reviewing the bridge removal work plan.

Bridge removal, demolition – These words are used interchangeably throughout this manual. Demolition is sometimes described as performing work in reverse order from construction. In transportation industry practice, bridge removal and bridge construction are often linked in widenings or barrier upgrades and are, at times, almost indistinguishable. Bridge removal/demolition is the planned, systematic removal or partial removal of a bridge, in a safe, controlled manner.

CalEPA; California Environmental Protection Agency – State agency, whose mission is to restore, protect, and enhance the environment, to ensure public health, environmental quality, and economic vitality.

Cal/OSHA; California Department of Industrial Relations, Division of Occupational Safety and Health (DOSH) – Cal/OSHA protects and improves the health and safety of working men and women in California.

CARB; California Air Resources Board – The primary State agency responsible for actions to protect public health from the harmful effects of air pollution. CARB guides the activities of 35 local air pollution control districts.

Contract documents – The combined documents, including the *Standard Specifications*, *Special Provisions*, *Information Handout*, project plans, standard plans, change orders, permits, licenses, agreements, and certifications that encompass the definition and scope of work as agreed to by Caltrans and the Contractor.

CDFW; California Department of Fish and Wildlife – Manages California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. CDFW administers the Lake and Streambed Alteration (LSA) Program and reviews projects that would alter any river, stream, or lake. CDFW must be notified if the project diverts or obstructs the natural flow of any river, stream, or lake; or if the project changes the bed, channel, or bank of any river, stream, or lake.

Demolition – Refer to bridge removal

DES – Caltrans Division of Engineering Services. This is the Division of Caltrans responsible for the design and construction of bridges within Caltrans' right-of-way. This includes oversight of bridges constructed by other agencies within Caltrans right-of-way or by other agreement outside Caltrans right-of-way.

US EPA; United State Environmental Protection Agency – The mission of the EPA is to protect human health and the environment.

ESA – Environmentally Sensitive Area as designated on the project plans and prominently identified on the project site to protect environmental and cultural resources.

NESHAP – National Emission Standards for Hazardous Air Pollutants

Protective Cover – Shielding installed between bridge removal work and any resource, utility, or public area to be safeguarded or preserved.

SC – Structure Construction. This is the subdivision within Caltrans DES responsible for the administration of bridge (and other structures) construction contracts within Caltrans' right-of-way or oversight thereof.

Silica – Naturally occurring mineral found in aggregates used to produce concrete; silica crystals are present in granite. Quartz is the most common form of crystalline silica and is the second most common mineral on the surface of the earth. Silica is commonly found in nature as sand. Silica becomes a hazard when the dust is airborne. Cal/OSHA's silica requirements can be found under Title 8, § 1532.3, of the California Code of Regulations.

Standard Specifications – Whenever the term "*Standard Specifications*" is used in this manual, it refers to the current edition of the *Standard Specifications* issued by the California Department of Transportation.

Temporary Bracing – Short term structural support, primarily to resist lateral forces. Bracing should be designed and constructed to resist actual horizontal forces and the minimum contractually specified horizontal forces.

Temporary Support – Short term structural support to an existing structure or structural element during bridge removal work. Used to control the bridge removal sequence or sometimes to support the entire bridge during jacking operations.

Traffic Opening – Provisions for the passage of public traffic through temporary works, including minimum clearances, impact resistant elements, and lighting.

USCG; Department of Homeland Security United States Coast Guard – Regulates structures over navigable waters. Any repairs, relocation, reconstruction, additions, or modifications to a bridge that will change any of the information shown on the plans (permit drawings) attached to the Federal Bridge Permit are considered an alteration of the bridge and require prior approval of the USCG.

Chapter 2: Review and Authorization of Bridge Removal Work Plans

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2-1 Introduction

This chapter covers Structure Construction (SC) policy with respect to the bridge removal work plan review process. Subsequent chapters cover specific review guidelines, procedures, and explanations where necessary to ensure uniform and impartial contract administration. As noted in Chapter 1, *Introduction*, review and authorization of the Contractor's bridge removal work plan is delegated to SC's Structure Representative in responsible charge of structure work at the project site. While the actual review of the bridge removal work plan may be performed by a qualified member (authorized reviewer) of the Structure Representative's staff, the Structure Representative is expected to give their personal attention to the review while it is in progress and provide concurrence before the drawings are authorized.

The contract requirement for submission of the bridge removal work plan should be discussed with the Contractor at the preconstruction conference, with emphasis on the need for a complete submittal before the review period begins. If the bridge removal work is subcontracted, strongly encourage the prime contractor to have the bridge removal subcontractor attend the preconstruction conference as they should be considered "key personnel" per the *Contract Specifications* Section 8-1.03, *Prosecution and Progress – Preconstruction Conference.* The Contractor should be reminded that bridge removal must not begin until the plan is authorized. The Contractor must submit a separate bridge removal work plan for each structure.

2-2 Design Calculations and Shop Drawing

A bridge removal work plan is required for all bridge removal. If a bridge removal work plan includes superstructure removal, a protective cover, temporary bracing, temporary support, or temporary shoring, the Contractor must furnish design calculations signed by a California registered civil (or structural) engineer. The *Contract Specifications* require the design calculations to show the stresses and deflections in load-supporting members. In the specification context, the term "load-supporting members" will be construed as meaning the design-controlling members. The contract documents requires that protective covers, temporary bracing, temporary supports, and temporary shoring be designed and constructed in accordance with *Contract Specifications,* Section 48, *Temporary Structures,* and Section 60-2.02*, Existing Structures – Structure Removal – Bridge Removal*. The *Falsework Manual* is an essential tool in the administration of Section 48, *Temporary Structures,* although loading requirements may differ when compared to bridge removal.

The design calculations furnished by the Contractor are for information only; they are not for review and authorization. Likewise, any required design or construction details which may be shown in the form of sketches on calculation sheets must be included in

the bridge removal work plan as well; otherwise, the plan is incomplete. Bridge removal work plans are not to be authorized in any case where it is necessary to refer to calculation sheets for information needed to complete the independent design review, or where information shown only on the calculation sheets will be needed for construction. In most cases, it is unnecessary to refer to the Contractor's calculations during the design review. However, in the event a load-supporting member is overstressed or is otherwise determined to be inadequate, reference to the calculations may reveal the reason for the design deficiency.

2-3 Bridge Removal Work Plan Review

2-3.01 Initial Review

Immediately upon receipt of the first submittal of a bridge removal work plan, the authorized reviewer will perform an initial review of the documents received. The purpose of the initial review is to ascertain whether the plan and all required supporting data are included in the submittal. Determining whether the submittal is complete involves a certain degree of subjectivity, and the authorized reviewer will be expected to exercise judgment when making this determination. The basic requisite is that the plan contains enough information to enable the authorized reviewer to verify that the design meets the contract requirements. The initial review is not a contractual requirement but is the practice of SC to identify incomplete or deficient submittals early in the review process.

The bridge removal work plan should include the following:

1. Details of removal activities
2. Methods and removal sequence, including staging of removal activities and equipment locations
3. Temporary support shoring or bracing, including details for stability during all stages of removal
4. Locations where work is performed over traffic, utilities, or railroad property
5. Locations and types of protective covers
6. Protection of people, property, utilities, and improvements
7. Methods for preventing material, equipment, debris from falling onto traffic, railroad property, or other protected area

The initial review is to be completed within two working days following the receipt of the bridge removal work plan. The purpose of this is to assure a timely notice to the Contractor in the event the work plan is not complete. Since the only purpose of the initial review is to discover omissions that would prevent completion of a subsequent design check, neither calculations nor an evaluation of design details is required; thus, completion within two working days is reasonable.

2-3.02 Review

Appendix B, *Bridge Removal Work Plan Review,* includes a comprehensive list of items that are to be considered and/or investigated during the review of the bridge removal work plan. Prior to authorization of the bridge removal work plan, the reminder list should be reviewed to verify that no requirement has been overlooked. The importance of having a complete plan and thorough review cannot be overemphasized when it comes to bridge removal as the effort invested in preparation and review of the bridge removal work plan pays dividends when field work commences.

2-3.02A Procedure when Railroad Company is not Involved

Except for work that is adjacent to or over a railroad, the bridge removal work plan may be authorized when the Structure Representative is satisfied that the bridge removal work plan meets all contract requirements. Authorization should follow the procedure discussed in section 2-3.03, *Engineering Analysis*, of this manual. Each sheet must be signed by the Structure Representative or authorized reviewer. One set of the authorized bridge removal work plans will be returned to the Contractor, with a cover letter signed by the Structure Representative.

2-3.02B Procedure when Railroad Company Approval is Required

In order to expedite the review process of the bridge removal work plan by railroad companies, it is advisable that the drawings submitted by the Contractor adhere to the requirements of the guidelines produced by the associated railroad. The two main railroad demolition guidelines are listed below:

- Union Pacific Railroad (UPRR): *Guidelines for Preparation of a Bridge Demolition and Removal Plan for Structures Over Railroad*
- Burlington Northern Santa Fe Railway (BNSF): *Guidelines for Preparation of Bridge Demolition & Removal Plan Over the BNSF Railway*

The *Special Provisions* will also list any clearance requirements that need to be maintained. Horizontal measurements are taken from the centerline of the railroad tracks and vertical measurements are taken from the top of the high rail. If there are no clearances included in your contract documents, then refer to BNSF-UPRR Std. Dwg. No. 711000, *Temporary Clearance Envelope,* found in the BNSF/UPRR Guidelines for Railroad Grade Separation Projects. Also review the railroad agreement included in the *Information Handout* for project specific information.

Where there is a conflict between the *Contract Specifications* and the guidelines issued by the railroad, the *Contract Specifications* prevail. However, any conflict should be discussed with the SC Falsework Engineer as soon as it is discovered so it can be resolved.

2-3.02B(1) Railroad Requirements

Some common requirements are often overlooked and have resulted in submittals being returned by the railroad. The bridge removal work plan must state that all removal will comply with the latest railroad demolition guidelines. The bridge removal work plan must note how the Contractor will gain access to the site, particularly if they must cross the railroad tracks. Track protection details are shown in the aforementioned guidelines, and details must be included in the demolition plans.

The bridge removal work plan must note if there are any existing drainage facilities, including drainage ditches, or access roads being affected by the Contractor's operations. If there are no existing drainage facilities or access roads, the drawings must note this fact. Railroad personnel who are unfamiliar with the site often review the bridge removal work plan.

The above railroad requirements must be discussed at the preconstruction conference with the Contractor. Remind the Contractor that authorization of bridge removal work plan over and/or adjacent to railroad tracks will be contingent upon the railroad authorizing the plans.

2-3.02B(2) Distribution of Bridge Removal Work Plan

The Structure Representative will review the bridge removal work plan and if necessary, return them to the Contractor for correction. After the Structure Representative is satisfied that the bridge removal work plan meets the specification requirements, send the following items to the SC Falsework Engineer via the sc.office.associates@dot.ca.gov email address:

1. The Contractor's bridge removal work plan.
2. The Contractor's calculations tabbed to show key elements affecting the bridge removal over and adjacent to the railroad company's tracks.
3. The Structure Representative's calculations tabbed to show key elements affecting the bridge removal over and adjacent to the railroad company's tracks.
4. Manufacturer's data relative to all manufactured devices.

Note: The Structure Representative must not stamp the bridge removal plans "Authorized" until SC Falsework Engineer has notified them that the railroad has reviewed and authorized the plans.

2-3.02B(3) Railroad Review and Authorization

After the SC Falsework Engineer receives the bridge removal work plan, a cursory review of the plan is performed to verify the submittal is complete. An incomplete or

unsatisfactory submittal will be returned to the Structure Representative for correction. Upon confirming that the plans and calculations are complete and satisfactory, the information will be forwarded to the railroad for their review and acceptance.

Please note that all correspondence with the railroad regarding the status of submittals under their review must be directed to the SC Falsework Engineer. Under no circumstances should the Structure Representative contact the railroad directly.

When the railroad review is complete and determines the plans to be acceptable, the railroad notifies the SC Falsework Engineer, who will advise the Structure Representative to proceed with authorization of the bridge removal work. The Structure Representative will then stamp the plans "authorized" with the date of authorization and return to the Contractor along with the engineering analysis report. Assuming proper notification has been made to the railroad that their horizontal and vertical clearances will be impaired and that a flagger is required, the Contractor may begin removal work. Keep in mind that a flagger is required even when clearances are not impaired, such as working in the railroad right of way or when something can fall into the railroad right of way. Note that the Contractor **must not begin** any removal within the railroad right-of-way until the authorized plans have been issued to the Contractor.

2-3.03 Engineering Analysis

The bridge removal work plan is authorized pursuant to *Contract Specifications,* Section 5-1.23, *Control of Work – Submittals.* The *Contract Specification's* review time for bridge removal work plans is 20 days. Although this is the case for the majority of bridge removal work plans, check the *Special Provisions* if there is railroad involvement or other factors that may necessitate a longer review period.

SC's practice is to perform an independent engineering analysis on bridge removal work plans that are required to be stamped and signed by a California registered civil engineer. The independent review can be a simple review or a complex analysis with assistance from the bridge design engineer, bridge construction engineer, or the SC Falsework Engineer.

Upon completing the engineering analysis of the bridge removal work plan, the Structure Representative or authorized reviewer is to present the findings in an engineering analysis report (similar to the temporary structure analysis report used for falsework). The report is to be stamped and signed in accordance with the Professionals Engineers Act (Business and Professions Code), Section 6735. This is in addition to any temporary structures used as part of the overall bridge removal work plan that would require their own engineering analysis report as detailed in the *Falsework Manual*.

The engineering analysis report is an engineering document and therefore must be stamped and signed by a civil engineer registered in the State of California in responsible charge of the independent engineering analysis.

The engineering analysis report is to be completed for authorized and rejected submitted bridge removal work plans. The report is to contain a brief chronological record of the pertinent dates related to the submission, review, rejection (if applicable) and authorization of the plan, including the number of review days. The Structure Representative is to transmit the report to the Contractor through the project's normal transmittal process. An example of the bridge removal analysis report is provided in Section 2-3.04, *Sample Engineering Analysis Report*.

When the bridge removal work plan cannot be authorized, complete the engineering analysis report and list the reason(s) that the bridge removal work plan is rejected. Elaboration is unnecessary and corrective measures should not be suggested. Prior to sending the report to the Contractor, contact the bridge removal work plan engineer of record by phone or in person to discuss the reason(s) for rejecting the submittal. Document this discussion in the chronological record and the daily report.

When the bridge removal work plan is authorized, complete an engineering analysis report. The report must include the following paragraphs:

1. "The bridge removal work plan for <*identify specific location*> of the <*bridge name and number*> is found acceptable based on an independent engineering analysis and is authorized to the extent provided in the *Contract Specifications*, Section 5-1.23, *Control of Work – Submittals.*"
2. "Your attention is directed to your responsibilities pursuant to *Contract Specifications*, Sections 5-1.23, *Control of Work – Submittals*, 7-1.04, *Legal Relations and Responsibility to the Public – Public Safety*, and 60-2.02, *Existing Structures – Structure Removal – Bridge Removal,* and to the applicable requirements of the *Construction Safety Orders*."
3. "You are reminded that bridge removal must conform with the authorized bridge removal work plan."
4. If protective covers, temporary supports, temporary bracing or temporary shoring is included in the bridge removal work plan then also include the following paragraph:

    > "The materials used must be of the quality necessary to sustain the stresses required by the design, and the workmanship must be of such quality that the temporary structure will support the loads imposed."

A sample engineering analysis report is provided below and can be used as a template.

2-3.04 Sample Engineering Analysis Report

Engineering Analysis Report

<Insert Date>

Project Information

Contract Number
Dist-Co-Rte-PM
Bridge Name
Bridge Number

Type of structure reviewed: *<Insert partial, complete, or component of bridge removal>*

Chronology

Plans were received: *<date>*
Plans rejected: *<date>*
Revision No. 1 received: *<date>*
Revision No. 1 rejected: *<date>*
Revision No. n received: *<date>*
Revision No. n rejected: *<date>*
Plans authorized: *<date>*
Elapsed review time: *<calendar days>*

Introduction

This report presents the results of an independent engineering analysis of the bridge removal work plan for *<bridge name, bridge number, and specific location (in cases of partial or stage removal)>.*

Discussion

Authorization – No exceptions were found.

Rejection – This portion of the report describes specific deficiencies found with the bridge removal work plan that would be cause for rejection.

For clarity, redline clouds may be made on the bridge removal work plan and then described here.

Conclusion

Authorization (the paragraphs below must be included):

"The bridge removal work plan for *<identify specific location>* of the *<bridge name and number>* is found acceptable based on an independent engineering analysis and is authorized to the extent provided in the *Standard Specifications*, Section 5-1.23, *Control of Work – Submittals*."

"Your attention is directed to your responsibilities pursuant to *Standard Specifications,* Sections 5-1.23, *Control of Work – Submittals*, 7-1.04, *Legal Relations and Responsibility to the Public – Public Safety*, and 60-2.02, *Existing Structures – Structure Removal – Bridge Removal,* and to the applicable requirements of the *Construction Safety Orders*."

"You are reminded that bridge removal must conform with the authorized bridge removal work plan."

If protective covers, temporary supports, temporary bracing or temporary shoring is included in the bridge removal work plan then also include the following paragraph:

"The materials used must be of the quality necessary to sustain the stresses required by the design, and the workmanship must be of such quality that the temporary structure will support the loads imposed."

Rejection:

The bridge removal work plan for *<identify specific location>* of the *<bridge name and number>*, is rejected based on an independent engineering analysis. The deficiencies are listed above.

If you have any questions regarding this report, please contact *<insert Structure Representative or authorized reviewer's name>* at (XXX) XXX-XXXX or *<insert email address>*.

(Signature of reviewer)
Loren N. Bridge, P.E.
Structure Representative
Structure Construction

2-4 Safety and Cal/OSHA Requirements

All construction safety standards apply to bridge removal work. Bridge removal work includes additional safety concerns that often result from various unknowns.

Cal/OSHA regulations contain many safety requirements for demolition (bridge removal) projects, and it is not the intent of this section to cover all the Cal/OSHA regulations but rather remind the Structure Representative and those involved with bridge removal of these requirements. However, there are a couple of Cal/OSHA requirements to note prior to commencing bridge removal activities, found in the California Code of Regulations, Title 8, Division 1*, Department of Industrial Relations*:

Chapter 3.2 *Cal/OSHA Regulations*, Article 2, § 341, *Permit Requirements*

> Under §341 (d)(3) To conduct the demolition or dismantling of any building or structure more than 36 feet in height, the Project Administrator must hold a Project Permit and all other employers directly engaging in demolition or dismantling activity must hold an Annual Permit.

Obtaining the permit required pursuant to this Article is the Contractor's responsibility.

Although the Structure Representative has neither the authority nor the duty to enforce this Article, as a matter of policy, verification that the Contractor has a valid permit will be done before the bridge removal work plan is authorized in any case where a permit is required. The date of verification should be noted in the project diary.

Furthermore, the *Construction Safety Orders* (subchapter 4 of Chapter 4*, Division of Industrial Safety*), Article 31, *Demolition*, § 1734, *Supervision,* requires:

a. Demolition work shall at all times be under the immediate supervision of a qualified person with the authority to secure maximum safety for employees engaged in demolition work.

b. (1) Prior to permitting employees to start demolitions operations, a qualified person shall make a survey of the structure to determine the condition of the framing, floors, and walls, and the possibility of an unplanned collapse of any portion of the structure. Any adjacent structure where employees may be exposed shall also be similarly checked.

   (2) The survey shall be in written form, kept on the job-site and made available to the Division upon request. The written survey shall be maintained for the duration of the demolition project.

These requirements should be discussed with the Contractor at the preconstruction conference. The supervision requirement by Cal/OSHA is a separate requirement from

the requirement in the *Contract Specifications* for the engineer signing the bridge removal work plan to be present during bridge removal activities.

Bridge removal requires attention to fall hazards and possible hazards of working over water. All elevated work is subject to gravity and the stored energy in an elevated mass. Personnel fall hazard protection and falling debris control requires planning and is addressed in the authorized bridge removal work plans and supporting documents. The bridge removal site is frequently changing, noisy, sometimes dusty, and often congested with equipment working at a fast pace. Competent supervision is essential to safely accomplishing the construction goals.

At sites where emergency access is not obvious, emergency response personnel should be invited to the site for a visit prior to bridge removal in order to minimize response times in the event of a future emergency.

Some key safety references:

1. Authorized bridge removal work plan, protective cover plan, temporary supports, etc.
2. Contractor's Injury and Illness Prevention Program (IIPP)
3. Code of Safe Practices (COSP)
4. Permits
5. Respirator protection, heat illness prevention program, fall protection plan, safety data sheets, certifications
6. Cal/OSHA Construction Safety Orders
7. Lead compliance plan
8. Stormwater pollution prevention plan

On-site hazard warning and posters:

1. Cal/OSHA poster
2. Emergency phone numbers
3. Controlled access zones
4. Lead and asbestos warning posters

In summary, the Cal/OSHA regulations, authorized bridge removal work plan, competent supervision, clear communication, and preparation are all key elements to a safe bridge removal work site.

2-5 Design Revisions to Authorized Plans

Design revisions to the authorized plans may occur for many reasons including the following: the Contractor decides to change a particular means or method, something is identified prior to bridge removal that was not known before, an unplanned event occurs, or the removal activities deviate from the authorized work plan.

If an unplanned event occurs or the removal activities deviate from the authorized work plan, the Contractor must immediately stop work and submit procedures to correct or remedy this occurrence. Any proposed revision must be signed by an engineer who is registered as a civil engineer in the State, as prescribed in the *Contract Specifications*, Section 60-2.02, *Existing Structures – Structure Removal – Bridge Removal*.

The *Contract Specifications* address the possibility of the Contractor submitting a revised plan after the original removal plan has been reviewed and authorized. The Structure Representative is allowed sufficient time for a review, not to exceed the time originally allowed. In cases far in advance of the bridge removal work commencing or with significant changes to the bridge removal work plan before the work starts, the amount of review time may be similar to what was originally allowed. In cases where an unplanned event occurs or the removal activities deviate from the authorized work plan, it is of utmost importance to prioritize the review so that the Contractor can proceed with the bridge removal.

Administratively, and as defined in *Contract Specifications*, Section 5-1.23B, *Control of Work – Submittals – Action Submittals*, any revision to an authorized bridge removal work plan will be viewed as a new submittal, and as such will be reviewed pursuant to the applicable specification requirements.

The Contractor must show the revision number on the revised bridge removal work plan, uniquely number each revised detail, and describe and date the revisions in a legend. The revision is to be identified with an inverted triangle or revision cloud. A complete submittal must be provided with each revision to the bridge removal work plan. Refer to *Contract Specifications,* Section 5-1.23B(2), *Control of Work – Submittals – Action Submittals – Shop Drawings.*

Chapter 3: Bridge Removal Methods

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3-1 Introduction

Bridge removal can be divided into the following two general categories: partial removal and complete removal. The *Contract Specifications*, Section 60, *Existing Structures,* and Section 15, *Existing Facilities,* work in tandem to describe the bridge removal in general and places limits on the means and methods to be employed. In all situations, it is required that the best general practices are to be used. Note that when the *Contract Specifications* are referenced in a general sense throughout this chapter, it is referring to Section 60-2.01C, *Existing Structures – Structure Removal – General – Construction*.

The Contractor is contractually obligated to provide for the safety and convenience of the public during all stages of bridge removal. The Department has considered the needs of the travelling public and has prioritized safe transit through or around our projects for pedestrians, including the disabled. Communication of closures and construction duration helps with community support and acceptance.

Safety is always the number one objective. If an operation cannot be done safely, then it should not proceed. Expediency and economic considerations are never to take priority over safety when removing a bridge.

3-2 Bridge Removal Types

As stated in the introduction, bridge removal generally falls into two categories in the scope of the work performed by Caltrans: partial bridge removal and complete bridge removal. Partial bridge removal is the most common type of bridge removal encountered on Caltrans projects and can vary from concrete barrier rail removal to removal of lacing from steel truss bridges and everything in between. Similarly, complete bridge removal can vary from a single span concrete box girder to a multi-span cantilever steel truss bridge.

The focus of this manual is to provide a reference and resource for the most common bridge removal types at Caltrans – partial and complete bridge removal of concrete and steel girder structures. There are many other types of structures and methods such as cantilever steel trusses or explosive demolition that are relatively uncommon and will not be discussed in detail, with only an overview provided in sections 3-7.01 and 3-5.11, respectively.

Appendix A, *Removing Concrete from Bridges NCHRP 169*, is a useful reference prepared by the Transportation Research Board – National Cooperative Highway Research Program. The following sections of this chapter discuss bridge removal in detail, including typical equipment, temporary supports, and special locations.

3-3 Partial Bridge Removal

Partial removal of bridge elements is incidental to many rehabilitation or widening projects.

Typical partial removal situations include:

1. Rail replacement
2. Widenings
3. Joint seal replacement and repair
4. Complete deck replacement
5. Deck surface replacement
6. Bent replacement
7. Seismic retrofit
8. Installation of access openings
9. Hinge repair or replacement

Whenever partial removal of a monolithic concrete element is required, and limiting the spalling of concrete that is to remain in place is desired, a limited depth saw cut is necessary. The *Contract Specifications* require a 1-inch-deep saw cut when the joint line will be visible in the finished work. The limited depth saw cut is also used to preserve reinforcing steel, a common component of bridge widening projects. Where both sides of an element are going to be visible, a saw cut is required on both surfaces; a common example is where the overhang of a deck is partially removed for a widening. In some cases, a full 1-inch-deep saw cut may be in conflict with the need to preserve existing embedded steel reinforcement; in such situations, good engineering judgment should prevail.

The *Contract Specifications* limit the means and methods of any partial removal of an element supported by a bridge. The intent is to protect the structure to remain in place. No free-falling mass, or a mass attached to a cable such as a ball-and-crane, is permitted because it is too difficult to control. No hammer with a manufacturer's rated striking energy greater than 1,200 ft-lb per blow is permitted. These specific equipment prohibitions alone do not ensure that the existing structure will not be damaged. Other factors that can damage the existing structure are operational frequency of the impact hammer, tool tips used to break concrete, skill of operator, and duration of breaking operation.

Operator skill is an important element to a successful partial removal. For instance, the operator might have to adjust their angle of attack, tool point, or work rate. A skilled

demolition operator is not developed overnight. It can take years for an operator to become familiar with the equipment and the many demolition situations encountered. Tractor mounted hydraulic hammer breakers have a variety of tools available; an efficient moil point might be swapped out for a chisel or blunt tool to limit damage. Hammers, as mechanical devices, eventually wear out and require maintenance to function satisfactorily and in a controllable manner. Some manufacturers are producing hydraulic breakers that can automatically vary the frequency and energy of the tool impact for improved efficiency and results. When detail work is required or where appropriate, handheld pneumatic hammers are used on bridge removal projects.

Partial removal operations require monitoring to limit damage to the portion of the bridge that stays in place. Besides the general contractual requirement that the process be supervised as well as monitored by the Contractor's engineer, the State's field engineer should intercede if unintended damage is occurring. In almost all cases, it is more cost efficient to limit unintended damage than to make corrective repairs after the fact.

3-4 Complete Bridge Removal

Complete bridge removal is required when a structure is abandoned or replaced. Sometimes staged removal and construction is required where traffic is shifted to reduced lanes (number and/or width) while a portion of the bridge is removed, and a portion of the new structure is built.

Complete bridge removal methods and sequencing is dependent upon the structure type and materials. For structures that are not too tall, all the demolition equipment can be positioned on the ground, and removal can proceed relatively safely without concern for falling debris. The situation becomes more complex if the demolition equipment is operated from the bridge deck, as in the case of tall bridges and bridges over water, or if falling debris is a hazard to traffic, existing facilities, or the environment.

Complete bridge removal with workers and equipment on the structure must consider and ensure that there is adequate structural stability of the remaining structure during all intermediate demolition stages.

Generally, the *Contract Specifications* develop over time to meet the objectives and intent of similar work. Historically, unfortunate bridge demolition incidents have directly resulted in the development of bridge removal *Contract Specifications* and guidance. Well-developed *Contract Specifications* combined with experience and cautious engineering judgement are required to administer a bridge removal contract.

3-5 Typical Equipment

3-5.01 Excavator

The excavator is the workhorse of most modern bridge removal projects encountered on State highway bridges. The modern excavator is a versatile piece of machinery that has made it one of the most popular tools for bridge removal. Often, the bridge removal site has several excavators at work. Excavators come in a wide range of sizes and configurations, from mini-excavators to long reach excavators. The size and resultant high self-weight of the excavator become a concern when operating from a bridge deck or temporary structure. The excavator can exert large lateral loads when operating on a structure. With the wide range of implements, from percussive hammers to hydraulic-operated crushers, the excavator is used for everything from initial breaking of the deck to loading out trucks. See Figures 3-1 through 3-4, for photos of excavators.

Common excavator attachments used in bridge removal work are:

1. Hydraulic breaker
2. Bucket with thumb
3. Metal shear
4. Rock crusher.

Figure 3-1. Long Reach Excavator at Mulholland Drive, Los Angeles

Figure 3-2. Excavator Ballet at Doyle Drive, San Francisco

Figure 3-3. Excavator Removing Control House, Potato Slough

Figure 3-4. Excavator Removing Concrete Deck on Steel Girders

3-5.02 Loader

The loader is most often used during bridge demolition for material handling in removing debris and loading trucks. On occasion, the loader may be used to apply a lateral force to topple or stabilize a bridge element. See Figure 3-5 for a photo of a loader.

Figure 3-5. Loader on a Low-Boy Trailer

3-5.03 Concrete Saws

Concrete saws are an essential tool used in bridge removal, bridge rehabilitation, or anywhere a portion of the structure is to remain intact. The common types of concrete saws used in bridge removal are:

1. Circular water cooled (see Figure 3-6)
2. Diamond wire saw (refer to section 3-5.04 for a more in-depth discussion)
3. Small handheld dry cut.

Concrete saws do have some hazards that warrant attention. Most concrete saws generate slurry during the cutting operation, which can be hazardous to aquatic life and can become an airborne hazard when dry. Concrete saws, including water-cooled models, can generate sparks that may pose a fire hazard in some environments.

Figure 3-6. Water Cooled Concrete Saw

3-5.04 Diamond Wire Saws

The diamond wire saw is almost unlimited, dimension wise, in its ability to cut reinforced concrete structural elements. It has been very successful in underwater cutting of larger pier structures, or in cutting bent caps or other elements that need to remain intact. See Figures 3-7 and 3-8 for photos of diamond wire saws.

Figure 3-7. Diamond Wire Saw

Figure 3-8. Diamond Wire Saw, Colorado River

3-5.05 Pneumatic Hammers

Pneumatic handheld hammers (illustrated in Figure 3-9), come in many sizes; everything from rivet busters to jackhammers. Handheld hammers are most frequently employed where access or demolition control is an issue. The operator is in close proximity to the work which affords adjustments to the operation to prevent unwanted damage. There is a wide range of bits available, including moil points, chisels, and bushing heads. Pneumatic hammers require a high-capacity air compressor. The air supply lines are vulnerable to damage and wear and require frequent inspection and coupler restraints.

Figure 3-9. Handheld Pneumatic Hammer, Bear River

3-5.06 Drills

Drills are used for any location where a hole is required. Examples include a place to thread a diamond wire cable, installing a pick hole, or preceding the installation of expansive chemicals. Drills come in many configurations; of particular note for bridge removal is the impact or hammer drill which can be very efficient. Core drilling through concrete with water cooling generates slurry which needs to be contained to protect aquatic life and to conform with Storm Water Pollution Prevention Program (SWPPP) requirements.

3-5.07 Flame Cutting

The primary methods of flame cutting encountered in bridge removal are:

1. Oxyacetylene torch (see Figures 3-10 and 3-11)
2. Air carbon arc cutting
3. Magnesium torch used in underwater cutting.

These tools are essential for cutting structural steel and bar reinforcement. Lead abatement is usually required if the steel has a lead-based coating. Handheld torches are usually employed in bridge removal work, producing fumes and hot slag as typical hazards. The transportation and storage of gas cylinders are also safety concerns. Personal protective equipment is required, and in some areas, fire protection is required.

Figure 3-10. Oxyacetylene Torch Setup

Figure 3-11. Torches Removing Column Reinforcement, Mulholland Drive, Los Angeles

3-5.08 Expansive Chemicals

Expansive chemicals are generally mixed as a grout type mixture and placed in pre-drilled holes. The chemicals expand as they cure, breaking up the concrete. This method is less effective with highly reinforced concrete elements. Their advantage lies in that they work with minimal sound and vibration, compared to other methods.

3-5.09 Hydroblasting

Hydroblasting uses high pressure water to remove unsound concrete. It has the advantage of leaving a concrete surface and reinforcement well prepared for bonding. This method of bridge removal is well suited for removal of unsound concrete from a bridge deck. Hydroblasting produces fewer micro cracks in the remaining concrete when compared to typical impact hammer techniques. Hydroblasting has potential stormwater pollution implications that must be considered as well. See Figure 3-12 for an illustration of hydroblasting.

Figure 3-12. Hydroblasting for Partial Deck Removal

3-5.10 Free Falling Mass (Crane and Wrecking Ball)

The *Contract Specifications* prohibit the use of a free-falling mass (wrecking ball) as well as demolition by explosives. There are occasions where the contract *Special Provisions* allow for the use of one of these methods if they are deemed to be more effective than the standard bridge removal methods, or if there is an emergency situation. As such, these methods will be briefly mentioned.

Since the middle of the 20th century, the wrecking ball (illustrated in Figure 3-13) has been commonly used in the demolition of masonry and concrete structures. Recently, its use in the removal of bridges has diminished. This method has concerns for safety with a free-falling mass during bridge removal since the majority of bridge removal occurs near traffic or adjacent structures. Furthermore, this method is particularly ineffective and inefficient in removing modern reinforced concrete box girder bridges since they are highly reinforced, massive structures. More controllable and efficient means are available to contractors and, as previously mentioned, this method is prohibited by the *Contract Specifications.*

Figure 3-13. Wrecking Ball, Pfeiffer Canyon

3-5.11 Explosive Blasting

This method is rarely used or allowed by the *Special Provisions*. Blasting is prohibited by the *Contract Specifications* for reasons of safety and environmental concerns. However, there are situations where weighing the expediency and hazards make the option desirable. Blasting requires significant professional planning and experience in execution as well as multi-agency involvement. Blasting in maritime environments also requires significant mitigation measures such as bubble curtains to protect aquatic life as well as seismic and environmental monitoring.

Figure 3-14. Explosive Demolition of a San Francisco-Oakland Bay Bridge Pier

3-6 Temporary Supports

Temporary supports are structural elements used to support existing structures during partial or complete bridge removal when necessary to support the bridge loads (dead, live, and lateral) while performing removal activities, as illustrated in Figure 3-15. Temporary supports are commonly used during hinge reconstruction and stage construction where bridge columns or abutments are pinned connections. See Figure 3-17 for an illustration of temporary supports at a hinge.

Commonly, temporary supports are designed similar to falsework and the *Falsework Manual* is used to analyze the structural elements. However, a major difference

between falsework and temporary supports are the loads applied to the temporary structure. Typically, the vertical and horizontal loads for the temporary supports are shown on the contract plans for a particular location. On occasion, the Contractor may elect means and methods that use a temporary support that was not anticipated in the contract plans and for which loads are not provided. In these cases, the loads will need to be checked by the Structure Representative. The minimum horizontal load shall not be less than wind and 5 percent of the vertical dead load of the structure being removed per *Contract Specifications*, Section 48-3.02B, *Temporary Structures – Temporary Supports – Materials – Design Criteria*. The 5 percent is only a minimum and it may be higher depending on the site-specific conditions. The bridge design engineer should assist in developing loads in cases where live traffic will remain on the bridge.

Figure 3-15. Temporary Support for Bridge Removal, Chico

Temporary supports are not always similar to falsework; they can be attached to existing structures as concrete or steel elements, they can be truss or suspended structures, or drilled or driven pile structures, among others. Figure 3-16 illustrates the use of a temporary support to suspend a portion of a compromised bridge. Temporary supports can also serve as multi-functional temporary structures in cases where the temporary support is also used as a protective cover or falsework; see Figure 3-17 for an illustration.

Figure 3-16. Piggy Back Beam, Oroville

Figure 3-17. Combined Temporary Supports, Falsework, and Protective Cover, Elk

All these scenarios require close attention to detail by the Structure Representative since there may be many loading scenarios applied to the temporary supports at different stages of use. There may be additional loading applied to the temporary supports that was not anticipated in the contract plans, such as heavy equipment.

Hydraulic jacking systems are typically employed to transfer the vertical load to the temporary support, as illustrated in Figure 3-19. Careful monitoring of the bridge is required during jacking operations as required by the *Contract Specifications,* Section 48-5, *Temporary Structures – Jacking.*

Figure 3-18. Hinge Temporary Supports, San Francisco

Figure 3-19. Jacking System Transferring Load to Temporary Support, San Francisco

3-7 Special Locations

3-7.01 Cantilever Steel Truss Bridges

Large cantilever steel truss bridges are complex structures with heavy and complex loads that require extensive planning and design to remove safely. These structures usually have many contract plan sheets dedicated to the removal sequence and loads. The Contractor usually has a detailed bridge removal work plan (or multiple plans) that is reviewed by both the Structure Representative and bridge design engineer and may involve other specialists to complete the review. These structures are sometimes retrofitted for various reasons and may have smaller scale, elemental bridge removal that still requires extensive review of the bridge removal work plan.

3-7.02 Suspension Bridges

Complete removal of suspension bridges is uncommon. However, like cantilever steel truss bridges, they are subject to various retrofits or rehabilitation which may involve partial or staged/sequenced bridge removal, as illustrated in Figure 3-20. Since suspension bridges are complex structures, a detailed analysis is required when removing and replacing structural elements.

Figure 3-20. San Francisco-Oakland Bay Bridge Retrofit Included Partial Bridge Removal on a Suspension Bridge

Chapter 4: Loads

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4-1 Introduction

The number one goal of an engineering plan to remove a bridge, or an element of a bridge, is to do it safely. The other goals of protecting worker health, property, and environmental resources cannot be achieved if the bridge removal is not performed in a controlled and predictable manner. The bridge removal work plan must consider the overall stability of the entire structure and the individual capacity of local supporting elements. A fundamental part of the bridge removal work plan is the removal sequence and necessary staging that is part of the plan. It is only possible to evaluate the stability and capacity if the sequence of removal is well defined, including the placement of equipment on the structure.

The need for possible temporary supports, temporary covers, or lateral bracing can be evaluated with a well-defined removal sequence.

The use of protective covers to control debris requires consideration of the impact falling debris has on such a cover. The *Contract Specifications*, Section 60-2.01C, *Existing Structures – Structure Removal – General – Construction,* requires that the minimum protective cover be equivalent to 2-inch Douglas-fir planking on posts spaced at 5-foot centers. This specification anticipates a typical situation where concrete debris is dislodged from an element like a deck slab. Because the concrete is rattled out from closely spaced rebar and is falling a modest height, experience has demonstrated that this type of prescriptive cover is adequate.

4-2 General Loading Requirements

The basic requirement for temporary supports, temporary covers, and temporary lateral bracing is that they must resist the sum of all loads imposed.

Temporary supports and temporary covers for bridge removal are designed under the *Contract Specifications*, Section 48, *Temporary Structures*. The minimum vertical loads are consistent with the requirements for new falsework construction. The minimum horizontal loading for wind is likewise consistent with new falsework construction. However, the minimum horizontal loading requirement found in the *Contract Specifications*, Section 48-3.02B, *Temporary Structures – Temporary Supports – Materials – Design Criteria*, is the force as specified, plus an allowance for wind but not less than a percentage of the total dead load of the structure being removed as described in Section 4-5, *Horizontal Loads.*

4-3 Dead Loads

Dead loads include the weight of all concrete, bar reinforcement, and self-weight of the temporary structure. The minimum dead load for normal weight concrete and rebar is 160 pcf, which is reduced to 130 pcf for lightweight concrete. The concrete dead load generally includes the weight of concrete material, forms, and bar reinforcement. Site specific evaluation may be necessary to determine if the weight of forms will be included in the dead load calculation or if it is calculated separately. If calculated separately, then the dead load of concrete is to be not less than 150 pcf for normal weight concrete and 120 pcf for lightweight concrete. See Figure 4-1 for an illustration of a bridge typical section, used to calculate concrete dead load.

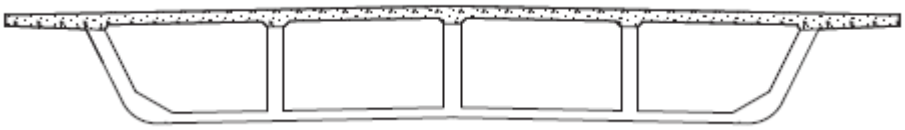

Figure 4-1. Typical Box Girder Cross-Section (Dead Load)

4-4 Live Loads

Any temporary structure needs to support the actual live load, including all equipment to be supported during the bridge removal such as excavators and loaders, with a minimum uniform live load of not less than 20 psf. See Figure 4-2 for an illustration of live load due to equipment.

Cal/OSHA *Construction Safety Orders (CSO)*, § 1717, *Falsework and Vertical Shoring*, requires a minimum of 100 psf for vertical shoring supporting concrete and Cal/OSHA *CSO*, § 1637, *General Requirements,* requires that the walkway (scaffold) support four times the maximum live load plus self-weight of the structure without failure (i.e., ultimate load). Note that the *CSO* is found in the California Code of Regulations (CCR) Title 8, Division 1, Chapter 4, Subchapter 4.

Figure 4-2. Typical Equipment Live Load, Carpinteria Creek

4-5 Horizontal Loads

The minimum horizontal wind loading is consistent with new falsework construction. The minimum wind load is specified in the *Contract Specifications*, Section 48-3.02B, *Temporary Structures – Temporary Supports – Materials – Design Criteria*.

The minimum horizontal loading requirement found in the *Contract Specifications*, Section 48-3.02B, *Temporary Structures – Temporary Supports – Materials – Design Criteria*, is the force as described and an allowance for wind but not less than

5 to 10 percent of the total dead load of the structure being removed (refer to the project specific contract documents for the applicable minimum percentage). This minimum horizontal loading is increased from the standard 2 percent for new construction to 5 percent for bridge removal because of the greater uncertainties involved.

Operating equipment on a structure can impart significant horizontal loads to the resisting elements of the structure. For example, dynamic forces like wheel braking from a vehicle or construction equipment get transferred to the structure as a horizontal load. Also, an excavator boom can exert horizontal forces that approach the dead weight of a vehicle.

4-6 Removal Sequence

As most structures are not perfectly symmetrical, beginning bridge removal from one abutment and proceeding to the other abutment is not the equivalent of the reverse order of construction. There must be an agreement as to the abutment and bent numbering for a written sequence to be valid. It is not common, but some older bridges have had their bents numbered inconsistently from one contract to another. If working from the as-built project plans, it is essential to verify that the bents are numbered in the same manner as the contract and bridge removal work plans indicate.

The *Contract Specifications*, Section 60-2.02C(3), *Existing Structures – Structure Removal – Bridge Removal – Construction – Preliminary Work*, defines the nature of preliminary work. The bridge removal work plan should detail the sequence of work sufficiently to remove any ambiguity of what is considered preliminary work as authorized by the Engineer.

While the removal sequence is essential in evaluating the structural stability of the remaining structure, it is also important in scheduling lane closures, railroad flaggers, and other auxiliary work requirements. When a successful bridge removal operation is dependent on time of completion, the steps in the removal sequence should have a duration allocated to them so that adjustments can be made in the allocation of resources if the schedule lags.

4-7 Stability

The *Contract Specifications,* Section 60-2, *Existing Structures – Structure Removal*, requires that the structure remain stable during each stage of removal. The *Contract Specifications* also require that calculations must be submitted, demonstrating stability for each stage.

The details in the as-built project plans are essential in the planning stages of removal and evaluating stability. Whether columns are assumed fixed or pinned is partially

dependent on the original design but also on the actual conditions at the time of removal. Due to scour and erosion of the riverbed, the piles may be exposed. Even if the footing has been shored up with riprap, the piles may have issues with corrosion because of exposure to the atmosphere. Because a compromised foundation may not be able to resist any significant moments during removal operations, the actual condition needs to be evaluated carefully at each site. Even in an arid site, there may be hidden or unknown conditions that have led to deterioration of bridge components; thus, actual conditions must be investigated at all sites.

Figure 4-3. Temporary Support During Partial Removal and Bridge Raising, Oroville

Occasionally the proposed bridge removal work plan includes the use of equipment to provide temporary stability. An excavator or other similar equipment could be used as a simple dead weight to stabilize an element like a girder or a column. If the stability plan requires active participation from an equipment operator to be successful, the complexity increases by an order of magnitude. Is the operator able to see and hear well enough to be effective or is the operator relying upon direction from a spotter? Crane operators often work in cooperation with a certified signal person, but an equipment operator may not be as experienced in receiving critical direction from third parties, especially in noisy environments where the line of sight is impaired. Careful planning, clear lines of authority and direction, and preparation are required when active participation from equipment is part of the bridge removal work plan.

Precast girders and steel girders are not usually stable as stand-alone individual components. During bridge construction, these elements often require temporary lateral support until the diaphragms are installed. Some steel girders may have been erected in pairs with the diaphragms preinstalled; a removal sequence may benefit from a similar strategy. Since the bridge deck provides considerable stability to individual girders, removing or compromising the integrity of the bridge deck as part of the removal sequence requires evaluation of stability. Girders with a horizontal radius between bents can become globally unstable as the deck is removed. Girders and diaphragms can be damaged during removal operations. The intermediate diaphragms in steel girder bridges can suffer fatigue cracking during their years of service which would compromise their ability to provide stability during removal. Inspection of existing and developing conditions is essential in planning and executing a bridge removal. Knowing that steel girders are sensitive to damage, the integrity of the compression flange is a concern. Bridge deck removal by hydraulic breaker sometimes exposes the top flange to damage. When the top flange in compression gets bent and is no longer restrained by the deck, buckling can occur which could lead to collapse. A better option is to clearly mark girder locations and use a more controlled removal method near the girder.

Prestressed elements have energy stored in the tendons. Most prestressed elements have tendons that are grouted and fully bonded to the structure and there is little danger of damage to the anchorage. There are exceptions; unbonded tendons can release almost explosive energy when an anchorage is removed. This is a good reason to review the as-built project plans and proceed with caution during bridge removal. There are some structures that have auxiliary tendons installed in conduits beside the original girders. The grouted conduits are relatively slender compared to the stored energy and cutting the tendon from the girder might cause it to suddenly bend out of plane.

Removal of the bridge deck from a post-tensioned structure can damage the girders, as the bridge was originally post-tensioned after deck installation, and the deck acts an integral top flange. The removal of the deck dead weight can unbalance post-tension forces, causing deflection and associated cracks in the girders.

Removing girders with a crane is common over water or areas with difficult access. A crane on a barge has additional operational concerns as a barge can pitch and roll with loading. The capacity of a crane operating from a barge should be downrated because of uncertainties. Crane manufactures can require up to 50 percent reduced maximum capacity when operation is from a barge. Removing girders with two crane picks increases the complexity and introduces communication issues, and again because of uncertainties the maximum capacity of the cranes should be downrated. Cal/OSHA *CSO*, § 1616.7, *Multiple-Crane/Derrick Lifts – Supplemental Requirements,* requires a qualified person other than the operators to direct the operations and generally requires a minimum 25 percent reduction in crane capacity for two crane picks. Successful removal of existing girders by crane is dependent on many details such as wind and

weather, rigging, supporting mats and pads, engineering assumptions, and site management, as well as operational communications. Once the girder is landed off the structure, there continue to be stability and hazardous material issues as it is processed and removed from the site.

See Figure 4-3 for an illustration of a unique situation where temporary supports were used to facilitate both partial removal and bridge raising. See Figure 4-4 for an illustration of a precast girder being removed with an excavator.

Figure 4-4. Precast Girder Removal with Excavator, Hat Creek

Chapter 5: Design Considerations

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5-1 Introduction

A protective cover is a temporary structure used to control and contain debris from bridge removal operations. Protective covers can be used to control debris from falling vertically or projected laterally from the bridge removal operation. Sometimes protective covers are installed by the Contractor for the Contractor's convenience as part of their means and methods. Most often, however, protective covers are required by the contract with the intent of providing specific protection to life, property, or the environment. A protective cover can also serve a multi-purpose function as part of a temporary support, work platform, and/or falsework. A protective cover must be designed to support all loads imposed on it, including assumed horizontal loads.

Protective covers can be self-supporting or, as often the case in partial removal operations, be attached to the existing structure. Often, protective covers use common building materials and sometimes use manufactured proprietary devices such as overhang brackets.

5-2 Protected Facilities

All traffic is to be protected, including pedestrian, railroad, waterway, and highway. All transportation facilities and other improvements which remain in place are to be protected. All utilities are to be protected, including underground, overhead, or on the structure. The *Contract Specifications*, Section 15-1.03A, *Existing Facilities – Construction – General*, makes the Contractor responsible to repair or replace any damaged facility. Protection from falling debris includes fine dust. Before a protective cover is removed, it should first be cleaned of debris and fine dust.

All environmental resources are to be protected, including Waters of the State.

The *Contract Specifications*, Section 12-4.04C, *Temporary Traffic Control – Maintaining Traffic – Temporary Pedestrian Access Routes – Construction*, requires protective overhead covering for a pedestrian route. *Contract Specifications*, Section 16-2, *Temporary Facilities – Miscellaneous Temporary Facilities*, requires the minimum pedestrian overhead covering protection to be ¾-inch plywood or solid wood planking with a nominal thickness of 2 inches.

5-3 Types of Protective Covers

During roadway closures when traffic is detoured, debris from bridge removal activities may fall directly onto the roadway provided the pavement is protected with a minimum of 2-foot-thick earthen pad or a 1-inch-thick steel plate, per the *Contract Specifications,* Section 60-2.02*, Existing Structures – Structure Removal – Bridge Removal.* See

illustration of an earthen pad in Figure 5-1. These are minimum requirements and the Contractor may use a more robust system, as authorized by the Structure Representative. This minimum protective cover intended to protect pavement may need to be more robust for sensitive facilities or utilities.

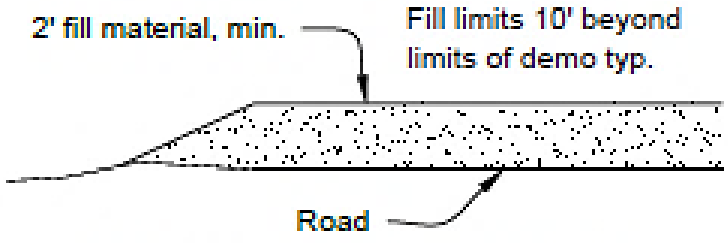

Figure 5-1. Typical Roadway Protective Cover Detail with 2-foot Fill Option

Often the bridge itself provides an adequate protective cover, as is the case of a box girder bridge, where the demolished deck is allowed to fall onto the enclosed soffit, as illustrated in Figure 5-2.

Figure 5-2. Box Girder Soffit Used as a Protective Cover, Santa Anita

Protective covers may be supported from the bottom flange of concrete and steel girders during concrete deck removal for bridges without an enclosed soffit.

Suspended scaffolding, as illustrated in Figure 5-3 and 5-4, can also be employed for bridge removal operations. Suspended scaffolding is frequently used for bridge painting and retrofit work but has also been used for partial bridge removal work. Suspended scaffolding is usually proprietary, and the engineered design is provided by the manufacturer.

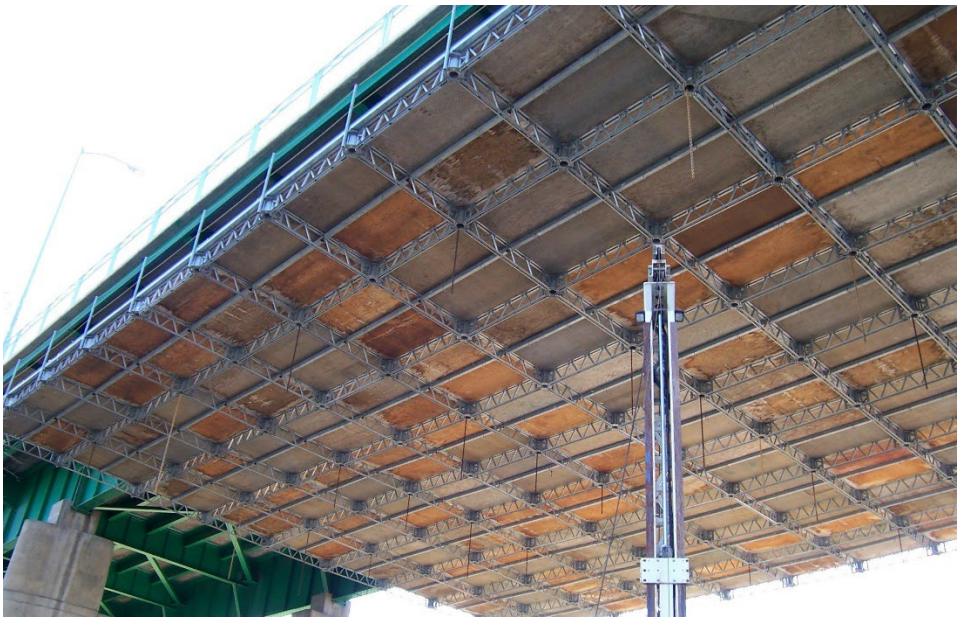

Figure 5-3. Suspended Scaffolding over River Span, Marysville

Figure 5-4. Suspended Scaffolding on Overhang for Debris Containment, Marysville

Temporary overhang brackets are sometimes used for bridge rail replacement or widening work. Overhang brackets can be a proprietary design that is bolted to the exterior girder or a contractor designed job-specific system. Drilling holes for these systems requires permission from the Structure Representative. Holes must not damage the post-tensioning system or critical tension reinforcement in the case of concrete bridges, nor damage tension flanges and zones in the case of steel girder bridges. When holes are drilled or fasteners embedded in the existing bridge, the bridge removal work plan must include a plan to repair the holes and provide resistance to corrosion. See Figure 5-5 for an example of a protective cover suspended from the overhang, supported by threaded rod.

Figure 5-5. Four-Foot-Wide Protective Cover for Rail Removal, Sacramento

The *Contract Specifications* requires the protective cover to extend at least 4 feet from the face of the rail in locations where only railing is removed, and to extend at least 10 feet beyond the face of the railing at locations where entire girders are removed, as illustrated in Figure 5-6.

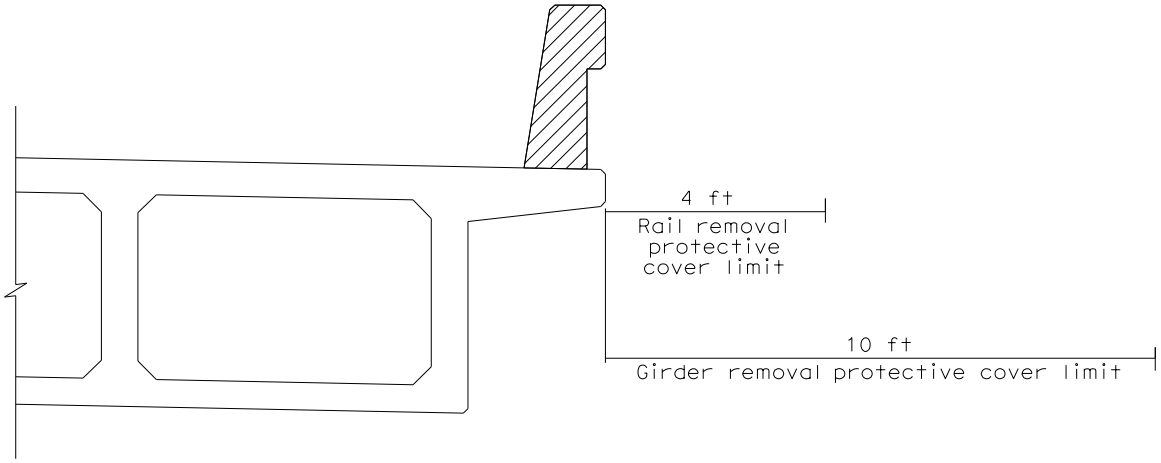

Figure 5-6. Protective Cover Minimum Limits

A protective cover can take the form of a trestle over a waterway, as illustrated in Figure 5-7, or can resemble traditional post and beam falsework used in cast-in-place concrete bridge construction.

Figure 5-7. Trestle Type Protective Cover Over Waterway, Simmerly Slough

5-4 Protective Cover Design

The design and construction of protective covers must conform to the *Contract Specifications*, Section 48, *Temporary Structures*. Often, protective covers are similar to falsework and will be analyzed as such, however the loads will typically be different than the loads used in falsework. The *Falsework Manual* should be referenced for review of the protective cover design.

When protective covers are used, they must be supported by calculations and be part of the bridge removal work plans signed by an engineer registered as a civil engineer in the State. Protective covers are a vital safety component of the bridge removal work plan and require a thorough review.

Protective covers are considered an action submittal and must be submitted as part of the bridge removal work plan and conform to *Contract Specifications*, Section 5-1.23B(2)*, Control of Work – Submittals – Action Submittals – Shop Drawings.*

5-5 Traffic Openings

Contract Specifications, Section 60-2.02C(2), *Existing Structures – Structure Removal – Bridge Removal – Construction – Protective Covers,* requires a protective cover over traffic to be in place prior to the beginning of bridge removal work. Traffic control must conform to *Contract Specifications*, Section 12-4, *Temporary Traffic Control – Maintaining Traffic*, and minimum clearances of 15 feet vertically and 8 feet horizontally of traffic lanes or shoulders open to the public must be maintained, unless specified otherwise in the *Special Provisions*.

Contract Specifications, Sections 16-2.02A(1), *Temporary Facilities – Miscellaneous Temporary Facilities – Temporary Pedestrian Facilities – General – Summary,* and 48-2.03E, *Temporary Structures – Falsework – Construction – Falsework Lighting*, are applicable where the safety of the public prevails, including provisions to light pedestrian openings through the work. *Contract Specifications*, Section 7-1.04, *Legal Relations and Responsibility to the Public – Public Safety*, addresses the general intent of the contract towards public safety, including the installation of temporary illumination.

5-6 Railroad Requirements at Railroad Openings

Contract Specifications, Section 5-1.20C, *Control of Work – Coordination with Other Entities – Railroad Relations,* provides a contractual link between the *Contract Specifications* and any existing agreement between the railroad and the Department. These agreements often detail specific protective cover requirements. The agreements should be included in the project *Information Handout.*

Contract Specifications, Section 5-1.36B, *Control of Work – Property and Facility Preservation – Railroad Property,* requires the prevention of any material, equipment, and debris from falling onto railroad property. As such, protective covers must be provided over railroad property as outlined in *Contract Specifications*, Section 60-2.02C(2), *Existing Structures – Structure Removal – Bridge Removal – Construction – Protective Covers*. See Figure 5-8 for an illustration of suspended scaffold over a railroad, and Figure 5-9 for an illustration of steel plates used to protect railroad tracks.

Railroad approval is required for bridge removal work plans, including protective covers. The bridge removal work plan, including the protective cover plans, must be routed through the Structure Construction (SC) Falsework Engineer for railroad review and railroad approval prior to the Structure Representative's authorization of the plan.

The railroads offer guidelines and checklists to assist in the development of demolition plans, which are available from SC Headquarters upon request.

Figure 5-8. Suspended Scaffolding Over Railroad for Edge of Deck Removal, Marysville

Figure 5-9. Protective Cover with Steel Plates Over Railroad, Dunsmuir

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.

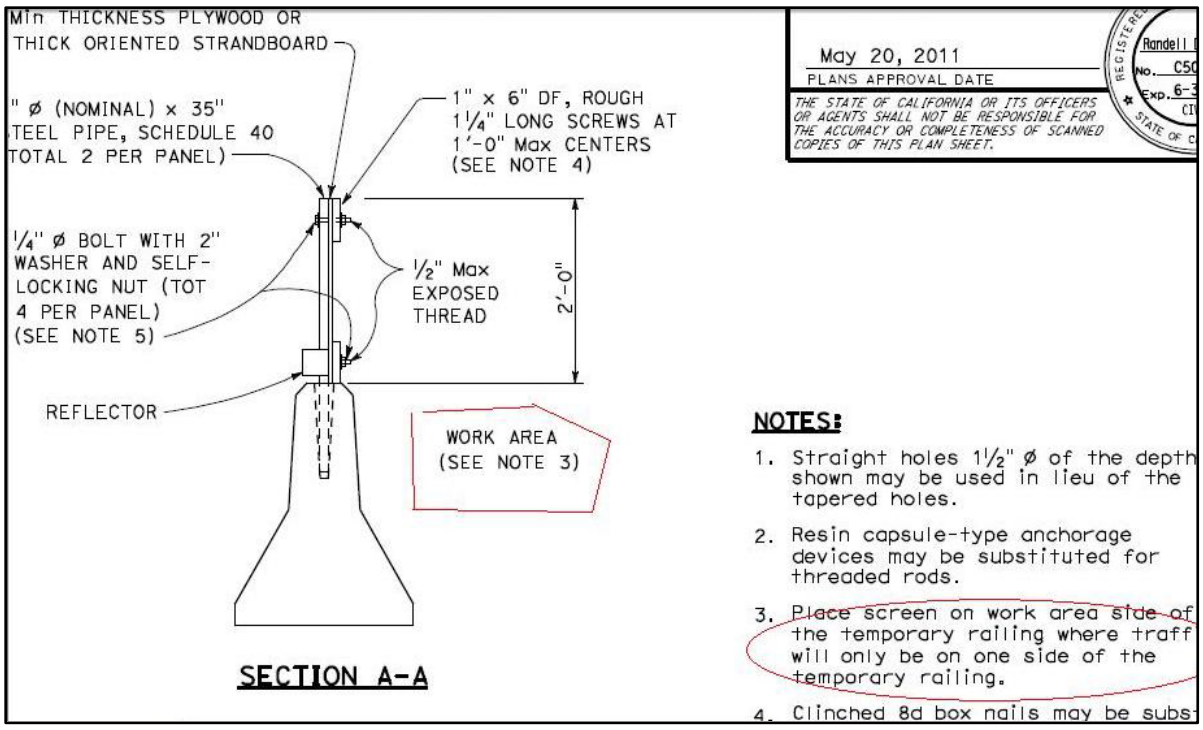

Figure 6-1. Gawk Screen Example

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

Chapter 7: Environmental Considerations

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7-1 Introduction

A structure cannot be built, maintained, or removed without having an impact on the environment. The very scale of bridge removal projects imposes costs upon the environment in which we live. With that acknowledgment, the goal is to minimize negative impacts of the improvement on the environment. Many of the methods of achieving this goal are formally codified in the laws, permits, licenses, and certifications that are relevant to the execution of bridge removal operations. Good judgment and the best general practices are to be applied, as it is not possible to delineate every possible situation that might arise in the course of the work.

In the *Contract Specifications*, Section 14, *Environmental Stewardship,* the acronym PLAC is used for the permits, licenses, agreements, and certifications that are specific to the work and the job site. To fulfill the requirements of the PLACs, the Structure Representative and the Contractor must be familiar with these documents. The PLACs are sometimes supported by reports or opinions that can give a more complete understanding of the resource being protected. During the project development stage, the assistance from a representative from Structure Construction can be useful in identifying means and methods for bridge removal that are appropriate to the work and the site.

The contract requires the Contractor to submit, for authorization, detailed plans for bridge removal. A significant part of these plans addresses the goal of minimizing environmental impacts. Early familiarization of the PLACs will aid in the timely review of the Contractor's plans. See Figure 7-1, 7-3, and 7-4, for illustrations of debris containment and processing.

Environmental stewardship is broader than merely keeping demolition contaminates out of the air and water. Bridge demolition can be disruptive to neighbors, commerce, and natural habitats. Environmental stewardship includes protection of cultural resources of known or suspected archaeological sites. Sometimes even the bridge itself has historical significance that is worth preserving. All projects benefit from planning that anticipates appropriate stewardship, but the execution in the field of the authorized bridge removal work plan is the task that pays the most dividends and minimizes costs.

The PLACs and contract requirements for environmental resource protection are extensive and cover a wide range of topics and disciplines. The intent of this chapter is not to repeat or attempt to educate on these matters in depth but to make the reader aware, in a general sense, of the requirements and to investigate further when bridge removal is required as a part of the project.

7-2 Stormwater Pollution Prevention Program (SWPPP)

The best stormwater management practices are to be utilized on all construction projects. Bridge removal has the potential for generating objectionable material that requires containment and removal from the site to a proper disposal location. Methods need to be employed to keep contaminants out of runoff and the Waters of the State. This can be a difficult task, especially if the demolition is a bridge over water. Debris platforms, impenetrable barriers, diversions, or other means can be deployed. See Figure 7-1 and Figure 7-5 for illustrations of water diversion through bridge removal projects. A substantial part of any bridge removal work plan will involve containment of contaminants and handling of potential stormwater runoff.

Under the National Pollution Discharge Elimination System, administered by the Federal Environmental Protection Agency (EPA), there are very specific requirements for sites over one acre.

The *Contract Specifications*, Section 13, *Water Pollution Control,* addresses the general contract considerations pertinent to this topic. Detailed in Section 13 is a list of several Department manuals regarding the administration and best general practices to limit water pollution. The Department continues to invest in mandatory training to protect the waters of the State. The Structure Representative and staff benefit from participation in this training, and the project benefits from the consistent and uniform administration of the best management practices (BMPs).

A review of the provisions in Section 13 will emphasize that the protection of the Waters of the State is an active, involved task. Minimizing water pollution during bridge removal requires considerable training, planning, execution, monitoring, sampling, and documentation.

Figure 7-1. Clear Water Diversion Through Culverts with Bridge Removal on Gravel Pad, Sulpher Creek

Figure 7-2. Debris Containment Platform, Honcut Creek

Figure 7-3. Debris Processing/Storage Area, Marysville

Figure 7-4. Debris Processing with Water Pollution BMPs in Place, Simmerly Slough

Figure 7-5. Water Diversion, Romero Creek

7-3 Air Quality

The *Contract Specifications*, Section 14-9, *Environmental Stewardship – Air Quality,* requires compliance with specific government codes. The *Special Provisions* and PLACs will address specific identified hazards applicable to the project.

The Federal EPA sets minimum national air pollution standards. The California Air Resources Board (CARB) works in tandem with the EPA and addresses California's specific needs with additional standards and enforcement. CARB addresses statewide sources of pollution including mobile sources of pollution such as vehicles. California has 35 local air districts that address emissions from businesses and stationary sources of pollution. Local geography and population density uniquely impact air quality which results in regulations that vary regionally.

Bridge removal and construction in general, are potential local sources of air pollution.

7-3.01 Asbestos

The California Air Resources Board enforces compliance with the Asbestos National Emissions Standards for Hazardous Air Pollutants (NESHAP) regulation for asbestos and investigates all related complaints, as specified in the California Health and Safety Code (HSC), Section 39658(b)(1).

Of the 35 air districts in California, 16 of these districts do not have an asbestos program in place. In these "non-delegated" districts, a demolition/renovation notification is required for compliance with the Asbestos NESHAP (note that this notification is not equivalent to a permit). The Contractor must submit their Asbestos Notification form to the EPA with a copy of the notification submitted to CARB, who in turn reviews and investigates the notifications. The local air district can be contacted for compliance requirements.

Asbestos can be a concern in bridge removal. Naturally occurring asbestos is sometimes present in aggregates used to produce structural concrete or present in the local geology. Manufactured asbestos products may be present in bearings, rail shims, piping, or joint material in older bridges. Asbestos' ability to resist fire and microbial attack once made it a popular component in siding, shingles, insulation, flooring, and stucco products. These typical building products were once frequently used in the control houses on movable bridges. Sometimes materials containing asbestos can be identified on bridge as-built project plans, but usually the only way to accurately determine the presence of asbestos is through a survey that includes sampling and testing.

Asbestos removal is to be performed by a qualified contractor. Means and methods of asbestos removal can include containment barriers, worker protections, and air monitoring. Refer to Figure 7-6, which shows asbestos shim removal on a bridge project.

Figure 7-6. Asbestos Shim Removal from a Bridge Rail

7-3.02 Burning

The *Contract Specifications*, Section 14-9.02, *Environmental Stewardship – Air Quality – Air Pollution Control*, prohibits the disposal of waste by burning.

7-3.03 Dust

Nuisance dust can be a hazard and adequate control is required. Water is a common dust palliative used during bridge removal. See Figure 7-7 for an example of dust control application.

Often, dust generated by bridge removal activities has an increased hazard potential. Saw cutting or grinding concrete, or any activity that places silica into the air, is a concern. Excavations that disturb the aerially deposited lead near transportation facilities might produce hazardous dust. The *Contract Specifications*, Section 14-11.04, *Environmental Stewardship – Hazardous Waste and Contamination – Dust Control,* requires any activity that might generate hazardous dust must not result in visible dust migration.

Figure 7-7. Water Applied to Control Dust, Simmerly Slough

7-4 Lead Compliance

Demolition activities that disturb the lead paint on steel structures will likely require specific means and methods. Cutting lead painted steel with a torch generally requires that the lead paint be abated first to avoid lead fumes, which are highly toxic. Peeling and flaking lead paint might require a containment barrier (illustrated in Figure 7-8) to keep the paint out of the air, soil, and water.

Figure 7-8. Containment System and Work Platform, Feather River

7-5 Biological Protection

7-5.01 Environmentally Sensitive Area (ESA)

This is generally delineated on the project plans as an ESA and is usually one of the first orders of work. The Department will mark the specific ESA locations in the field. The Contractor will install high visibility fencing to protect the resource; an example of this is illustrated in Figure 7-9. Environmentally Sensitive Areas are used to protect many categories of resources, including but not limited to archaeological, biological, and paleontological. A single plant or an entire ecological area can be protected by an ESA. The standard operating procedure is to install the ESA fencing before the work begins and then stay out of the area.

Bridges are often over or adjacent to soils that are sensitive to disturbance or compaction, generally found in wetlands. The *Special Provisions* sometimes require temporary protective mats to limit damage by vehicles. These can be common wooden crane mats or a specifically manufactured product. Sometimes round cobbles or river run gravels are used effectively for stream crossings.

Figure 7-9. High Visibility Fencing used for ESAs

7-5.02 Nesting Birds

Swallows, barn owls, and peregrine falcons are just a few species known to nest on bridges, as shown in Figure 7-10 and 7-11.

One of four international conservation treaties, the Migratory Bird Treaty Act protects most species of birds that nest on structures. The Act has significant fines associated with taking of any protected species, feathers, active nests, or eggs. A demolition project can be delayed an entire season if actions are not taken to exclude birds from the bridge. In California, exclusion netting may have to be installed in the winter to be in compliance with the Act. In addition to exclusion netting, removal of old nests is the general practice. Scheduling can be an issue on anticipated contracts, as the exclusion work may need to be performed prior to the contract award date. Exclusion netting is not always 100% successful. A poor installation or use of inappropriate materials may entrap and kill birds. Netting may require significant maintenance and require the constant removal of new unpopulated nests. Refer to Figure 7-12 for typical bird netting

installation. Demolition work should anticipate the expense and time required to maintain compliance with the Act.

It has become common to require bird surveys near a demolition project and ongoing monitoring of the bird population during construction. It is sometimes required that a qualified biologist produces a comprehensive wildlife management plan and monitors the implementation of the plan during construction. Often, the Department enters into a permit agreement for construction work with a lead wildlife agency for the duration of the work with specific requirements and date restrictions for all work. Such a permit is usually made part of the construction contract and all parties are bound by its provisions. Construction activities, including demolition and noise generation, can impact nesting birds in adjacent habitats. Harassment activities can be restricted or prohibited, especially if an endangered species is present.

Figure 7-10. Common Location for Swallows' Nests on Bridges

Figure 7-11. Swallows Nests

Figure 7-12. Bird Netting Installed Prior to Demolition

7-5.03 Bats

Most bats are migratory and exclusion methods are often employed prior to bridge removal work. Bats often reside within colonies and their numbers can be significant on a structure. Bats can roost and raise their young within box girder bridges, bridge joints, or hollow piers. A long period of habitation can result in significant quantity of bat guano that can be a health concern for workers. New bridges often include provisions to mitigate the removal of bat habitat, as shown in Figure 7-13.

Figure 7-13. Bat Habitat on New Bridge

7-6 Noise

Many demolition methods produce objectionable levels of noise. In some jurisdictions this may limit the means and methods or hours of operation. Noise can have negative impacts on fish or other wildlife. On occasion, it is necessary to relocate adjacent residents or compensate commercial establishments for the disruption. It is always best to anticipate potential problems and plan to mitigate as effectively as possible. Sometimes it is necessary to monitor noise levels for contract compliance. Cal/OSHA requires contractors to protect employees from noise hazards. *Contract Specifications*, Section 14-8, *Environmental Stewardship – Noise and Vibration,* limits the maximum nighttime noise level.

The primary regulation and enforcement of objectionable noise is the responsibility of local governments. Local jurisdictions may limit volume or hours of operation. Bridge removal operations can be impacted by noise complaints from adjacent citizens and businesses.

Many jurisdictions in California have noise ordinances. Emergency work is often specifically exempted from local ordinances because it is recognized as necessary to preserve life or property. Sacramento City Code, for example, has a typical ordinance that prohibits the use of a hammer or hydraulic hammer between 2200 and 0700 hours. Permissible lane closure times and nighttime work windows may conflict with local ordinances restricting noise and should be anticipated. Restrictions often reference the background noise level, which can be elevated near transportation facilities. Noise restriction may require the use of alternate methods in lieu of hammers, or the erection of baffles or some other means of mitigation; refer to Figure 7-14 for an illustration of sound control blankets in use. Public notification of the purpose and duration of potentially objectionable noise might promote public acceptance of short-term impacts. Notification to nearby neighbors with a contact number may help resolve issues. Documentation of noise levels may also be required and prove useful. A few urban jurisdictions issue noise permits for construction activities. Generally, a noise permit gives specific permission to exceed noise levels for documented activities and time frames.

Somewhat related to noise are ground vibrations and underwater sonic disturbances. Installing temporary piles for an access trestle or a containment structure has many of the same impacts as a permanent installation. Fish and wildlife impacts may require mitigation through the use of bubble curtains.

Figure 7-14. Sound Control Blanket on the Continuous Truss of Bay Bridge

Chapter 8: Inspection

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8-1 Introduction

Benefits of the substantial effort to produce and review a bridge removal work plan are only realized if the plan is properly executed. Field inspection of bridge removal operations is also necessary to reduce adverse outcomes. The Contractor's authorized field representative and the State's field inspector are an important link between the authorized bridge removal work plan and the actual field implementation, including communication with the team members doing the physical work. Even the most well thought out plan may include reasonable assumptions that prove to be erroneous once the work is underway. The State inspector is expected to develop a comprehensive understanding of the project goals and verify that these goals are satisfactorily met during the removal operations.

Field inspection is much more than watching the Contractor work and documenting progress. There is a significant difference between "watching the work" and "inspecting the work." Inspection is active pursuit that originates with a knowledge of what is to be accomplished and what results are expected. Some of the inspector's best tools are becoming familiar with the project requirements and constraints, as well as setting expectations with the Contractor. This can be accomplished with a pre-bridge removal meeting, attending the Contractor's tailgate safety meetings, and simply providing feedback as the work progress. Something as simple as showing up when the Contractor starts work for the day and discussing the day's operations and expectations can be very beneficial towards the goal of a safe and productive operation. Figure 8-1 shows a measurement being taken for a bridge removal operation.

Figure 8-1. An Inspector Documents the Depth of Soffit Saw Cut

8-2 Project Plans and As-Built Project Plans

Ideally, the as-built project plans detail what currently exist, and the project plans detail what is to be removed. Where the project plans include dimensions regarding the existing structure, they most often originate from the as-built project plans. The project plans are supplemented by the *Contract Specifications*. For example, these written specifications might detail the minimum depth that an element is to be removed below finished grade or the minimum sawcut depth. Such contract requirements are often not detailed on the authorized bridge removal work plan; thus, it is imperative that the field inspector be knowledgeable with the *Contract Specifications*.

During the bidding phase, as-built project plans are available to the Contractor through Structures Maintenance and Investigations (SM&I) and can be requested per *Contract Specifications*, Section 2-1.06B, *Bidding – Bid Documents – Supplemental Project Information.* A prudent contractor should request and review the as-built project plans that pertain to bridge removal during the bidding phase. Some bridges are security sensitive, and a confidentiality agreement is required with the Contractor prior to providing the as-built project plans. The as-built project plans provide valuable information; however, they can be deficient. As-built project plans are simply the contract bid plans that document changes during construction. As bridges have often been modified, through bid contracts, emergency contracts, or maintenance work throughout their lifecycle, there could be changes that were not incorporated into the published as-built project plans. Concrete elements are often slightly larger than shown on the as-built project plans because concrete form deflection is often not considered when preparing as-built project plans. Such minor deviations are within construction tolerances and considered normal and expected within the industry. However, the inspector should be on the lookout for anomalous and abnormal deviations from the as-built project plans that adversely impact the Contractor or might require a modification of the authorized bridge removal work plan. Footings are often poured oversized and "neat" to the soil. If a footing is significantly oversized and removal is necessary, a contract change order may be appropriate to compensate the Contractor for the additional effort required to remove the footing that could not have been anticipated at bid time. Oversized footings were common during earthquake retrofits and can be expected on bridges that were repaired after earthquakes or during earthquake retrofits.

Additionally, the as-built project plans sometimes fail to include the incorporation of hazardous materials such as asbestos, thus necessitating coordination with the District's environmental division and a change order to capture the cost of handling and disposal.

Contract Specifications, Section 2-1.07, *Bidding – Job Site and Document Examination*, requires that the Contractor examine the job site during the bid phase. Consequently, visible potential issues not detailed on the as-built project plans may not be cause for

a contract claim. An example is visible rip-rap placed near an abutment or pier. Often, there are District contracts or maintenance work that add rip-rap to a bridge that is not shown on the latest bridge as-built project plans. A simple site examination by the Contractor will make the Contractor aware of this during bidding. Another example could be a dimension shown on the project plans as “varies.” If this was deemed a significant issue at the time of bid, the Contractor could make a bidder inquiry or a site visit and make a determination of the extent of the variable dimension.

Issues related to site access, soffit elevations, and clearances are easily observed during a site visit. The Structure Representative and all field staff assigned to a project should make a site visit prior to bid and take extensive photographs of the bridge removal location, including photographs of the site as a whole and individual bridge elements. This could provide valuable information of the existing visible conditions.

As-built project plans are maintained by SM&I through their Bridge Inspection Records Information System (BIRIS), which can be accessed through the Caltrans intranet.

Concurrent with the review of the Contractor’s proposed bridge removal work plan, the Structure Representative should download and review the as-built project plans, bridge inspection reports, and all other relevant information provided in BIRIS. This information can be obtained by contractors, outside agencies, and consultants with requests to SM&I as outlined above. The Area Bridge Maintenance Engineer (ABME) and the Bridge Maintenance Superintendent are also valuable resources that should be consulted prior to bridge removal, especially if there are minimal or no as-builts records and/or if the bridge is complicated or unique.

8-3 Bridge Removal Work Plan

The authorized bridge removal work plan must be available at the site prior to bridge removal. The Contractor’s bridge removal superintendent and onsite engineer must have the authorized bridge removal work plan. The Structure Representative and field staff should discuss the authorized bridge removal work plan with the Contractor’s staff prior to the commencement of bridge removal operations. If there are multiple bridges on a project that require removal, then each bridge on the project will have a site-specific bridge removal work plan. All bridges, no matter how similar, have site specific considerations that need to be addressed in the bridge removal work plan. Something as simple as identical bridges with reversed skews can have a catastrophic impact to removal operations, illustrating the importance of site-specific bridge removal work plans.

Any hazardous materials must be addressed as a first order of work prior to authorization of the bridge removal work plan. This includes asbestos abatement, lead removal, bat guano, and crystalline silica protection among others. As an industry

standard and a Cal/OSHA requirement, a hazardous waste survey must be made prior to bridge removal. The survey identifies the nature and estimated quantity of hazardous materials. The survey generally includes a review of as-built project plans, bridge inspection reports, and other relevant bridge data as well as samples taken from the site and evaluated as necessary. Common hazardous materials found in bridges include lead, asbestos, and crystalline silica. Lead is often found in structural steel coatings, yellow traffic stripe, and soils around the bridge. Lead in the soil adjacent to the bridge can be the result of aerial deposit from vehicle exhaust in the days when gasoline was leaded in California or from previous painting or paint removal operations. Asbestos may be found in some geologic formations, concrete aggregates, sheet packing and shims, piping, and bearing materials. The quantity of hazardous materials must be estimated since special containers and handling requirements may be necessary, including disposal at an approved hazardous waste landfill. Hazardous materials generated from the bridge removal are often stored in sealed containers and, if short term storage is necessary on site, security fencing must be provided. In most cases, the goal with lead in the soil is to not increase the existing lead levels in the soil from the bridge removal operations, which is verified by pre and post bridge removal sampling evaluations.

The bridge removal work plan will detail the removal sequence. The order of operations may list preliminary work that will precede more significant bridge removal activities. Preliminary work may be authorized to proceed with protective covers, as required. Preliminary work is defined in the *Contract Specifications*, Section 60-2.02C(3), *Existing Structures – Structure Removal – Bridge Removal – Construction – Preliminary Work*, as work that will not reduce the structural strength or stability of the bridge or cause debris or materials to fall onto the roadway.

The structure must be stable during each stage of bridge removal. Unanticipated structural collapse can have severe consequences and must be avoided. Temporary bracing or supports are often installed to ensure stability during progressive demolition. The design of temporary supports requires an extensive engineering review and calculations, coupled with a good understanding of the design and as-built conditions of the bridge being removed. Care is required both in the selection and installation of temporary supports, and to verify that the materials used are adequate and fit for purpose. Assumptions such as soil bearing values should be verified. The inspection of these temporary supports is required, similar to typical falsework construction. It is common during partial bridge removal operations to establish survey controls and monitor the bridge for movement.

The bridge removal work plan shall identify locations where work is to occur over traffic, utilities, railroad property, or an environmentally sensitive area. These are common locations for the installation of protective covers. Protective covers must contain not only the larger debris, but also any dust or slurry generated from the removal operation.

Protective covers should be augmented with any barriers or engineering controls required to prevent debris and dust from migrating from the containment site.

The bridge removal work plan will identify areas where debris can be processed, sorted, and loaded out for removal from the project site. Frequently, reinforced concrete is processed on site for recycling by removing reinforcement from the concrete. Some projects may have an embankment where the disposal of concrete debris may be appropriate, under certain conditions and restrictions. Inspection should verify that debris is contained within the areas anticipated and that adequate final clean-up is accomplished.

The bridge removal work plan should specify where and when saw cutting will take place. Where partial bridge removal is performed, the depth of the saw cut and preservation of existing reinforcement will be detailed. The depth of the saw cut may be reduced to preserve existing reinforcement. The Contractor is required to protect any existing reinforcement that will be incorporated into the new work, and this should be clearly detailed in the bridge removal work plan. See Figure 8-2, which illustrates the close working quarters and congested nature of reinforcement retained, during a partial hinge replacement. This figure also depicts the hazards of working near a tangle of reinforcement, and the need for the workers to be cognizant of their surroundings, while employing the use of personal protective equipment.

The State has a proprietary interest in the ultimate disposal locations for demolition debris. The State can be held accountable, as the generator, for debris not properly disposed of. Hazardous materials are accounted for on a manifest and the manifest becomes a record in the project files. Due to its high alkalinity, concrete debris can be detrimental to aquatic life; therefore informal agreements between a landowner and the Contractor may not be appropriate for concrete debris disposal. The inspector should document debris disposal locations in the daily diary.

8-4 Traffic

The order and pace of work of bridge removal operations is often greatly influenced by the traffic handling and lane closure restrictions. Traffic handling is usually a significant part of the project plans, which requires training and experience for successful implementation. Temporary lane closures are carefully planned and scheduled in advance, and are continually evaluated for effectiveness and safety. While partial bridge removal of the edge of a bridge deck is behind a temporary barrier, access might require temporarily closing the adjacent lane for access. Traffic handling can be further complicated by night work. Adequate illumination that doesn’t adversely affect drivers can be an ongoing challenge. Construction activities can also distract drivers. Periodic observation of the traffic flow can reveal the effectiveness of the traffic control operations. The inspector should loop around and drive the project limits through

the reduced lanes, to reveal the experience of the traveling public. During this loop, special attention is given to the placement of warning signs, flashing arrows, lane tapers, and placement of light towers to verify functionality of the same.

If a bridge is to be completely removed, bridge removal work shall not begin until the bridge is completely closed to, and cleared, of public traffic.

Demolition falsework that is over or adjacent to traffic requiring a protective cover or temporary supports has minimum horizontal and vertical clearance requirements. The minimum horizontal clearance is 8 feet to a lane or shoulder open to traffic. The minimum vertical clearance is 15 feet. Any anticipated reduction of vertical or horizontal clearances needs to be reported to the Caltrans Permits Office at least two weeks in advance of the reduction in clearance; refer to BCM C-6, *Required Documents to be Submitted During Construction* and Attachment 2, *Guidance for Completing Required Documents Submitted to SC HQ*, for guidance. The Contractor is required to report any planned reduction of clearances to the Resident Engineer at least 25 days prior to the actual reduction. After the temporary supports are erected, the inspector is to verify that the actual clearance is not less than the planned and reported clearance.

8-5 Protective Covers

Protective covers can be structurally independent, entirely mounted to the existing structure, or a portion of the existing structure, or a hybrid installation. Mounting to the existing bridge requires additional inspection since the goal is to provide a mounting system that fulfills the intent of the design without causing damage to the existing bridge that is to remain in place. Any temporary anchors installed need to be eventually removed and the holes repaired, as outlined in *Contract Specifications*, Section 51-1.03F, *Concrete Structures – General – Construction – Finishing Concrete.*

When protective covers are part of the authorized bridge removal work plan, they must be field worthy and effective. Part of the inspection process involves an evaluation of the effectiveness of the protective cover. If the cover is not protecting as designed, a revision to the removal plan or operational mechanics is required.

Verify member dimensions, anchor installations, and that the required workmanship of the authorized protective cover plans is adhered to. Inspection is not limited to the installation process. As debris accumulates and is removed, the protective cover can be damaged or overloaded, or simply rendered ineffective. Inspection vigilance is an ongoing requirement until the protective cover is removed. Most often, the protective cover design is similar to falsework in nature and the *Falsework Manual*, Chapter 9, *Inspection,* will prove to be a useful reference.

8-6 Equipment and Crew

The authorized bridge removal work plan will be very specific regarding the equipment to be used. If equipment is operated from the bridge deck, the operating weight is a significant consideration. Equipment that exceeds the capacity of the bridge deck might be restricted to only operating over the bridge girders or other specified locations. Sometimes for heavy lifting, equipment might be operated on top of dunnage to distribute the load. Whatever the situation, no change in the authorized equipment should be made without an amendment to and reauthorization of the removal plan. Field staff tasked with inspecting this operation should be very familiar with the equipment listed in the bridge removal work plan, how to identify this equipment, and any restrictions on its use.

The energy of hydraulic breakers is limited by the contract when used for partial removal situations where the in-situ concrete is to be preserved. The *Contract Specifications*, Section 60-2.01C, *Existing Structures – Structure Removal – General – Construction,* limits the striking energy to 1200 ft-lb per blow. Excessive striking energy increases the likelihood of damage including micro fractures in the remaining concrete. Micro fractures are especially detrimental when they occur adjacent to embedded reinforcement, as this promotes future corrosion and eventual delamination of the concrete which can lead to costly repairs or failure of the bridge.

Generally, the Department's field staff does not direct the Contractor. Communication between the inspector and the Contractor's engineer, foreman, and/or superintendent directing the work is the usual protocol. However, the inspector should intercede directly with an operator if errors or significant damage is occurring, and the Contractor's usual supervision is not immediately available.

The skill level of operators varies, sometimes dramatically. A new operator on rented equipment might benefit from some close observation and feedback. It is not the inspector's task to train apprentices, but unacceptable results should be brought to the Contractor's attention as soon as possible.

Furthermore, in situations where a freeway or other public thoroughfare is being closed under a limited time frame, it is paramount that the inspector verifies that all of the crew and equipment that are required to be onsite are there before bridge removal operations commence, including supervision.

Figure 8-2. Workers Removing a Portion of a Hinge, San Francisco

8-7 Superstructure

Safety and stability are always concerns, but especially when the work is elevated. When work is elevated, the workers and the equipment are often situated on the bridge deck. Along the leading edge, there are fall hazards and the potential for falling debris.

Not usually an explicit part of a written plan is a limitation on unnecessary personnel or equipment near removal operations. Common sense makes this even more of a concern when the work is elevated. Curious, nonessential personnel have been injured while visiting the site of demolition work. Access should be controlled; if access is desired for someone like a photographer or to accommodate a job tour, a natural pause in the work or a temporary recess can be utilized. With a pause in the work, directions, explanations, or verbal cautions are easily communicated by the chaperone.

There is a lot going on in the partial bridge removal in the Figure 8-3 photograph. The work is taking place in the number one lane. Traffic is passing on the other side of the median barrier and the number two lane is open to traffic behind the photographer. This is a noisy environment as the workers are using small pneumatic hammers. The

schedule is such that there is very little room for unanticipated events. This bridge joint repair can only be accomplished in one shift if the well thought out plan was executed as anticipated. However, the plan must provide for contingencies. If the work cannot maintain the anticipated schedule, then some means of temporarily bridging the joint will be necessary. The inspector will have verified that the contingency provisions are in place before the works begins and then monitor the progress of the work throughout the night as tasks are completed. Often with such time constraints, progress is monitored in minutes. Even if there are no complications such as equipment breakdowns, concrete curing issues, or traffic accidents, the inspector will have a very busy shift verifying the workmanship, materials, and adherence to the schedule.

Figure 8-3. Repair of Bridge Joint at Night, Yuba River

Partial bridge removal is sometimes required on brand-new structures before they are placed into service to correct deficiencies in materials or workmanship on individual elements. The next photograph in Figure 8-4 is a soffit repair on a new structure where the concrete was defective. Concrete removal on a new bridge is similar to working on an existing bridge; all the best general practices apply. Some cases may require a remediation plan or bridge removal work plan, depending on the extent of the repairs.

Figure 8-4. Soffit Repair at Doyle Drive, San Francisco

8-8 Substructure

Usually by the time the demolition reaches the substructure, the Department's inspector has fostered a working relationship with the demolition crew and many of the early concerns have been resolved.

However, there is still a substantial portion of the removal plan to execute. Elements of the substructure in the water can still pose challenges, and safety continues to be a priority. Substructure removal in open water situations might require cofferdams, divers, or water diversions. Old construction debris or other debris adjacent to piers in water can impede progress, since the old debris will likely need to be removed prior to the bridge removal work, and may not have been anticipated in the schedule. Previously undocumented obstructions should be included in the daily reports, as potential adjustments in compensation might be necessary. Regardless of the actual field conditions, it is still important to protect the natural resources and meet any commitments made to resource agencies.

8-9 Special Locations

The Caltrans *Falsework Manual* and the *Contract Specifications*, Section 48-2.02B(4), *Temporary Structures – Falsework – Materials – Design Criteria – Special Locations,* list locations with special concerns and requirements. These locations are subject to vehicular impacts, and any temporary supports or falsework in these locations require additional impact resistant elements. Falsework over or adjacent to traffic and railroads will be identified on the bridge removal work plan and will include the required resistive design and elements. Special locations have requirements for additional signage or lighting when encroached upon by falsework. Sometimes it is not anticipated that temporary works might shadow or obstruct existing signage, traffic lights, or reduce sight distance to the same. An inspector should evaluate negative impacts that temporary works and activities might have on traffic, and mitigate as appropriate.

The inspector needs to verify that the additional requirements at special locations are met. This includes documentation of vertical or horizontal clearance changes.

8-10 Contractor's Engineer

The Contractor is responsible for quality control and jobsite supervision. Contract Specifications, Section 60-2.02A(4)(c), Existing Structures – Structure Removal – Bridge Removal – General – Quality Assurance – Quality Control, requires that for bridge removal work plans signed by a registered engineer, the Contractor's engineer must be present at all times during bridge removal activities.

The Contractor's engineer is required to write daily inspection reports that must be available at the site at all times. The Contractor's daily report should document the progress of the work, as well as document the condition of the remaining structure each day. For partial removal, the diary should document any damage to the existing structure. Stability of the structure should be documented in cases of complete removal or partial removal, where major load-supporting members are altered or removed. The inspector must verify that the Contractor's engineer is onsite at all times during active bridge removal and that the reports are available. Figure 8-5 illustrates the collaborative working relationship of personnel in the field during removal operations.

Figure 8-5. Engineers Discussing Plan

Appendix A: Removing Concrete from Bridges NCHRP 169

This appendix includes a link to a useful reference on the technical aspects of removing concrete from bridges. This reference was prepared by the Transportation Research Board – National Cooperative Highway Research Program, and is Synthesis of Highway Practice 169, titled *Removing Concrete from Bridges*.

The reference can be accessed by clicking on the "View this PDF" tab.

Appendix B: Bridge Removal Work Plan Review

This appendix has been developed to assist field personnel responsible for the administration and review of the bridge removal work plan. It is intended to address common issues and the quality assurance measures to be employed when reviewing demolition operations. The review and processing of a removal work plan needs to be thorough and well documented.

The following information is a general outline and is not to be taken as an all-inclusive list for bridge removal review. Safety is the priority; if something does not look appropriate, do not compromise safety. If further assistance is needed, consult the Bridge Construction Engineer or contact the Structure Construction (SC) Falsework Engineer. The information presented is based on the requirements described in the *Contract Specifications*, Section 60-2.02, *Existing Structures – Structure Removal – Bridge Removal*; however, the *Special Provisions* may modify these requirements.

B-1 Prior to Plan Submittal

Submittals involving bridge removal are often lacking required information. Thorough consideration, pre-planning, and early communication with the bridge removal contractor can minimize delays with authorization and ensure a quality bridge removal work plan is submitted. Begin communication before the bridge removal work plan is submitted. Though not required by the contract, a pre-submittal meeting or phone call would help to ensure the Contractor understands all that is expected in the submittal. Topics to consider include the following:

1. Recommend that the Contractor investigates the as-built condition of the structure and determines if any special conditions exist, e.g. column pins and deck hinges may need to be restrained during bridge removal operations. A site visit and/or a meeting with the local bridge maintenance supervisor may be helpful when discussing as-built conditions. The Resident Engineer's Pending File will include the as-built project plans for the structure to be removed. If the as-built project plans are not included, obtain them from BIRIS.
    a. *Contract Specifications*, Section 2-1.06B, *Bidding – Bid Documents – Supplemental Project Information*, directs the Contractor to request the as-built project plans from Structures Maintenance and Investigations (SM&I). Due to current confidentiality standards, SC staff are not to give out as-built project plans to the Contractor.

2. A complete bridge removal work plan must be submitted to receive an expeditious authorization. Some items worth reminding the Contractor include:
    a. If protective covers are required or superstructure removal is performed, the bridge removal work plan must include substantiating calculations and be signed by an engineer who is registered as a civil engineer in the State of California.
    b. The review time is 20 days unless modified by the *Special Provisions.*
    c. The plan must detail the procedures and sequence for removing portions of the bridge(s), including all features necessary to remove the bridge(s) in a safe and controlled manner.
    d. Where calculations are required, the calculations must demonstrate the stability of the structure at each stage of removal.
    e. Before removing portions of monolithic concrete elements, make a 1-inch deep saw cut along the limits of removal on elements that will be visible in the completed work.
    f. If the Contractor is removing a portion of a bridge (e.g., barrier rail only, edge of deck for a widening), the removal operations must be performed without damage to any portion of the structure that is to remain in place. In such cases, tools with a manufacturer's rated striking energy in excess of 1,200-foot pounds per blow must not be used for breaking or removing concrete, which is attached to, or supported by, the bridge.
        i. If work is performed over or adjacent to a railroad, review the additional requirements contained in Chapter 2, *Review and Authorization of Bridge Removal Work Plans.* Last minute modifications to the submittal will cause a delay in the authorization.

B-2 Initial Review

When the bridge removal work plan is submitted, perform an initial review to verify that the submittal is complete and contains all information necessary for SC staff to perform the review. This is useful for complicated submittals where review time is a factor. The plan must be suitable for the site conditions present and must provide information clearly outlining the removal procedures proposed by the Contractor. The following are some basic items to check for in your initial review:

1. When protective covers are required or superstructure removal is performed, verify calculations are provided and the bridge removal work plan is prepared by an engineer who is registered as a civil engineer in the State of California.
2. Verify calculations for vertical shoring, restraining systems for columns, and deck hinges are included when these elements are included in the bridge removal work plan.

3. Ensure that descriptive information including the removal methods, staging, and sequence of removal is included.
4. Verify that equipment lists, axle loadings, and proposed equipment placement locations are included.
5. Verify timeline, milestones, and contingency plans are included when traffic closures, potential safety problems, or construction windows are of concern.
6. Verify information providing for the protection of existing utilities and non-highway facilities is included, as required in the *Contract Specifications*, Section 5-1.36, *Control of Work – Property and Facility Preservation.*
7. If bridge removal is intended over and/or adjacent to railroad tracks, ensure the additional requirements described in Chapter 2 are included.

B-3 Review

1. Verify the safe work areas for the Contractor's personnel and Caltrans personnel are shown on the bridge removal work plan. Verify the protection of public traffic and private property is adequate, including the safe routing of public traffic during demolition operations.
2. Review the equipment described is adequate to perform the removal work. Review the location of the demolition equipment and the method in which the equipment will be used to remove the structure.
3. Verify the calculations are adequate to demonstrate the stability of the structure during all stages of the removal operations. Evaluate the stability of the structure under live loads during bridge removal per *Contract Specifications*, Section 5-1.37B, *Control of Work – Maintenance and Protection – Load Limits*. This is critical when a portion of the structure is to remain standing with equipment on the structure.
4. Verify a freely falling mass or a falling mass attached to a cable, rope, or chain is not to be used for breaking or removing concrete attached to or supported by the bridge.
5. Verify concrete attached to or supported by the bridge is not to be demolished within 30 feet horizontally of any area open to the public unless adequate protective shields are in place. Verify any necessary debris shields needed to protect the surrounding area, structural elements, and falsework are detailed and shown on the bridge removal work plan.
6. Evaluate the potential for damage due to demolition debris falling on the roadway section, adjacent structure, supporting falsework, protective cover, or structural elements supporting the structure being removed. If debris buildup is anticipated, these loads should be considered in addition to the equipment loads.

7. Verify dust control and hazardous material provisions are adequately addressed.
8. If traffic closures are involved, verify operational timelines are reasonably within the traffic closure windows. Verify progress is monitored against planned progress milestones, and a reasonable contingency plan is provided should the work fall behind planned progress.
9. Verify the location of temporary handrailing and barrier railing for bridge decks is adequate for staged bridge removal for the protection of construction staff and the traveling public.

B-4 External Agency Requirements

Often bridge removal involves external agencies. Some of the coordination efforts that must take place are identified below:

1. The Contractor must comply with all local sound, water, noise, and air pollution control requirements.
2. The Contractor must coordinate with other entities per *Contract Specifications*, Section 5-1.20A, *Control of Work – Coordination with Other Entities – General*. One typical example may include obtaining a disposal permit for disposal of material outside the highway right-of-way.
3. A Cal/OSHA permit is required for demolition of any structure over 36 feet.
4. If bridge removal is performed over or adjacent to railroad tracks, a railroad agency review of the bridge removal work plan is required. Notify the agency through the SC Falsework Engineer well in advance of the work, especially if the demolition work is a critical path item on the project schedule. Information regarding working with railroads can be found in the following locations:
    a. *Contract Specifications*, Section 5-1.20C, *Control of Work – Coordination with Other Entities – Railroad Relations.*
    b. Section of the project specific *Information Handout*, titled *Railroad Relations and Insurance Requirements*.
    c. Chapter 2, *Review and Authorization of Bridge Removal Work Plans*. The procedure for authorizing these plans is identical to that used for falsework plans. The instructions can be found in the Falsework Manual, Chapter 2, *Review of Shop Drawings,* Section 2-4.02B, *Review Procedure when Railroad Company is Involved.*