Chapter 6: Bearing Replacement

Table of Contents

6-1 Introduction

Caltrans Structure Technical Policy 14.1, *Bridge Bearings*, and American Association of State Highway and Transportation Officials (AASHTO) define bearing as "a structural device that transmits loads while facilitating translation and rotation." There are a variety of bearings that have been used on Caltrans projects. The AASHTO LRFD *Bridge Design Specifications* (BDS) Section 14, *Joints and Bearings*, provides a list of some bearing designs and their definition; note that the LRFD BDS can be obtained via ACCURIS link (account setup and login required). Figures 6-1 to 6-4 provide examples of some of the common types of bearings used worldwide:

Figure 6-1. Pot Bearing (Google PMG Series)

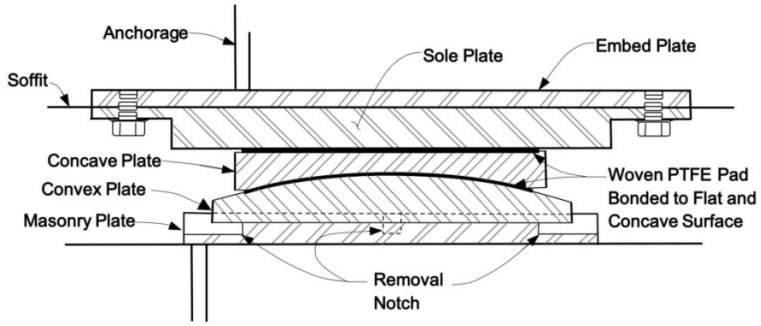

Figure 6-2. PTFE Spherical Bearing (From AASHTO LRFD BDS Section 14)

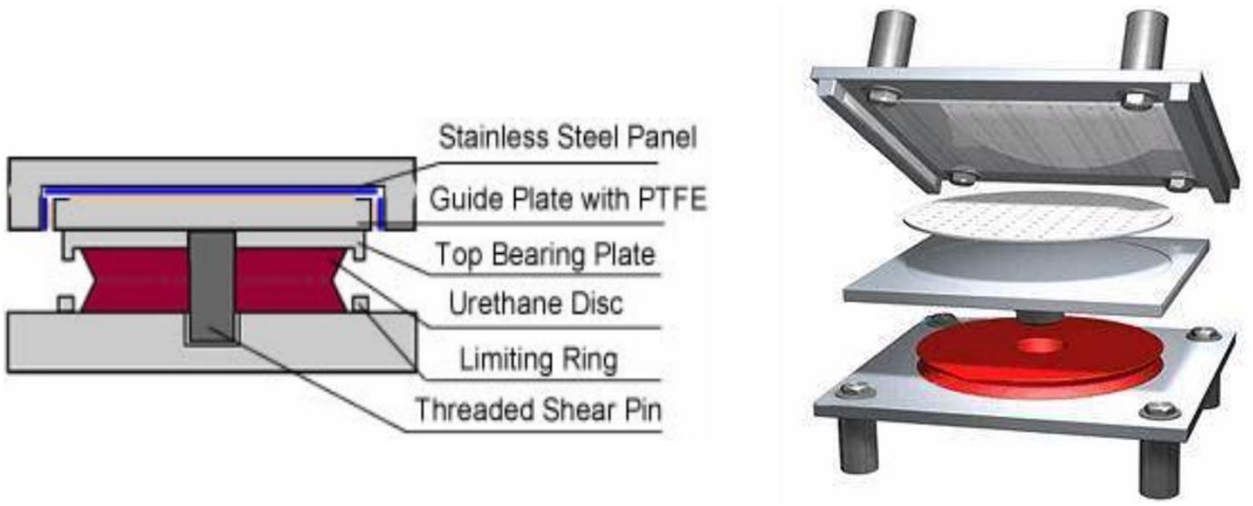

Figure 6-3. Disc Bearing

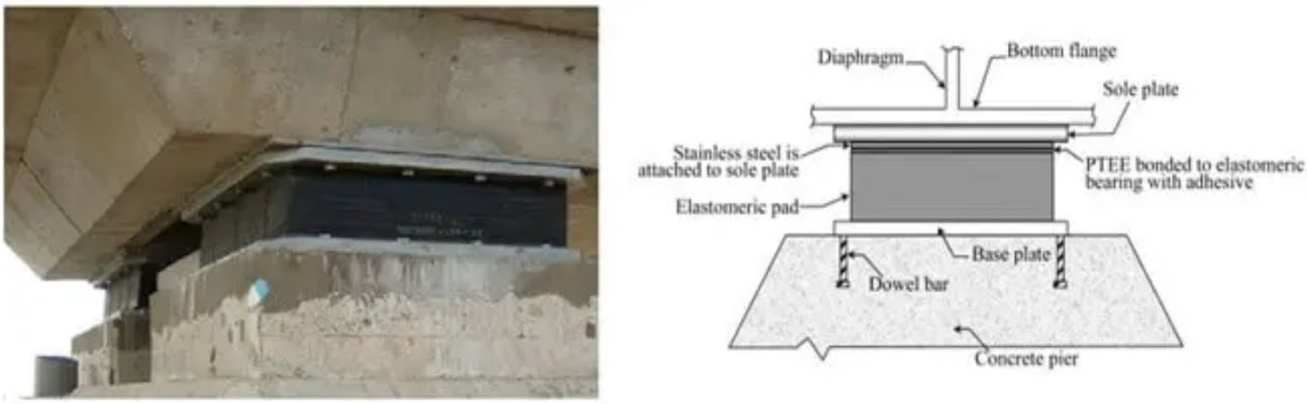

Figure 6-4. PTFE/Elastomeric Bearing

Loads, displacement, rotation, deflection, geometry, maintenance, and policy are some of the factors used in selecting a bearing design. For typical hinge and abutment configurations, elastomeric bearing pads have proven to be highly reliable and should be considered the preferred type of bearing for all structures. Per Caltrans Memo To Designers (MTD 7-1), *Bridge Bearings*, *Bearing Selection* section (page 2), it is the official policy of the Division of Engineering Services Bridge Design (DES-BD) to use conventional reinforced elastomeric bearing pads when shear deformation of the bearing pad can provide the required characteristics. Designers explore the option of PTFE/Spherical or PTFE/Elastomeric bearings when the practical limits of elastomeric bearing pads are exceeded (PTFE stands for polytetrafluoroethylene, which is a low-friction fluoropolymer). These three bearing pad types satisfy the design requirements of most structures. Accordingly, when discussing bearing pad replacement, the information

presented in this chapter is focused on elastomeric bearing pads since this is the type of bearing pad that is most commonly utilized in Caltrans bridge construction. However, much of the information presented is still applicable to other types of bearing replacement projects.

As seen in the above figures, elastomeric bearings consist of alternate layers of elastomer and steel sheets or fiberglass fabric reinforcement. Due to their design, elastomeric bearings are relatively maintenance-free. However, as required by the Federal Highway Administration's (FHWA) National Bridge Inspection Program or by state/local government policies, all bearings need to be inspected periodically to verify that the bearings are functioning as designed. Examples of bearings that are not functioning properly are bearings that have "walked out" from under the bridge girder, over-translation, tearing, splitting, bulging, and plate corrosion. Bearing failure can result in roadway surface deflection, overstress beams or supporting structures, and in extreme cases a bridge failure. As such, when a bearing is found to not be performing as designed, it needs to be either repaired or replaced.

6-2 Understanding Contract Requirements for Bearing Replacement

6-2.01 Contract Plans

Structure Plans- Plan sheets that describe bearing replacement work typically consist of a "General Plan", "Bearing Replacement Details", and "Temporary Support Details". These plan sheets describe the contract requirements for bearing pad replacement, including the type of existing bearings to be removed, the placement location and quantity of the bearings, the type of replacement bearings, and the requirements for temporary support. See Figure 6-5 for an example of a typical "Bearing Replacement Details" plan sheet.

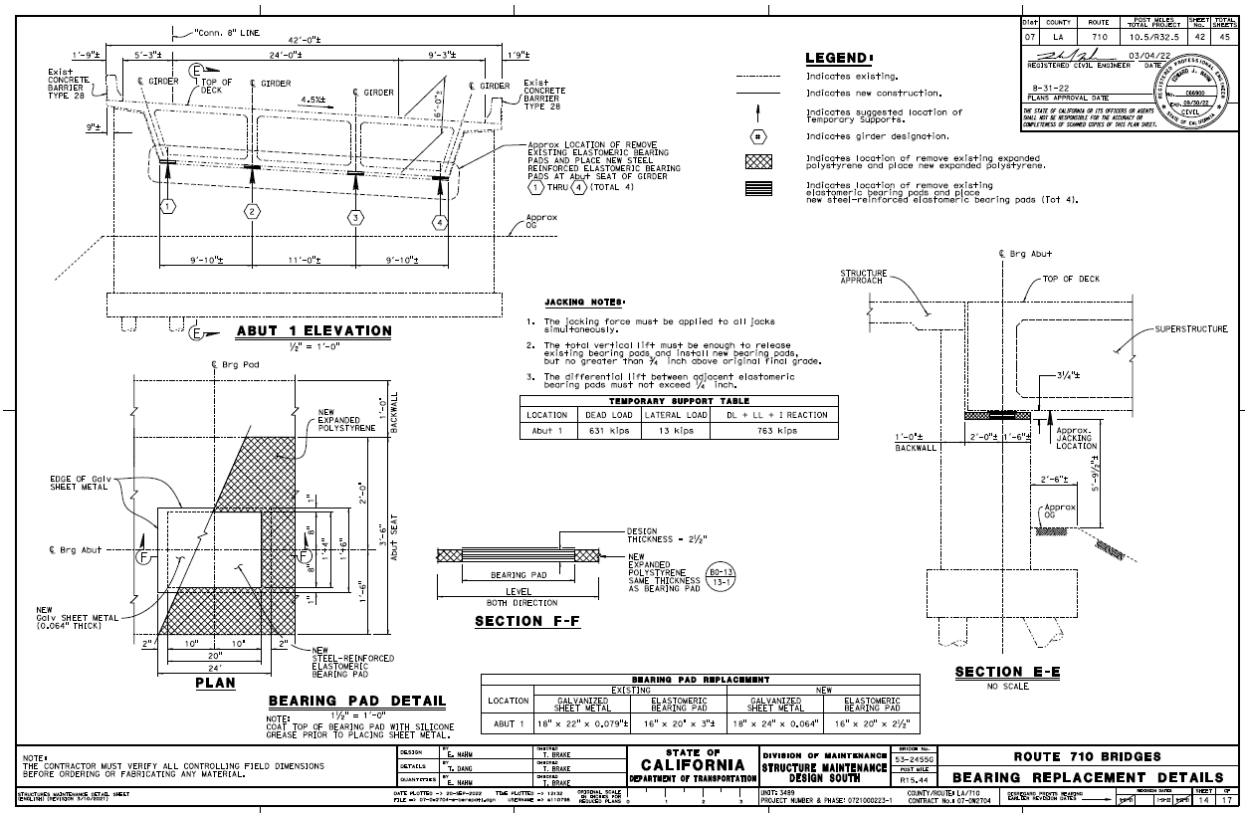

Figure 6-5. Example of Typical Bearing Replacement Details Sheet

6-2.02 Special Provisions

Section 48, *Temporary Structures*: This section of the special provisions might describe unique requirements for the design and construction of temporary supports used during bearing pad replacement projects.

6-2.03 Standard Specifications (SS)

In Chapter 1, several sections of the *Standard Specifications* that describe requirements for common rehabilitation activities were introduced and discussed. Please review the following *SS* sections from Chapter 1:

1. **Section 5-1.37, *Control of Work – Maintenance and Protection***, describes requirements for placing heavy equipment loading on the bridge, such as cranes for lifting forms.
2. **Section 7-1.04, *Legal Relations and Responsibility to the* Public *– Public Safety***, describes requirements for operations that would reduce the vertical and horizontal clearances.
3. **Section 14, *Environmental Stewardship***, describes requirements related to environmental compliance and environmental resource management. Examples

include species protection, hazardous waste (including lead paint and asbestos), air pollution control, dust control, and noise and vibration.

In Chapter 1, Section 48, *Temporary Structures*, and Section 60, *Existing Structures* of the *Standard Specifications* were also discussed. At this point, the requirements for these two sections concerning bearing replacement will be looked at in more detail.

1. **Section 48, *Temporary Structures***: During the construction of bearing replacement, temporary supports are often required for the jacking of the existing structure to remove and replace the existing bearings. See Figure 6-6 below for an example of temporary supports.

Figure 6-6. Temporary Support Example

Subsection 48-3, *Temporary Supports*, and subsection 48-5, *Jacking*, describe requirements for activities commonly performed during bearing replacement. Let's look at several subsections next.

a. **Subsection 48-3, *Temporary Supports***, describes the requirements for installation of the temporary supports, which are highlighted below:

   i. The requirement of the initial location survey of the existing structure by a registered civil engineer.

   ii. Submittal requirement of drawings and calculations. This includes (but is not limited to) describing all loads and equipment to be used, details of all jacking, erection, and removal plan of the support system, assumed soil bearing values, anticipated settlement, details of bracing, and detail/schedule of displacement monitoring system. Furthermore, calculations submitted must show stresses in the temporary support system, stresses in connections between temporary support and existing structure, and the stresses in load-supporting members.

iii. Compliance with American Welding Society (AWS) D1.1 for welding.

iv. Calibration requirement of jacking equipment, including jacks, gauges, and load cells.

v. Requirement for a registered civil engineer to be present during all jacking activities or adjustments. Daily reports for any jacking activities must also be provided by the registered civil engineer. Requirements for an immediate submittal of proposed procedures to correct or remedy unplanned occurrences.

vi. Displacement monitoring requirement of the temporary support and existing structure for specific construction activity and at specified frequency intervals; additionally, locations on the existing structure for displacement monitoring (such as bents) are also specified. This section also requires that the displacement monitoring used must be vandal-resistant.

vii. Material requirement of the temporary support is also provided in this section by describing the design criteria for supporting both vertical and lateral loads. Accordingly, the minimum design loading and the allowable stresses that must be supported are described in this section.

viii. Construction requirements of temporary supports. The requirements of this section aim to provide a safety mechanism for traffic protection as well as jacking equipment failure. The requirements of this section are also intended to minimize existing structure distortion and to prevent excessive stressing of the existing structure. An example of safety requirements is the installation of a crash cushion before the start of temporary support construction. Another example of a safety requirement is the requirement for a redundant support system during jacking in case of equipment failure. An example of minimizing existing structure distortion is the requirement of calibrated and accurate pressure gauges to simultaneously jack the structure. Also, the requirement to measure and limit the displacement of the superstructure is another example of minimizing existing structure distortion.

b. **Subsection 48-5, *Jacking*,** is another section that further describes the bearing pad replacement construction requirements. When comparing Section 48-5 to Section 48-3, it can be seen that both sections have very similar requirements covering different portions of the bearing pad replacement work. Section 48-3, *Temporary Supports*, “includes specifications for providing temporary supports for structures during retrofit, reconstruction, erection, and removal activities.” On the other hand, Section 48-5, *Jacking*, “includes specifications for jacking the bridge superstructure using a jacking support system.” In other words, to initially jack and support the existing bridge, SC staff need to refer to Section 48-3 and ensure

compliance with its requirements. After replacement of the bearing pad, and for lowering the superstructure back onto the bearing pad, SC staff need to look at Section 48-5. Accordingly, Section 48-5, *Jacking*, includes requirements for submittals, displacement monitoring, design criteria, and construction that are very similar to Section 48-3, *Temporary Support*, to minimize distortion to the existing structure, and to provide a safety mechanism for jacking equipment failure.

2. **Section 60-2.02, *Existing Structures – Structure Removal – Bridge Removal***, includes specifications for removing bridges or portions of the bridges. Accordingly, the portion of the bridge that is being removed is the bearing pad. To follow are some of the contract requirements for this process:
   a. Submittal requirements: the Contractor is required to provide a submittal for the removal sequence, temporary supports, locations where work is performed, and protection for people and traffic.
   b. Engineer of Record for bridge removal work plan requirement: general requirement for the registered civil engineer to be present during the removal; refer to your contract special provisions for any unique requirements.
   c. Bridge removal requirements when work is adjacent to or over traffic. Examples of traffic requirements might include:
      i. Having all necessary personnel, materials, and equipment to complete the work on-site before closing the roadway.
      ii. Performing activities without interruption until the roadway is reopened
      iii. Performing bridge removal activities only when the roadway is closed to traffic, except as specified for preliminary work.

In addition to the sections covered above, the following section describes contract requirements specific to bearing installation:

1. **Section 51-3, *Concrete Structures – Bearings***, describes the requirements for two types of bearings. The first type is the elastomeric bearing pads (plain elastomeric bearing pads and steel-reinforced elastomeric bearing pads) and the second type is the PTFE spherical bearings.

6-2.04 Standard Plans

While there is no detail in the *Standard Plans* specifically for bearing replacement, depending on the project, one or more standard plan details might still be called out.

6-3 Bearing Related Submittals

In Chapter 1, submittals that are commonly required for most rehabilitation projects, including temporary supports and information submittals, were mentioned. In this section, several submittals specific to bearing pad and PTFE spherical bearing replacement and installation will be discussed.

6-3.01 Elastomeric Bearing Pads

Standard Specifications Section 51-3.02A(3), *Concrete Structures – Bearings – Elastomeric Bearing Pads – General – Submittals,* covers submittal requirements of elastomeric bearing pads. The specifications require that the Contractor submit bearing pad test samples for both plain and steel-reinforced elastomeric bearing pads. Although not contractually required, the Contractor may provide a shop drawing for SC review before submitting the test sample. When examining bearing pad shop drawings or test samples, the height of the bearing pad needs to be evaluated by comparing it with the thickness shown on the contract plan as well as by surveying the bearing seat and deck elevation to field verify appropriate deck elevation can be achieved with the replacement bearing pad. When verifying the required thickness of the bearing pad, compressive deflection of the bearing pad must also be considered as described in Appendix B*, Compressive Deflections of Reinforced Elastomeric Bearing Pads.*

It is important to note that different size bearing pads with different size anchor bolt openings might be used on the same bridge. For example, in a multi-span steel girder bridge, more than one size of beam could have been used due to differing bridge span lengths. As a result, the bearing pads used to support the stringers might not be the same size. As shown in Figure 6-7, the shape of the anchor bolt opening might differ at each beam's end due to the desired end condition. Accordingly, verifying with the Contractor that the correct count of each bearing pad size will be manufactured is very important. Lastly, besides providing material samples to the Engineer, the Contractor is required to provide a certificate of compliance with certified test results.

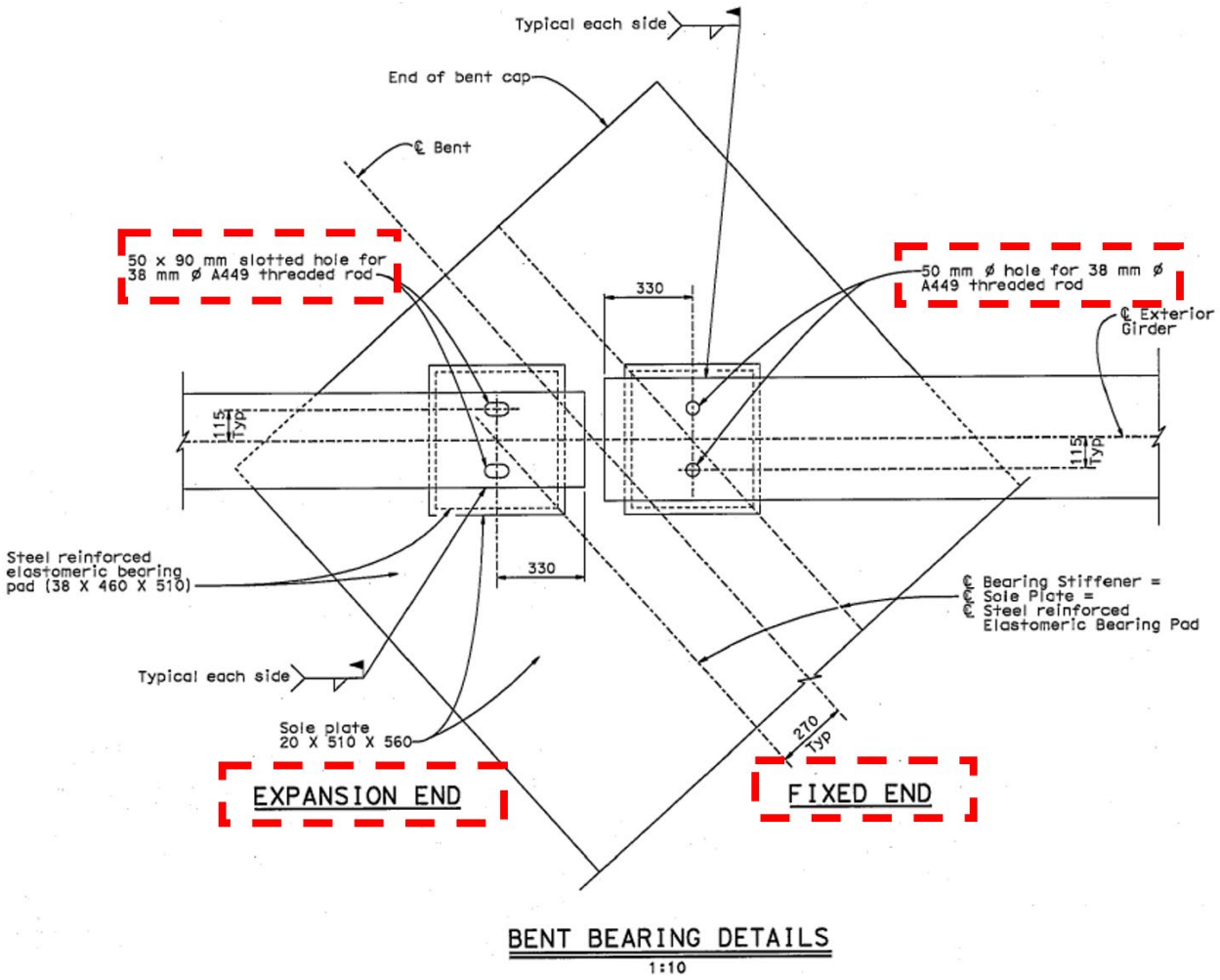

Figure 6-7. Differing Anchor Bolt Openings Due to Beam End Condition

6-3.02 PTFE Spherical Bearings

SS Section 51-3.03A(3), *Concrete Structures – Bearings – PTFE Spherical Bearings – General – Submittals,* states the submittals required for PTFE bearings. Submittal requirements include shop drawings and proof that the bearing manufacturer has furnished PTFE spherical bearings that have had at least 3 years of satisfactory service for 2 projects with similar conditions to the intended project. The Contractor must also submit certificates of compliance for the materials used in PTFE bearings. Lastly, test reports for proof-tested bearings – signed by the personnel conducting the testing – must also be submitted. It should be noted that PTFE bearings are typically inspected and released (Orange Tagged) by Materials Engineering and Testing Services (METS). Please refer to Appendix C*, PTFE Spherical Bearings Inspection Guidelines*, for more details.

6-4 Bearing Replacement Project Administration and Field Inspection

In this section, the typical construction sequence for bearing replacement is discussed, along with the activities performed by SC staff during the construction process to verify the Contractor's compliance with project requirements.

1. **Existing structure inspection**- Early inspection of the existing structure to help identify the extent of existing damage is important. Also, Bridge Inspection Reports should be reviewed for existing bridge defects, and the Area Bridge Maintenance Engineer (ABME) may be consulted for additional information. The jacking operation used during bearing pad replacement can cause distortion and introduce additional stresses, which can potentially weaken the structure. Existing damage needs to be identified and decisions should be made for any repairs that might be needed. All existing damage/cracks and their limits should be identified, marked, and monitored for crack propagation during the jacking operation.

   Another reason for existing structure inspection is to field verify the dimensions shown on the existing structure as-builts. Sometimes anchor bolts for steel stringers go through the bearing pads. For the new bearing pads to have the correct dimensions for bolt openings, it is important to verify the existing anchor bolt spacing. Furthermore, field verify the existing bearing seat elevation to ensure the replacement bearing pad achieves the desired deck profile.

2. **Grading/Surveying**- *SS* Section 48-3.01C(1), *Temporary Structures – Temporary Supports – Submittals – General*, requires the Contractor to provide an initial survey of the existing structure by a registered civil engineer before the start of the work on the temporary supports. The specifications also require that surveying be performed at specific intervals while the structure is being supported by a temporary structure. Surveying is used to confirm that the total vertical displacement at the control points is no more than ¼ inch from the elevations recorded before jacking. Surveying and limiting the total movement of control points accomplishes the following:

   a. Minimizes distortion to the existing structure

   b. Verifies no significant existing structure movement while temporarily supported

   c. Verifies enough clearance for removal and replacement of existing bearing pad.

   d. Confirms the replacement bearing pad has the proper thickness to achieve the desired deck elevation

3. **Anchor Bolts**- During installation of the temporary supports, various types of anchor bolts (including drill and bond and/or expansion type anchors) may be used to attach support members to the existing structure to resist lateral/vertical load. See Figure 6-8 for examples of expansion anchor bolts used in the construction of a temporary support.

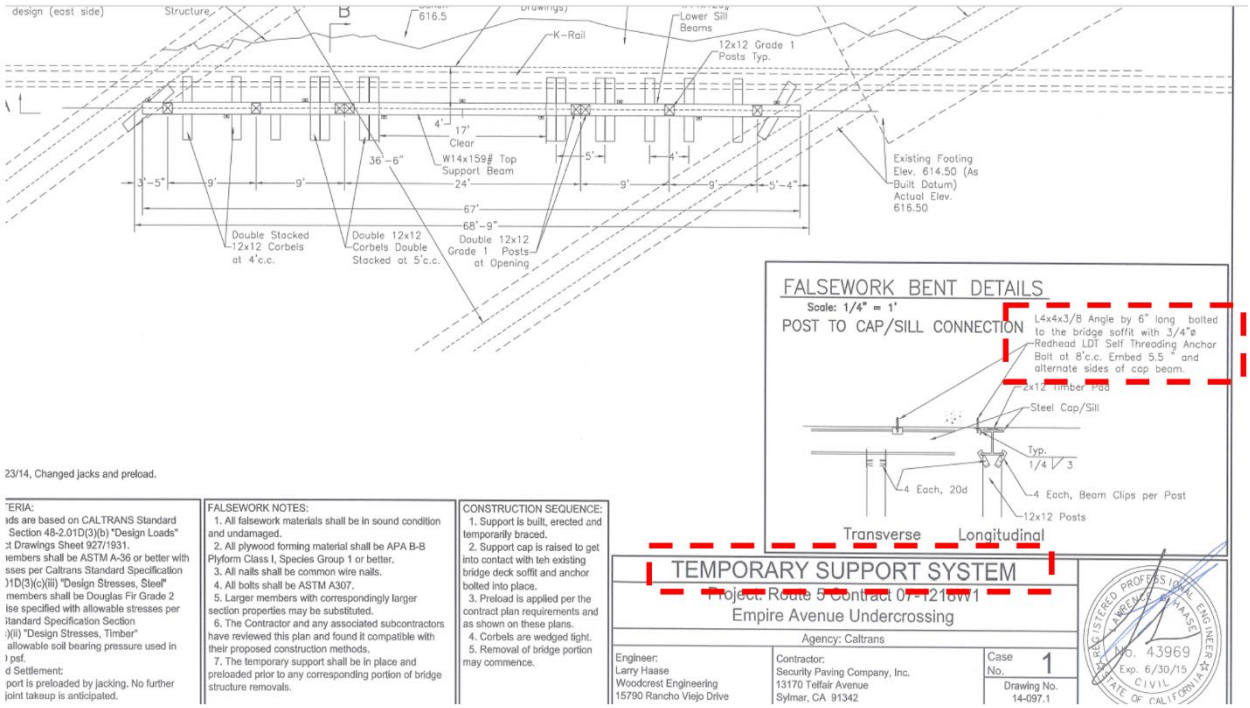

Figure 6-8. Expansion Anchor Bolt Used to Attach Temporary Support to an Existing Structure

Before attaching the temporary supports to the existing structure, SC staff must verify that the material used is as shown in the authorized submittal. BCM 95-1, *Epoxy – General*, provides information and instructions for the use of epoxy. BCM 51-1.03E, *Concrete Structures – General – Miscellaneous Construction*, provides further explanation of the process that SC staff must follow when inspecting bonding material. When installing drill and bond dowels or expansion anchors, the strength of the anchored dowel can be affected by the condition and cleanliness of the concrete. Refer to related Section 4-3.03, *Drill and Bond Dowels and Anchor Bolts*, for additional guidance, including the inspection tasks that SC staff are required to perform, to verify proper installation of dowels and anchor bolts.

4. **Temporary Support and Jacking**- To inspect the temporary support construction and jacking, the authorized submittal serves as the principal document of what needs to be done. SC staff and the Contractor must be working with the latest authorized version of the plan. For field inspection, the

Falsework manual explains in detail the construction of temporary structures. SC staff also need to review BCM 48-5, *Temporary Structures – Jacking*, for the review and authorization of submittals, quality assurance, installation and removal of jacking systems, and the procedure for jacking the bridge superstructure. Lastly, a Bridge Construction Engineer (BCE) field review of the temporary structures is advisable, similar to that required for falsework as outlined in BCM D-4, *SC Field Review of Temporary Structures (Falsework).*

After the temporary support is constructed and the jacking system is in place, the activities for the removal of the bearing pad may not start until the Contractor's engineer has certified the temporary support system. Per *Standard Specifications* Section 48-1.01D(2), *Temporary Structures – General – General – Quality Assurance – Temporary-Structure Engineer*, before starting bridge removal activities, the Contractor must have a Temporary-Structure Engineer to meet the following requirements:

1. Be registered as a civil engineer in the State.
2. Must inspect and certify that:
    a. Temporary structure is stable before jacking activities or adjustments and before concrete is placed.
    b. Temporary structure complies with the authorized shop drawings.
    c. Materials and workmanship are satisfactory for the work.
3. Must be present during all jacking and adjustment activities.
4. Stop activity if any unanticipated issues occur.
5. Propose revisions to the authorized shop drawings to address any issues.

In addition, the Temporary-Structure Engineer must prepare and submit daily inspection reports.

Per *SS* Section 60-2.02C(1), *Existing Structures – Structure Removal – Bridge Removal – Construction – General*, before the start of the bridge removal activity over or adjacent to a roadway, verify that the Contractor has "all necessary personnel, materials, and equipment to complete the work on-site before closing the roadway. Perform activities without interruption until the roadway is reopened."

Bridge removal may also involve other agencies and entities, such as railroad companies or water agencies. As an example, when working within railroad right of way, the presence of a railroad employee and certain safety requirements/procedures might be required before the start of the bridge removal.

Sometimes bridge removal requires complex structural analysis, and the responsible design unit (e.g., Bridge Design or Structures Maintenance & Investigations) can be asked to aid. To resolve any conflict or problem that might arise during the bearing replacement operation in a timely fashion, the Structure Representative (SR) should discuss the operation with the BCE to ensure the SR has the necessary resources and support.

When inspecting the work of elastomeric bearing pads replacement, SC staff need to read BCM 51-3.02, *Concrete Structures – Bearings – Elastomeric Bearing Pads*. When inspecting the work of PTFE spherical bearings replacement, SC staff need to read BCM 51-3.03, *Concrete Structures – Bearings – PTFE Spherical Bearings*; additional information is contained in Appendix C, *PTFE Spherical Bearings Inspection Guidelines*. Lastly, having suitable bearing pad material is very important. Accordingly, verify any repair material meets all contract requirements; seek METS Rep assistance as needed.

6-5 Outputs

SC staff are required to collect and maintain certain project records and to submit certain records to SC Headquarters (HQ) during the construction and upon completion of the project. BCM C-6, *Required Documents to be Submitted During Construction,* describes the process and the documents to be sent to SC HQ. For bearing replacement activity, SC staff are required to provide the following documents to SC HQ at the end of the project:

- As-built bridge plans with permanent reference elevations for bearings.