Chapter 9: Inspection

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9-1 Introduction

The role of the field engineer during the construction phase is to provide inspection of the falsework as it is erected. The field engineer verifies that construction is in accordance with the authorized shop drawings, only sound materials are used, quality workmanship is employed, and all contract requirements are met. However, inspection by the field engineer does not relieve the contractor of his contractual responsibility for the falsework.

Timely inspection is essential. It is advantageous to verify member sizes match shop drawings while the falsework is still on the ground. Any deficiencies, such as construction which does not conform to the authorized shop drawings, poor workmanship, and use of unsound or poor-quality materials, should be brought to the contractor's attention at once. If the contractor fails to take corrective action, a non-conformance letter should be written and provided to the contractor. The letter should list the deficiencies that require remedial action, but specific corrective measures should not be ordered, nor should any predictions be made.

It is the contractor’s responsibility to comply with all Cal/OSHA requirements; however, the field engineer inspecting the falsework should be familiar with the Cal/OSHA Construction Safety Orders §1717, *Falsework and Vertical Shoring*. See Section 9-3.21, *Cal/OSHA Requirements*.

Special requirements apply to falsework over or adjacent to roadways or railroads that are open to traffic. These requirements establish a higher standard of design and construction at locations where public safety is involved. The field engineer should refer to Section 9-3.20, *Falsework Over or Adjacent to Roadways or Railroads,* to verify that the special requirements have been implemented.

9-2 Material

9-2.01 Introduction

Inspect the falsework material as it arrives at the job site. Verify material type and dimensions and verify that the material is in good condition. Reference specific members erected each day in your daily report and note the sizes and locations of the members.

9-2.02 Wood and Timber Members

Wood materials should be inspected for damage. Used wood should be examined for evidence of damage, decay, or distortion of shape; and defective or substandard pieces rejected.

Rough sawn timbers should be measured to determine their actual dimensions. Unlike surfaced material, the dimensions of rough-cut timbers are not uniform from piece to piece. The variation may be appreciable, particularly in the larger sizes commonly used for falsework posts and stringers. If the actual dimension is smaller than the dimension assumed in the design, the member may not be capable of carrying the intended load without overstress.

For a discussion on checks, shakes, and splits in wood, see *Falsework Manual,* Appendix A, *Wood Characteristics*, Section A-4.03, *Checks, Shakes, and Splits*.

Verify that the contractor has provided a certificate of compliance for all wood and timber members per the *Contract Specifications,* Section 48-2.01C(1), *Falsework – Submittals – General*.

9-2.02A Structural Composite Lumber (SCL)

Each piece of SCL must be marked for identification. Identification markings must include:

- Wood species
- Material grade
- Manufacturer's name or identifying symbol
- Date of manufacture or lot number
- Intended use, e.g., forming or shoring

The contractor must furnish a certificate of compliance pursuant to the *Contract Specifications,* Section 6-2.03C, *Certificates of Compliance,* and Section 48-2.01C(1), *Falsework – Submittals – General,* for each delivery of structural composite lumber to the work site. The certificate must:

- Be signed by the supplier who furnishes the material. In the case of used material, the certificate must be signed by the supplier from whom the contractor originally purchased the material.

When inspecting the use of SCL in falsework pay attention to the following:

- SCL products that are designed to support wet concrete must be stored properly to protect them from direct sun light and water. When stored on the project site, they must be covered and placed on dunnage as per manufacturer's recommendations.
- SCL must be installed per the manufacturer's recommendations. Products may be marked for specific orientation.

- SCL should not be used as posts or diagonal bracing.

For design requirements and additional information about SCL, see Section 5-2.06, *Structural Composite Lumber*.

9-2.03 Steel Members

Steel materials should be inspected for damage. Steel members in falsework construction are typically recycled and are not in new condition. Used steel members should be examined for evidence of distortion of shape, bent flanges, holes in webs and flanges, and excessive corrosion. Defective or substandard members must be rejected.

Structural steel is commonly used in falsework construction for members such as cap beams, posts, and stringers. The steel members should be labeled with the definition of the structural shape (e.g. HP14 x 117). Flange thickness and web thickness on beams and wall thickness on posts must be measured to confirm that the dimensions match the label per the AISC Manual.

9-2.03A Used Structural Steel

Used steel members, particularly members salvaged from a previous commercial use, should be examined carefully for loss of section due to welding, rivet or bolt holes, or mechanical damage, e.g. kinks or notches in flanges, etc., all of which may reduce the load carrying capacity of the beam.

9-2.03B Welding Steel Members

Refer to the *Contract Specifications,* Section 48-2.01D(2), *Falsework – Quality Assurance – Welding and Nondestructive Testing,* for welding requirements. The *Contract Specifications,* Section 11, *Welding,* does not apply to welding of falsework members. Welding and inspection of steel members must comply with the following:

- All welding must comply with AWS D1.1, *Structural Welding – Steel,* welding standard.
- All welds must be performed by a certified welder. The contractor must submit a copy of the welder's certification.
- The contractor is responsible for performing an independent inspection of the welds per the AWS D1.1. This may be done by a qualified person and the inspection documented, for example in a foreman's diary. The contractor is not required to submit this documentation.
- Caltrans Materials Engineering and Testing Services (METS) can be contacted for assistance with welding.

9-2.03B(1) Welded Splices

Special requirements apply to welded splices. The contractor is required to follow the requirements in the *Contract Specifications,* Section 48-2.01D(2), *Falsework – Quality Assurance – Welding and Nondestructive Testing,* when splicing steel members by welding. These requirements include:

- The contractor must perform nondestructive testing (NDT) on welded splices using ultrasonic testing (UT) or radiographic testing (RT).
- Each weld and any repair made to a previously welded splice must be tested.
- The contractor must select locations for testing.
- The length of a splice weld where NDT is to be performed must be a cumulative weld length equal to 25% of the original splice weld length.
- The cover pass must be ground smooth at test locations.
- The acceptance criteria must comply with the specifications for cyclically loaded nontubular connections subject to tensile stress in clause 8 of AWS D1.1.
- If repairs are required in a portion of the weld, perform additional NDT on the repaired sections.
- The NDT method chosen must be used for an entire splice evaluation, including any repair.

For welded splices, the *Contract Specifications,* Section 48-2.01C(1), *Falsework – Submittals – General*, require the contractor to submit a letter of certification. The letter must be:

- Certified that all welding and nondestructive testing (NDT), including visual inspection, complies with the contract and the welding standard shown on the shop drawings.
- Signed by a civil engineer registered in the State of California.
- Submitted before any concrete is placed on the falsework being certified.

9-2.03B(2) Previously Welded Splices

The *Contract Specifications,* Section 48-1.01B, *Falsework – Definitions*, defines previously welded splices as *splices made in falsework members in compliance with AWS D1.1 or other recognized welding standard* before contract award.

For previously welded splices, the *Contract Specifications,* Section 48-2.01D(2), *Falsework – Quality Assurance – Welding and Nondestructive Testing,* require the contractor to perform and document all necessary testing and inspection required to certify the ability of the falsework members to sustain the design stresses.

For previously welded splices, the *Contract Specifications,* Section 48-2.01C(1), *Falsework – Submittals – General*, require the contractor to submit a welding certification. The certification must:

- Itemize the testing, inspection methods, and acceptance criteria used.
- Include tracking and identifying documents for previously welded members.
- Be signed by a civil engineer registered in the State of California.
- Be submitted before erecting the members.

9-3 Erection

9-3.01 Erection Plan

The *Contract Specifications,* Section 48-2.03A, *Falsework – Construction – General,* require the use of construction methods, which include temporary bracing, when necessary, to withstand all imposed loads and to prevent overturning or collapse of the falsework during erection, construction, and removal. The means by which the contractor complies with this specification requirement during erection and construction of the falsework is commonly referred to as the "erection" plan.

Before erection begins, the erection plan, as described in the authorized shop drawings, should be discussed with the contractor's field representative who will be responsible for supervising the erection. The purpose of the discussion is to verify that the erection plan is appropriate for the site and conditions to be encountered, and that all persons involved with the work (both the contractor and owner representative) are familiar with the erection plan.

The *Contract Specifications,* Section 48-2.03, *Construction,* discusses falsework erection. The *Contract Specifications*, Section 7-1.04, *Public Safety*, prohibits erection over traffic.

9-3.02 Foundations

9-3.02A Introduction

The *Contract Specifications,* Section 48-2.03B, *Falsework – Construction – Foundations,* permit the contractor to set falsework pads and drive falsework piles before the shop drawings are authorized. However, pad placement and pile driving must be inspected, to the extent necessary to verify the adequacy of the foundation, at the time the work is done, even though the shop drawings may not yet be authorized.

Foundation layout must be confirmed before the foundation is constructed. Appropriate surveying methods should be used.

Refer to Section 9-3.20, *Falsework Over or Adjacent to Roadways or Railroads,* for horizontal clearances and necessary protection of the falsework foundation.

9-3.02B Pads

The pads are designed based on an assumed soil bearing value shown on the shop drawings. Since the pad design is based on this value, the foundation material should be inspected before the pads are set and a realistic soil bearing value assigned. Timely inspection is necessary to verify that the assumed value does not exceed the actual soil bearing value as determined by Section 8-4.06, *Soil Bearing Values,* or by a soil load test.

To provide uniform soil bearing, pads must be level and set on material that provides a firm, even surface, free of humps or depressions within the pad bearing area. To obtain uniform bearing, a thin layer of well compacted base material may be used to fill in surface irregularities.

The soil bearing capacity of some soils is greatly reduced when the ground becomes saturated. To prevent loss of support, pad foundations must be protected from flooding and undermining from surface runoff, and the pad area should be graded so the water drains away from the pads. If the pad area is flooded by a rainstorm, or other event, the contractor must re-evaluate soil bearing capacity to verify that the soil can still adequately support the falsework loads as per the authorized shop drawings.

When pads are set on material backfilled around pier walls or columns in stream channels or other locations where there are no specific compaction requirements, care must be taken to verify that the backfilled material is sufficiently compacted to provide the required soil bearing value for the falsework foundation.

Benches in slopes should be cut into firm material, with the pad set back from the edge of the bench. The cut of the slope and the location of the pad must be as shown on the authorized shop drawings. The layout must comply with the requirements in the Cal/OSHA Construction Safety Orders, Article 6, *Excavations*.

9-3.02B(1) Soil Load Test

The *Contract Specifications,* Section 48-2.03B, *Falsework – Construction – Foundations,* require the contractor, when requested by the engineer, to perform load tests to verify the that the design soil bearing values do not exceed the soil capacity. Therefore, the engineer should request a load test if there is uncertainty as to the ability of the foundation material to support the loads to be imposed. Section 8-4, *Soil Load Tests and Soil Bearing Values,* provides information about load testing. This section should be reviewed prior to the performance of any load test to verify the adequacy of falsework foundation materials. The Division of Engineering Services (DES) Geotechnical Services is available for consultation and advice as to the suitability of a particular load test in a given field situation, as well as interpretation of test results.

9-3.02B(2) Timber Pads

Timber pads should be inspected for damage. Used timber pads should be examined for evidence of decay and distortion of shape, and defective or substandard pieces rejected.

Rough sawn timbers should be measured to determine their actual dimensions. If the actual dimension is smaller than the dimension assumed in the design, the pad may not be capable of carrying the intended load without overstress.

Continuous pads should be inspected to verify that joints are located as shown on the authorized shop drawings.

9-3.02B(3) Concrete Pads

The contractor may use the authorized concrete pads in Section 7-6.02, *Authorized Concrete Pads*, or fabricate their own pads per Section 7-6.03, *Other Concrete Pads*. Verify that the contractor has submitted a certificate of compliance as required in Sections 7-6.02C, *Certificate of Compliance,* and 7-6.03C, *Certificate of Compliance*.

Inspect the pads for damage. Examine used pads for cracks, chipping, and corrosion of the reinforcement. Defective or substandard pads must be rejected.

9-3.02C Piles

Falsework pile driving operations must be inspected to the extent necessary to verify that the required bearing values are obtained, and design assumptions are met. The *Contract Specifications*, Section 48-2.03B, *Falsework – Construction – Foundations,* refers to the *Contract Specifications*, Section 49, *Piling,* for pile installation.

The pile resistance value required to support the design load will be shown on the shop drawings. Piles that are plumb and properly installed per the shop drawings may be considered as capable of this resistance. The actual nominal pile resistance must be at least twice the falsework design load, i.e. **SF = 2.0**, see also Section 8-6.02, *Pile*

Resistance. Resistance values for falsework piles are determined by the *Contract Specifications,* Section 48-2.03B, *Falsework – Construction – Foundations*. These specifications refer to the formula in the *Contract Specifications,* Section 49-2.01A(4)(c), *Piling – Driven Piling – Department Acceptance*. Use of the formula and inspection procedures will be the same for falsework piles as for permanent piles. The equipment required for falsework pile installation is the same as for permanent piles and is listed in the *Contract Specifications,* Section 49-2.01C(2), *Piling – Construction – Driving Equipment*.

Refer to Section 8-6.06, *Field Evaluation of Pile Capacity,* for a detailed discussion on how to address piles that are not in conformance with the shop drawings and how the contractor can resubmit revised shop drawings. It is emphasized that field personnel are not authorized to undertake any unilateral investigation or authorize a driven pile which does not conform to the requirements on the shop drawings.

Any pile that fails to reach the required penetration or deviates from its theoretical position greater than the allowable deviation shown on the shop drawings, may be rejected without further evaluation because it is not in conformance with the authorized shop drawings.

9-3.02D Pile Bents

Referring to Figure 8-23, *Pile Bent*, the design of piles in pile bents is based on certain assumptions as to penetration, driving tolerances (i.e. maximum allowable pile pull and pile lean) and the ground line pile diameter, all of which should be shown on the shop drawings.

Driving tolerances are particularly critical in pile bent designs. If little or no tolerance is permitted by the falsework design, this fact should be brought to the contractor's attention before driving begins. The orientation of H-pile cross sections must match what is shown on the shop drawings.

Falsework pile driving operations must be inspected to the extent necessary to verify that the required pile penetration and bearing values are obtained and design assumptions are met. The *Contract Specifications*, Section 48-2.03B, *Falsework – Construction – Foundations,* refers to the *Contract Specifications*, Section 49, *Piling,* for pile installation. Pile penetration cannot be verified by observation after the pile has been driven, and the distance a given pile has been pulled cannot be determined once the pile is in its final position under the cap. Section 8-6.04, *Timber Piles in Pile Bents,* includes a discussion of the assumptions that govern the design of timber pile bents, and their relative importance.

Refer to Section 9-3.20, *Falsework Over or Adjacent to Roadways or Railroads,* for horizontal clearances, necessary protection of the pile bents, and required lighting. Lighting must be installed before traffic is allowed to drive past the falsework after dark.

9-3.03 Corbels

Corbels must extend across the full width of the pads. Posts must be centered on the corbel in both directions. If other members are used to carry the post load, such as sand jacks or wedges, these members must be centered on the corbel in both directions. Verify that the spacing of the corbels complies with the shop drawings.

9-3.03A Timber Corbels

Inspect the timber corbels for damage. Used corbels should be examined for evidence of damage, decay, or distortion of shape, and defective or substandard corbels rejected.

Measure the corbels to determine their actual dimensions. If the actual dimension is smaller than the dimension assumed in the design, the corbel may not be capable of carrying the intended load without overstress.

9-3.03B Steel Corbels

Inspect the steel corbels for damage. Examine used corbels for distortion, bent flanges, or webs and holes in flanges or webs. Defective or substandard corbels must be rejected.

Measure the corbels to verify the actual structural shape. If the actual structural shape is different than what is shown on the shop drawings, the corbel may not be capable of carrying the intended load without overstress.

9-3.04 Built-Up Material

Excessive stacking of material to correct grade errors discovered during falsework construction or to accommodate short posts is an unacceptable construction practice and is not allowed. Built-up material must comply with the height to width ratio shown in Section 6-9, *Built-Up Material*.

Inspection includes, as a minimum, the following:

- Inspect the material for damage.
- Examine used material for evidence of decay or distortion of shape and reject defective or substandard material.
- Material placed on the sand jack plunger must have full bearing on the plywood plunger and must clear the frame of the sand jack by a minimum of 1/4-inch.

- Material must have full bearing and be stacked tight and neat to provide uniform bearing for the supported members.
- Verify that the built-up material complies with the shop drawings.

9-3.05 Sand Jacks

Sand jacks, which consist of compacted sand confined within a timber or metal frame, are often used to facilitate falsework removal. Typically, the sand jacks are installed on top of the corbels as shown in Figure 9-1, *Wood Sand Jacks*.

Figure 9-1. Wood Sand Jacks.

Figure 9-2. Steel Sand Jacks.

To prevent inadvertent settlement while a sand jack is still carrying a load, care must be taken to protect the sand jack from rain, flooding, or any other cause that might contribute to erosion of the sand.

The contractor has the following two options for wood sand jacks:

- Construct and use the pre-authorized wood sand jacks. See Section 7-3.01A, *Authorized Wood Sand Jack.*
- Construct sand jacks that deviate from the pre-authorized wood sand jacks and test them per Section 7-2, *Load Tests,* and 7-2.02, *Sand Jacks*. See also Section 7-3.01, *Wood Sand Jacks*.

Inspection includes, as a minimum, the following:

- Sand jacks must be new and manufactured for the current job. It is not acceptable to reuse old wood sand jacks.
- Verify that the sand jacks are manufactured by the pre-authorized details or by the authorized shop drawings.
- Sand jacks must have full bearing. A slight overhang over the supporting member is acceptable as long as the overhang is less than half the thickness of the sand jack frame.
- Plywood plunger resting on filler material (sand) must have full bearing and must clear all frame members by a maximum of 1/4-inch.
- Wood wedges or other material placed on the sand jack plunger must have full bearing on the plywood plunger and must clear the frame of the sand jack by a minimum of 1/4-inch.
- Filler material (sand) must comply with the authorized shop drawings and the filler material must be level
- Nails must be common nails. To prevent splitting, they must not be overdriven
- Quality workmanship and proper installation sufficient to bear the design load without any distress.
- Sufficient measures are in place to prevent erosion of the sand in case of rain or any other reason.

9-3.06 Wedges

Wedges are generally installed between the sand jack and the bottom cap to allow for falsework adjustment. Multiple sets of wedges (set side-by-side) are often used to keep the perpendicular-to-grain compression stresses within the allowable. Verify that the installation matches the shop drawings.

Inspection includes, as a minimum, the following:

- Inspect the wedges for damage.
- Examine used wedges for evidence of decay, or distortion of shape, and reject defective or substandard wedges.
- Wood wedges placed on the sand jack plunger must have full bearing on the plywood plunger and must clear the frame of the sand jack by a minimum of 1/4-inch.
- Wedges must have full bearing and be stacked tightly to provide uniform bearing for the supported members.
- Wedges may be used at the bottom or top of a falsework bent for adjustment, but not at both locations.

Cedar shingles, which are occasionally used as wedges, should be used with caution since cedar has a significantly lower perpendicular-to-grain strength than Douglas Fir or any of the commonly used hardwoods.

9-3.07 Bottom Caps

Refer to Section 9-3.20, *Falsework Over or Adjacent to Roadways or Railroads,* for horizontal clearances, necessary protection of the caps and mechanical connections due to impact loads.

Generally, sand jacks and wedges are placed between the corbels and bottom caps to allow for adjustment and removal of the falsework as shown in Figure 9-1, *Wood Sand Jacks*. Bottom caps must be centered on the wedges, sand jacks, and corbels. The caps must be installed level to provide a level bearing surface for the posts.

9-3.07A Timber Caps

Inspect the caps for damage. Used caps should be examined for evidence of damage, decay, or distortion of shape, and defective or substandard caps rejected.

Measure the caps to determine their actual dimensions. If the actual dimension is smaller than the dimension assumed in the design, the cap may not be capable of carrying the intended load without overstress.

9-3.07B Steel Caps

Inspect the caps for damage. Examine used caps for distortion, bent flanges, or webs and holes in flanges or webs. Defective or substandard caps must be rejected.

Measure the caps to verify the actual structural shape. If the actual structural shape is different than what is shown on the shop drawings, the cap may not be capable of carrying the intended load without overstress.

Contractors occasionally request to substitute W14 x 120 for HP14 x 117 caps. W14 x 120 may not be substituted for HP14 x 117 caps unless the authorized shop drawings specifically allow. HP14 x 117 and W14 x 120 have similar bending strength, but W14 x 120 has a thinner web and therefore is prone to web yielding or web crippling.

9-3.07C Cap Systems

Using multiple layers of caps to correct grade errors discovered during falsework construction or to accommodate short posts is an unacceptable construction practice and is not allowed. If a system of multiple caps is used, the system must comply with the height to width ratio shown in Section 6-8, *Cap Systems*.

9-3.08 Traffic Braces

Refer to Figure 4-12, *Application of 2000 Lb. Load,* traffic braces are typically installed to brace the bottom caps against traffic impact loads. The braces are installed in the transverse and longitudinal directions. The braces may carry the load to the foundations or directly to the ground and must be installed per the authorized shop drawings. In the *Contract Specifications,* Section 48-2.02B(4), *Falsework – Design Criteria – Special Locations*, the term *support footing* means the element of the falsework system that is set on the ground.

9-3.09 Posts

9-3.09A Introduction

Refer to Section 9-3.20, *Falsework Over or Adjacent to Roadways or Railroads,* for horizontal clearances, necessary protection of the falsework members, mechanical connections due to impact loads, and required lighting. Mechanical connections must be installed before traffic is allowed under the span. Lighting must be installed before traffic is allowed to drive past the falsework after dark.

9-3.09B Timber Posts

Inspection includes as a minimum, the following:

- Inspect the posts for damage.
- Examine used posts for evidence of decay or distortion of shape, checks, or splits, and reject defective or substandard posts.
- Inspect the posts before they are installed to verify that the material is acceptable. If the material is unacceptable, notify the contractor before the post is installed.
- Posts must be plumb and centered over the pad, corbel, or lower cap. Similarly, the web of the upper cap must be centered over the posts.
- Posts may be wedged at either the top or bottom for grade adjustment, but not at both locations.
- Blocking should be kept to the minimum amount needed for erection and adjustment. It is not acceptable to extend a short post by piling up blocks and wedges, since this can lead to instability.
- Full bearing must be obtained at all contact surfaces. Deficiencies in this respect may be improved by feather wedging; however, if the joint requires more than a single wedge, extra care should be taken to ensure that full bearing is obtained.

Prior to rejecting a post, several things need to be considered, such as post height, overall post quality, and bolted connection locations. Consult with the falsework reviewer for concerns about post quality. It is not unreasonable for the contractor to request banding to address checks in a post in lieu of replacing the post or adding a supplemental post. For a discussion on checks, shakes, and splits in wood, see Appendix A, *Wood Characteristics*, and Section A-4.03, *Checks, Shakes, and Splits*.

9-3.09B(1) Beam Clips

Beam clips, also known as post clips, mechanically connect steel cap beams to timber posts. The clips must be installed per the authorized shop drawings, including configuration and number of nails. The requirements for beam clips are discussed in Section 7-3.09, *Beam Clips*.

9-3.09C Steel Posts

Inspection includes as a minimum, the following:

- Inspect the posts for damage.
- Examine used posts for distortion, bent flanges or webs, and holes in flanges or webs. Reject defective or substandard posts.
- Measure the post to verify the actual structural shape. If the actual structural shape is different than what is shown on the shop drawings, the post may not be capable of carrying the intended load without overstress.
- Inspect the posts before they are installed to verify that the material is acceptable. If the material is unacceptable, notify the contractor before the post is installed.
- Posts must be plumb and centered over the pad, corbel, or lower cap. Similarly, the web of the upper cap must be centered over the posts.
- Posts may be wedged at either the top or bottom for grade adjustment, but not at both locations.
- Blocking should be kept to the minimum amount needed for erection and adjustment. It is not acceptable to extend a short post by piling up blocks and wedges, since this can lead to instability.
- Full bearing must be obtained at all contact surfaces.

9-3.09D Aluminum Posts

Aluminum posts may be used in falsework if shown on the authorized shop drawings. However, aluminum posts are not allowed in falsework over or adjacent to roadways or railroads, per the *Contract Specifications,* Section 48-2.02B(4), *Falsework – Design Criteria – Special Locations*.

Inspection includes, as a minimum, the following:

- Inspect the posts for damage.
- Examine used posts for distortion, bent flanges or webs, and holes in flanges or webs. Reject defective or substandard posts.
- Measure the post to verify the actual structural shape. If the actual structural shape is different than what is shown on the shop drawings, the post may not be capable of carrying the intended load without overstress.
- Inspect the posts before they are installed to verify that the material is acceptable. If the material is unacceptable, notify the contractor before the posts are installed.
- Posts must be plumb and centered over the pad, corbel, or lower cap. Similarly, the web of the upper cap must be centered over the posts.
- Posts may be wedged at either the top or bottom for grade adjustment, but not at both locations.
- Blocking should be kept to the minimum amount needed for erection and adjustment. It is not acceptable to extend a short post by piling up blocks and wedges, since this can lead to instability.
- Full bearing must be obtained at all contact surfaces.

9-3.10 Pile Bents

For installation of piles in pile bents, see Section 9-3.02D, *Pile Bents*. For bracing of pile bents see Section 9-3.12, *Bracing*.

9-3.10A Pile Friction Collars

Friction collars must conform to the requirements in Section 7-3.08, *Pile Friction Collars*. Typically, the friction collar is used to permit erection of falsework on the friction collars before the piles for flat slab bridges are cut to grade. The falsework cap will normally be set on sand jacks which sit on top of the friction collar brackets. Once the piles are cut to grade the yoke assemblies may be installed atop the pile. Friction collars may be used with or without the yoke assembly.

The use and installation of friction collars must be in conformance with the following:

- Must be installed as shown on the authorized shop drawings and used in compliance with the manufacturer's instructions.
- The collar must have full bearing on the pile.

- It is anticipated that friction collar slip will be slight after the load transfers to the yoke assembly.
- Grease may be placed on that portion of the threaded rod to be embedded in the concrete. The threaded rods in the yoke must be removed as part of the falsework removal, and the remaining holes in the structure must be finished in the usual manner.

9-3.11 Top Caps

Refer to Section 9-3.20, *Falsework Over or Adjacent to Roadways or Railroads,* for horizontal clearances, necessary protection of the caps and mechanical connections due to impact loads. Top cap webs must be centered on the posts. The caps must be installed to provide full bearing for the posts.

9-3.11A Timber Caps

Inspect the caps for damage. Used caps should be examined for evidence of damage, decay, or distortion of shape, and defective or substandard caps rejected.

Measure the caps to determine their actual dimensions. If the actual dimension is smaller than the dimension assumed in the design, the cap may not be capable of carrying the intended load without overstress.

9-3.11B Steel Caps

Inspect the caps for damage. Examine used caps for distortion, bent flanges or webs, and holes in flanges or webs. Defective or substandard caps must be rejected.

Measure the caps to verify the actual structural shape. If the actual structural shape is different than what is shown on the shop drawings, the cap may not be capable of carrying the intended load without overstress.

HP14 x 117 and W14 x 120 have similar bending strength, but W14 x 120 has a thinner web and therefore is prone to web yielding. W14 x 120 may not be substituted for HP14 x 117 unless the shop drawings specifically state so.

9-3.11C Cap Systems

Using multiple layers of caps to correct grade errors discovered during falsework construction or to accommodate short posts is an unacceptable construction practice and is not allowed.

9-3.11D Cap Beam Center Loading Strips

Center loading strips aid in transferring the vertical reaction load from stringer to cap concentrically. This prevents the stringer bottom flange from bearing on the flange edges of the cap. This is of a particular concern when stringers are placed on a steep longitudinal slope. If the stringer bears on the edge of the cap flange it can induce torsional rotation in the cap. Refer to Section 4-4, *Cap Beam Center Loading Strips,* for design considerations.

It is critical that center loading strips are centered on the web of the cap. See Figure 4-4, *Center Loading Strip Details*.

The maximum thickness of loading strips or shims must not exceed 6-inches. This limit also applies to multiple built-up strips or shims. This maximum thickness limitation eliminates excessive build-up between the cap and the stringer beam that could lead to stability problems.

9-3.12 Bracing

9-3.12A Wood Bracing

Refer to Section 9-3.20. *Falsework Over or Adjacent to Roadways or Railroads,* for horizontal clearances, necessary protection of the bracing and required connections due to impact loads.

Inspect the wood bracing for damage. Used bracing should be examined for evidence of damage, decay, or distortion of shape, and defective or substandard bracing rejected.

Measure the bracing to determine the actual dimensions. If the actual dimension is smaller than the dimension assumed in the design, the bracing may not be capable of carrying the intended load without overstress.

9-3.12B Timber Fasteners

9-3.12B(1) Introduction

Connections in timber framing for falsework bents and similar locations where engineered connections are required must be fabricated in accordance with industry guidelines as summarized in this section. See Section 5-3, *Timber Fasteners,* for the analysis of timber fasteners.

Timber fasteners must be installed per the authorized shop drawings. Verify the fastener type, number of fasteners, spacing, edge distances, and penetration.

9-3.12B(2) Nails and Spikes

Referring to Section 5-3.03B, *Required Nail Spacing*, the following governs the spacing of nails and spikes used to connect falsework bracing components:

- The average center-to-center distance between adjacent nails or spikes, measured in any direction, must not be less than the required penetration into the main member for the size of nail being used.
- The minimum end distance and the minimum edge distance in both side member and main member, must not be less than 1/2 of the required penetration.

The specific penetration requirements for nails and spikes are shown on the shop drawings. It is common to use a penetration of 10D, where **D** is the diameter of the fastener. Penetration requirements are discussed in Section 5-3.03A(2), *Lateral Resistance*. In most cases the penetration required to develop the design value of a given fastener can be obtained. However, when round posts are used, or the bents are skewed so that the bracing is not parallel to the side of the post, it can be more difficult to obtain the required spacing during installation. Verify that the minimum penetration is obtained, since nails or spikes having a penetration of less than the minimum will have no allowable lateral load carrying value.

9-3.12B(3) Toe-Nailed Connections

Toe-nails should be driven at an angle of approximately 30° to the member being toe-nailed, and started approximately 1/3 of the nail length, from the end of the member. See Figure 5-5, *Toe-Nailed Connection,* in Section 5-3.03C, *Toe-Nailed Connections*.

9-3.12B(4) Bolted Connections

Bolt holes and bolt installation must conform to the following:

- Bolt holes must be a minimum of 1/32-inch to a maximum of 1/16-inch larger than the bolt diameter.
- Holes in the main and side members must be aligned and the bolt centered in the hole. Tight fit requiring the forcible driving of bolts is not recommended industry practice.
- A washer or metal plate not less than a standard cut washer must be placed between the wood and the bolt head and between the wood and the nut.

Design values for bolted connections apply to bolts that have been snugly tightened. To ensure adequate strength, connections should be inspected again after the falsework is adjusted to grade and bolts retightened if necessary.

Refer to Figure 9-3, *Bolted Connection Parallel-to-Grain Loading,* and Figure 9-4, *Bolted Connection Perpendicular-to-Grain Loading*, for single fastener connections. For multiple bolt connections, see Section 9-3.12B(6), *Multiple Fastener Connections*. The end and edge distances for single bolt connections are measured from the end or side of the wood member to the center of the bolt hole, and must meet the following industry criteria for end and edge distance, where **D** is the bolt diameter:

For parallel-to-grain loading:

- Minimum end distance:
  - In tension, 7D
  - In compression, 4D
- Minimum edge distance:
  - In tension and compression, 1.5D

For perpendicular-to-grain loading:

- Minimum end distance:
  - 4D
- Minimum edge distance without load reversal:
  - 4D toward the side where the bolt is acting
  - 1.5D to the opposite edge
- Minimum edge distance with load reversal:
  - 4D to both edges. This is the case for diagonal bracing.

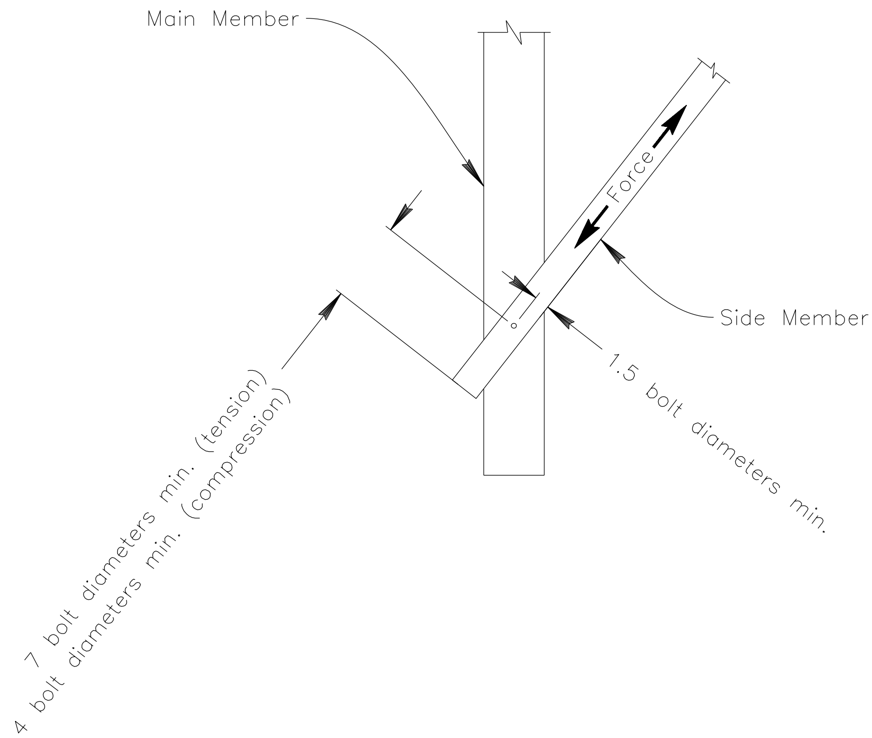


Figure 9-3. Bolted Connection Parallel-to-Grain Loading.

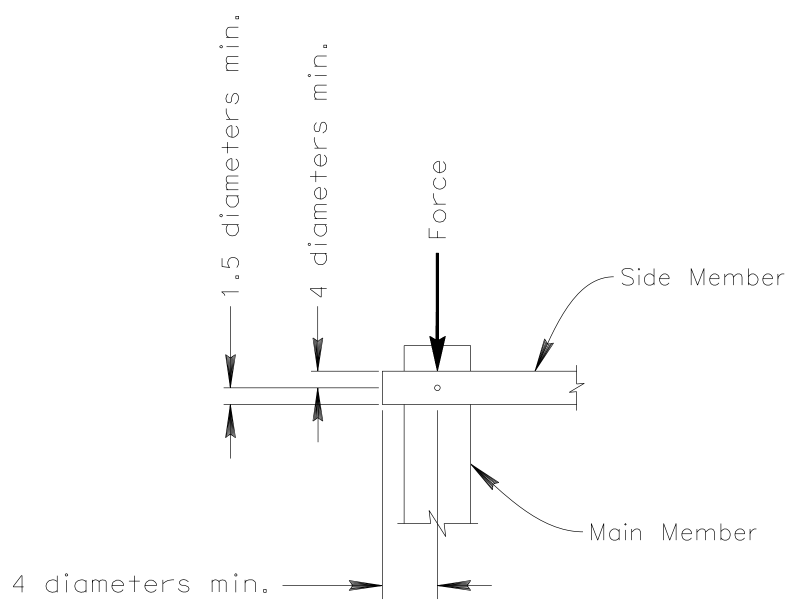


Figure 9-4. Bolted Connection Perpendicular-to-Grain Loading.

9-3.12B(5) Lag Screw Connections

Industry standards require the spacing, edge distance, end distance, and net section for lag screw connections, to conform to the requirements for bolted connections made with bolts having a diameter equal to the shank diameter of the lag screw. See Section 9-3.12B(4), *Bolted Connections*.

Lag screw installation must conform to the following:

- Insert in predrilled holes.
- The clearance hole through the first member must have the same diameter as the unthreaded shank and must go through the first member.
- The diameter of the lead hole for the threaded portion must be between 60% and 75% of the shank diameter, with the larger percentage applying to lag screws having larger diameters. The percentage range shown is for Douglas Fir Larch. For appropriate ranges for other wood species, contact the SC Falsework Engineer.
- The length of the lead hole must not be less than the length of the threaded portion.
- Lag screws are to be inserted in the lead hole by turning with a wrench, not by driving with a hammer.
- To facilitate installation, soap or other lubricant may be used on the screw or in the lead hole.

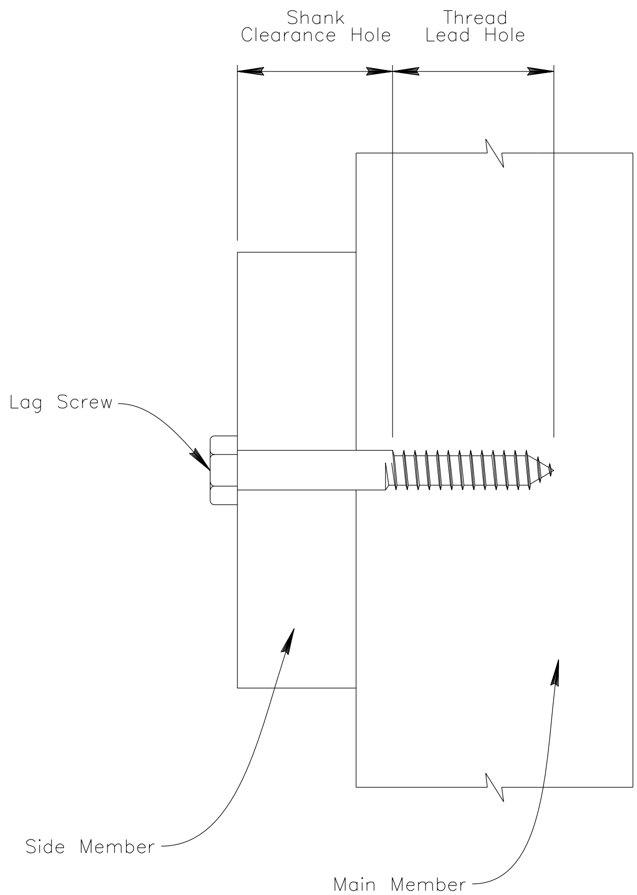


Figure 9-5. Lag Screw.

9-3.12B(6) Multiple Fastener Connections

The installation procedure discussed herein applies to both bolt and lag screw connections. In this section, the term fastener includes bolts and lag screws.

Spacing, end distance, edge distance, and the potential for wood splitting are critical for the integrity of the connection. Fastener type, diameter, length, and layout must comply with the authorized shop drawings.

Refer to Figure 9-6, *Multiple Fastener Connections*. The maximum spacing between adjacent rows of fasteners may not exceed 5 inches, regardless of other considerations.

Fastener spacing along a row is measured between the centers of adjacent fasteners, where **D** is the fastener diameter:

- For parallel-to-grain loading:
  - If the actual fastener load equals the allowable design load, the minimum spacing is 4D.

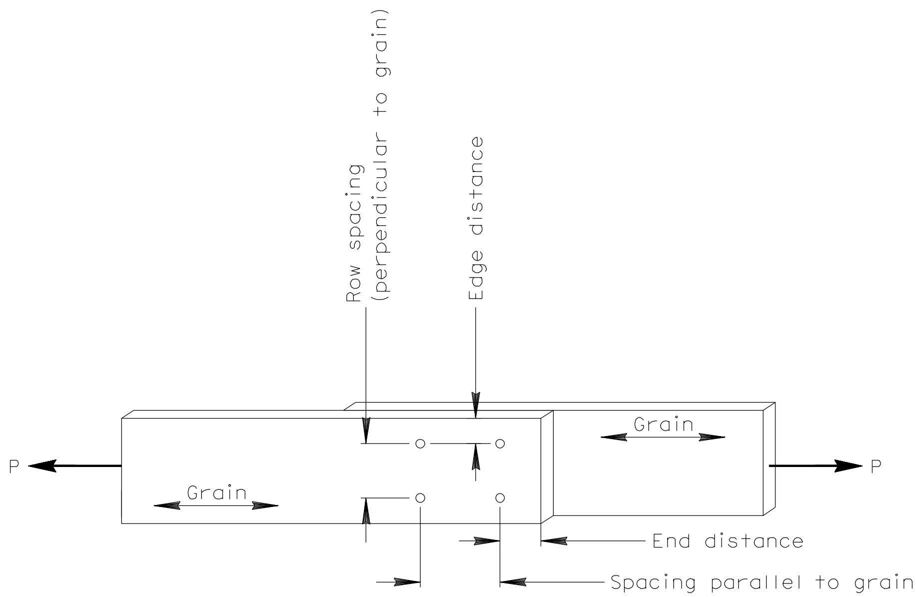
    - If the actual fastener load is less than the allowable load but not less than 75% of the allowable load, the spacing may be reduced proportionately, but not below 3D regardless of the actual fastener load.
- For perpendicular-to-grain loading:
    - Spacing between fastener in a row is limited by the spacing requirements of the attached member or members loaded parallel-to-grain.

Spacing between adjacent rows is measured between the row centerlines, where **D** is the fastener diameter:

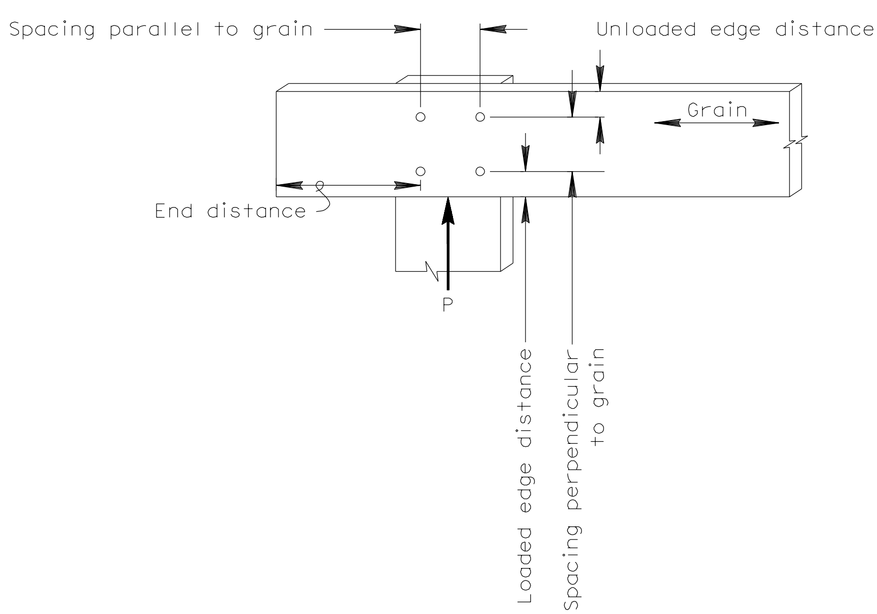
- For parallel-to-grain loading, the minimum spacing is:
    - 1.5D
- For perpendicular-to-grain loading, the minimum spacing is:
    - 2.5D for L/D ≤ 2
    - 5D for L/D ≥ 6
    - For 2 < L/D < 6, the minimum spacing may be obtained by straight-line interpolation

Except as provided in the following bullet, edge and end distance requirements for multiple fastener connections are the same as the requirements for single bolt connections, where D is the fastener diameter. For single bolt requirement, see Section 9-3.12B(4,) *Bolted Connections*.

- For parallel-to-grain loading in tension or compression, the minimum edge distance is:
    - 1.5D for L/D ≤ 6
    - 1.5D or 1/2 the distance between adjacent rows, whichever is greater for L/D > 6



Loading Parallel to Grain



Loading Perpendicular to Grain

Figure 9-6. Multiple Fastener Connections.

When a multiple fastener connection is loaded at an angle to the grain, as is the case with falsework bracing, industry practice requires that the gravity axis of each member in the connection must pass through the center of resistance of the fastener group to ensure uniform stress in the main member and a uniform distribution of load to all fasteners. (See NDS 12.6.2).

9-3.12B(7) Drift Pins and Drift Bolts

Drift pins and drift bolts for timber are to be driven into predrilled holes having a diameter l/16-inch less than the diameter of the drift pin or drift bolt to be installed. Drift pins and drift bolts are rarely used in falsework.

9-3.12C Steel Bracing

Steel bracing can consist of structural shapes such as angles, C-channels, or hollow sections. Rebar is sometimes used for bracing, but due to its minimal stiffness it is only considered as a brace in tension.

Inspect the bracing for damage. Examine used members for distortion, bent flanges or webs, and holes in flanges or webs. Defective or substandard members must be rejected.

Measure the bracing to verify the actual structural shape. If the actual structural shape is different than what is shown on the shop drawings, the brace may not be capable of carrying the intended load without overstress.

9-3.12C(1) Steel Fasteners

Bolted connections must comply with the authorized shop drawings. Verify the fastener type, number of fasteners, spacing, and edge distances.

9-3.12D Cable Bracing

9-3.12D(1) Introduction

Refer to Section 5-5, *Cable Bracing Systems,* for a detailed discussion on the design and application of cable bracing. Cable bracing systems may be used to resist both overturning and collapsing forces. Cable systems are effective in resisting the overturning of tall falsework. They are also commonly used as diagonal bracing to resist collapse of falsework bents. Moreover, cable is also used extensively as temporary bracing to stabilize falsework bents while they are being erected or removed.

As noted in Section 5-5.01, *Introduction*, the guidance provided herein can be used when prestressed strands are used for bracing.

9-3.12D(2) Cable Inspection

Cable bracing systems require thorough inspection to ensure that the type of cable used, and the field installation conform to the details shown on the authorized shop drawings. Prior to installation, the cable should be examined to verify that the size and type of the cable and its condition (new or used) is consistent with design assumptions.

Used cables must be in serviceable condition. Used cables in serviceable condition must comply with all the requirements for rope inspection in the current edition of the *Wire Rope User's Manual*, published by the Wire Rope Technical Board. Used cable should be inspected for strength reducing flaws. The use of worn cable should not be permitted. Cable inspection includes, but is not limited to the items below:

- Diameter reduction
- Corrosion
- External wear
- Internal wear
- Kinks
- Fraying
- Protruding core
- Peening
- Scrubbing
- Broken wires

Cables must be looped around an appropriately sized thimble or equivalent diameter steel pin as recommended by the cable manufacturer.

An exception is provided for cables looped around steel caps. Cables may be looped perpendicularly around steel caps provided that appropriately sized corner softeners are used.

An exception is also provided for cables looped around timber caps where wood crushing will form an adequate radius for the cable connection.

Table 9-1, *Thimble Diameters,* may be used to determine the required thimble diameter for a given cable size:

Table 9-1. Thimble Diameters.

Cable Diameter	Approximate Standard Thimble Diameter
(in)	(in)
1/4	11/16
3/8	15/16
1/2	1-1/8
5/8	1-3/8
3/4	1-5/8
7/8	1-7/8
1	2-1/2

Cables looped around thimbles or around an equivalent diameter anchoring device are usually connected to the working part of the cable by Crosby type wire rope clips. Clip installation should be carefully inspected, since properly installed clips are critical to the effectiveness of a cable system. Proper method of installing Crosby clips is discussed in Section 9-3.12D(4), *Cable Connectors*.

To ensure adequate holding strength, field engineers should review the clip installation procedure recommended by the manufacturer before work begins. The contractor should be requested to furnish technical information from the manufacturer showing the installation procedure, recommended torque values, and other pertinent data prior to beginning erection of any cable system.

Only forged clips must be used as connectors. Forged clips are marked *forged* to permit positive identification and have the appearance of galvanized metal. Malleable clips must not be used as connectors. Malleable cable clips appear smooth and shiny.

The method by which the cable will be attached to the falsework and the location of attachment will be shown on the shop drawings. No deviation is permitted.

When cables are released for grading or adjustment, pork-chops and come-alongs, or similar systems, must be used to control the release of the cable. Loosening the clips without control is not acceptable.

9-3.12D(3) Preloading Cable

After assembly, all cable units must be preloaded to remove any slack in the cable and connections. Preloading is necessary to ensure that the cable units will act elastically when the loads are applied.

The required preload values for all cable units will be shown on the shop drawings.

Applying the preload force is an essential part of the cable system installation, and the contractor must provide a means to verify or demonstrate that the required preload force has been applied. A method used by some contractors determines the preload force by measuring the elastic elongation within a short length of the cable. Measurements are made between tape bands placed around the cable to be preloaded. Measurements between the tape bands should be done after removal of any initial slack and again after the cable unit has been preloaded. The term "initial slack" refers to excessively large loops at the connections or any excessive drape remaining in the cable after installation. The initial slack must be taken up before the preload force is applied.

When this procedure is used, the elongation calculation must be based on the reduced value of **E**, since the preload force represents only a small percentage of the cable strength. In addition, unless a pre-stretched cable is being used, constructional stretch may be a factor for consideration, see Section 5-5.09B, *Cable Preload*.

The contractor may employ other methods to demonstrate that the correct preload force is being applied; however, the method must be accurate, readily verifiable, and must not rely on subjective considerations. Regardless of the method used, measurements to verify preload values are to be performed by the contractor in the presence of the engineer.

All cable units must be preloaded simultaneously to prevent frame distortion as the preload force is applied.

Preload tensioning devices must provide positive grip so that no cable movement will occur after final tensioning. Preloading can be done with turnbuckles or with come-alongs.

When cables are attached to timber members with an appropriate fastening device, the preload force must be applied twice. The first tensioning will permit the cable fastening device to bite into the wood. Following this initial tensioning, the cable should be unloaded and then re-tensioned to the required preload force. Any additional wood crushing at the point of attachment will be minor.

Since preload force and cable drape are proportional for a given cable system, knowing the expected cable drape over a range of preload values gives the engineer a method by which the actual applied preload force may be approximated by visual inspection after the falsework is erected. For example, assume that for a particular cable a preload force of 500, 1000, and 1500 pounds results in a calculated drape of 1-1/2, 3/4, and 1/2-inches, respectively. From the relationship between drape and preload force, the engineer can readily determine the preload force actually applied.

9-3.12D(4) Cable Connectors

Cable connectors must be installed in accordance with the requirements shown on the shop drawings.

The installation of cable connectors must conform to the manufacturer's requirements. Only forged clips must be used as connectors. Forged clips are marked *forged* to permit positive identification and have the appearance of galvanized metal. Malleable clips must not be used as connectors. Malleable cable clips appear smooth and shiny.

If U-bolt (Crosby type) wire rope clips are used as connectors, the number used and the spacing is shown on the shop drawings and must conform to the data shown in Table 5-3, *Number and Spacing of U-Bolt Wire Rope Clips*.

The only correct method of attaching U-bolt wire rope clips to rope ends is shown in Figure 9-7, *Applying Wire Rope Clips*. The base (saddle) of the clip bears against the live end of the rope, while the "U" of the bolt presses against the dead end. A useful method of remembering this is: "You never saddle a dead horse."

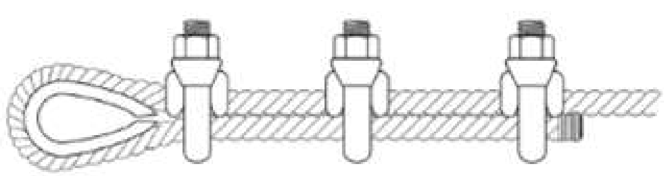


Figure 9-7. Applying Wire Rope Clips.

The clips are usually spaced about six rope diameters apart to give adequate holding strength. A wire rope thimble should be used in the loop eye to prevent kinking when wire rope clips are used. The correct number of clips for safe application, and spacing distances are shown in Table 5-3, *Number and Spacing of U-Bolt Wire Rope Clips,* in Section 5-5.04, *Cable Connector Design*.

Although the efficiency factor for Crosby clips is 80%, this value is valid only when the clip is properly installed and torqued in accordance with the manufacturer's recommendation. Tests to system failure have shown that clips that are not properly torqued will slip before the cable breaks.

9-3.13 Stringers

Refer to Section 9-3.20, *Falsework Over or Adjacent to Roadways or Railroads,* for vertical clearances and mechanical connections. It is not acceptable to install stringers so that the stringer rests on the edge of the cap. If the stringers are sloped longitudinally or if loading strips are used, see Section 9-3.11D, *Cap Beam Center Loading Strips*.

9-3.13A Timber Stringers

Inspect the stringers for damage. Used stringers should be examined for evidence of damage, decay, or distortion of shape, and defective or substandard caps rejected.

Measure the stringers to determine their actual dimensions. If the actual dimension is smaller than the dimension assumed in the design, the stringers may not be capable of carrying the intended load without overstress.

9-3.13B Steel Stringers

Inspect the stringers for damage. Examine used stringers for distortion, bent flanges or webs, and holes in flanges or webs. Defective or substandard stringers must be rejected.

Measure the stringers to verify the actual structural shape. If the actual structural shape is different than what is shown on the shop drawings, the stringers may not be capable of carrying the intended load without overstress.

W14 x 120 and HP14 x 117 have similar bending strength, however, substituting one for the other is not acceptable unless the shop drawings specifically allow.

9-3.13B(1) Steel Beam Banding

Many contractors use commercial steel banding material wrapped around pairs of adjacent cross braced beams. Steel banding is less expensive and easier to install and remove than other types of tension components. However, banding is not effective unless it is properly installed and tightened. When banding is used as part of a flange support system, some means must be provided to prevent an abrupt bend or kink at the point of contact with the outer edge of the beam flange. This is an important consideration because any kink or sharp bend in commercial banding is, potentially, a point of stress concentration, which can reduce the strength of the banding material. The use of softeners, such as PVC pipe, will reduce this stress concentration, see Figure 5-11, *Two-Stringer Cross Bracing.*

Steel banding is a commercial product. If there is any question as to the adequacy of banding installed in a given situation, the contractor should be required to furnish the manufacturer's catalog data and instructions. Bracing, blocking, steel banding, ties, etc., required for lateral support of beam flanges must be installed at right angles to the beam. Bracing in adjacent bays should be set in the same transverse plane, if possible. If, because of skew or other considerations, it is necessary to offset the bracing in adjacent bays, the offset distance should not exceed twice the depth of the beam

9-3.13B(2) Stringer Connector

Stringer connectors must conform to the requirements in Section 7-3.07, *Stringer Connector,* and Figure 7-10, *Stringer Connector Details*. The use and installation of stringer connectors must be in conformance with the following:

- Clip, bolt, and band details must match what is described in Section 7-3.07, *Stringer Connectors*
- Hole in upper part of the connector must be rounded to prevent the band from kinking when tensioned
- Bolt must bear against the stringer flange
- Angle between banding and stringer web must not exceed what is shown on the shop drawings

9-3.13C Beam Hangers

Refer to Section 7-3.03, *Beam Hangers,* and Figure 7-4, *Beam Hangers*. Beam hangers are hardware items which are placed transversely across the top flange of a beam or girder. Steel rods or bolts, which are inserted into threaded wire loops at the hanger ends, hang vertically to support the deck slab falsework, or diagonally outward to support a deck overhang bracket. Beam hangers are also commonly used for stay-in-place steel deck forms.

Verify that the beam hangers are installed per the shop drawings and used in compliance with the manufacturer’s instructions.

9-3.13D Sleepers

When falsework beams are considerably longer than the actual falsework span, the beam cantilever extending beyond the point of support will deflect upward as the main span is loaded. A filler strip (sleeper) is usually installed on the main span only, which allows free movement of the beam cantilever. The sleeper ends at the center line of the falsework top cap and does not extend into the cantilever section. The sleeper must be thick enough to offset the theoretical beam uplift on the cantilever. See Figure 4-1, *Sleeper on the Falsework Stringer*.

Sleepers are also used when the bridge has a steep cross slope. In this situation the sleeper provides clearance between the joist and the stringer top flange. See Figure 4-2, *Camber Strip and Sleeper Requirements*.

9-3.13E Camber Strips

The engineer orders the contractor to furnish camber strips. See the *Contract Specifications,* Section 48-2.03C, *Falsework – Construction – Erection*. Proper installation of the camber strips is important to achieve proper loading of the falsework beam. If camber strips are placed away from the centerline of a steel stringer, they may induce torsional stresses that were not considered in the design.

Camber strips and their installation must conform to the following:

- 1.5-inch minimum width
- Must be centered along the longitudinal centerline of the falsework beam
- The minimum height of the camber strip must be such that the joists will not come into contact with any part of the falsework beam under any loading condition.
- Must not extend onto the unloaded portion of a trailing beam cantilever
- If the amount of camber is large, as in the case where a parabolic curved bridge soffit is supported by a long falsework beam, the camber strips should be braced or built up with wide material to avoid lateral instability. The use of laterally unsupported tall, narrow camber strips is not permitted.
- Sleepers are required when the stringer does not follow bridge cross slope and camber strips do not include allowance for cross slope, see Figure 4-2, *Camber Strip and Sleeper Requirements,* in Section 4-2.02A, *Camber Strips*.

9-3.14 C-Clamps

Refer to Section 7-3.06, *C-Clamps,* and Figure 7-7, *C-Clamps*. Heavy-duty commercial or non-commercial C-clamps having a torque-tightening capacity of 90 ft-lb or more may be used as connecting devices in accordance with the criteria in this section.

9-3.14A Commercial C-Clamps

Commercial C-clamps must conform to the requirements in Section 7-3.06A, *Commercial C-Clamps*, and the contractor must furnish a catalog or manufacturer's technical data sheet describing the clamp in sufficient detail to verify compliance with product criteria listed in this section.

9-3.14B Non-Commercial C-Clamps

Non-commercial C-clamps must conform to the requirements in Section 7-3.06B, *Non-Commercial C-Clamps,* and Figure 7-9, *Non-Commercial C-Clamp*.

9-3.14C Installation

The use and installation of C-clamps must be in conformance with the following:

- Must be installed as shown on the authorized shop drawings
- Must be torqued to 90 ft-lb
- All flanges, angle legs, plates, etc. to be connected must have constant thickness.
- Must be installed on the span side, not on the tail end of beams or stringers
- Clamps used to connect continuous steel stringers to steel caps are to be placed on the most heavily loaded span side of the cap.

9-3.15 Joists

Wood and steel joists may be used for falsework construction. If the bridge has a steep cross slope, a sleeper may be required for clearance between the joist and the stringer top flanges, see Section 9-3.13D, *Sleepers*.

Blocking of joists must be installed per the authorized shop drawings. See also Section 5-2.04F(3), *Blocking to Prevent Rollover.*

9-3.15A Wood Joists

Joists must be installed per the authorized shop drawings. The joist spacing, and span length must not exceed what is shown.

Inspect the joists for damage. Used joists should be examined for evidence of damage, decay, or distortion of shape, and defective or substandard joists must be rejected.

Measure the joists to determine their actual dimensions. If the actual dimension is smaller than the dimension assumed in the design, the joists may not be capable of carrying the intended load without overstress.

9-3.15B Steel Joists

Joists must be installed per the authorized shop drawings and be used in compliance with the manufacturer's instructions. The joist spacing and span length must not exceed what is shown.

Inspect the joists for damage. Examine used joists for distortion, bent flanges or webs and holes in flanges or webs. Defective or substandard joists must be rejected.

Measure the joists to verify the actual shape and size. If the actual shape and size is different than what is shown on the shop drawings, the joists may not be capable of carrying the intended load without overstress.

9-3.16 Soffit Plywood

Soffit plywood sheets should be set with the face grain perpendicular to the joists with abutting ends of the sheets supported on a common joist unless the design warrants otherwise. Refer to the *Contract Specifications,* Section 51-1.03C(2), *Concrete Structures – Preparation – Forms,* for requirements for installation of soffit plywood.

9-3.17 Lost Deck Forms

Lost deck forms must be installed per the authorized shop drawings. Verify the forms are installed to the correct grade. Refer to the *Contract Specifications,* Section 51-1.03C(2), *Concrete Structures – Preparation – Forms,* for requirements for installation of lost deck forms.

9-3.17A Driven Nail Anchorages

The *Contract Specifications,* Section 51-1.03C(2)(a), *Concrete Structures – Preparation – Forms – General,* permits the use of driven type anchorages to fasten forms to interior surfaces of girder stems in PS box girder bridges where:

- Girders have more than 2-inch cover over the reinforcement.
- Anchorages do not penetrate the girder more than 2 inches.
- Anchorages have a minimum spacing of 6 inches.
- Anchorages are placed at least 3 inches clear from the edge of concrete.

9-3.17A(1) Inspection

The specification allows the use of nails driven with low velocity powder actuated hammers provided they are installed in conformance with the following criteria:

- Per the manufacturer's recommendations
- Girders have more than 2 inches of cover over the reinforcement

- Anchorages do not penetrate the girder more than 2 inches and have a minimum spacing of 6 inches.
- Anchorages are placed at least 3 inches clear from the edge of concrete.
- Minimum end and edge distances for wood members must not be less than that required in Section 5-3.03, *Nails and Spikes*.

9-3.18 Deck Overhang

Deck overhangs are typically either supported by falsework resting on stringers or supported by overhang brackets.

Overhang falsework must be installed per the authorized shop drawings. Inspect the members for damage. Used members should be examined for evidence of damage, decay, or distortion of shape, and defective or substandard members rejected.

Measure the members to determine their actual dimensions. If the actual dimension is smaller than the dimension assumed in the design, the members may not be capable of carrying the intended load without overstress.

9-3.18A Deck Overhang Brackets

Refer to Section 7-3.04, *Deck Overhang Brackets,* and Figure 7-5, *Deck Overhang Brackets*. Several types of commercial and noncommercial metal brackets specifically designed to support cantilevered deck overhangs are available. On some brackets the diagonal leg is wood. On precast concrete (PC) girders, these brackets are typically supported by beam hangers or by form bolt inserts cast into the top of the PC girder stems. On steel girders these brackets are typically supported by threaded rods or bolts extending through holes drilled in the web of steel girders. The brackets typically have a diagonal leg braced against the bottom flange of the girder.

Verify that the overhang brackets are installed per the authorized shop drawings and used in compliance with the manufacturer’s instructions. Verify that the loads are applied at the intended location and that screw jacks are within the allowable range.

9-3.19 Tell-Tales

The *Contract Specifications,* Section 48-2.03C, *Falsework – Construction – Erection,* requires the contractor to use tell-tales to measure the settlement during concrete pours. Tell-tales should be attached to soffit forms or joists next to stringers and located as close as possible to the supporting bent cap or post. Enough tell-tales must be provided to determine the total settlement where concrete is being placed. The tell-tale must be readable from the ground. Typically, the tip of the tell-tale hangs free next to a stake in the ground. The initial reading of the tell-tale is marked on the stake before the concrete pour. Stakes must be placed outside of the pad area, so they are not affected by pad settlement. The tell-tale can also be referenced to a stationary point marked on a permanent structure, such as a nearby bridge column, for added monitoring. The movement of the tell-tale must be inspected regularly during the pour. If the tell-tale movement exceeds the maximum allowable per the *Contract Specifications,* Section 48-2.03C, *Falsework – Construction – Erection*, the pour must be stopped, and the contactor must apply corrective measures.

Tell-tales used to depict beam deflection should be placed at the required locations.

9-3.20 Falsework Over or Adjacent to Roadways or Railroads

9-3.20A Introduction

Refer to Section 4-12, *Falsework Over or Adjacent to Roadways or Railroads*, for special requirements that apply to falsework over or adjacent to roadways or railroads that are open to traffic. These requirements are included to provide higher standards of design and construction at locations where public safety is involved.

9-3.20B Stability

The *Contract Specifications,* Section 48-2.03C, *Falsework – Construction – Erection*, require that if falsework is over or adjacent to roadways or railroads, all details of the system that contribute to horizontal stability and resistance to impact, except for bolts in bracing, must:

- Be installed when each element of the falsework is erected.
- Remain in place until the falsework is removed.

For administration of this requirement, the following is provided:

- The requirement applies to the connections that provide lateral restraint at the base of the falsework post, at the top of the post between the post and cap, and between cap and stringer.
- The requirement applies to permanent bracing, which contributes to horizontal stability. Connections on wood bracings may be nailed rather than bolted to facilitate adjustment of the falsework bent to grade. Nailed connections, when used in lieu of bolts, must provide the same capacity as the permanent bolted connection. The permanent bolted connection must be installed within 48 hours after the completion of falsework grade adjustment.
- If traffic is being detoured during falsework erection, the components covered by the specification need not be installed as the falsework is erected but must be installed before traffic is allowed to pass adjacent to or under the falsework.

9-3.20C Horizontal and Vertical Clearances

Refer to Section 4-12.02, *Falsework Openings*, for information on submittal requirements for horizontal and vertical clearances.

For horizontal clearance refer to Section 4-12.03, *Horizontal Clearance*, Table 4-1, *Clearance to Railing Members and Barriers*, Figure 4-10, *Clearance to Railing Members and Barriers,* and *Contract Specifications,* Section 48-2.02B(4), *Falsework – Design Criteria – Special Locations*.

Horizontal and vertical clearances must be measured to verify compliance with contract requirements as soon as the bents are erected and the stringers set in place. Actual clearances should be recorded in the job records. The actual vertical clearance provided when the falsework is first erected must include an allowance for beam deflection and settlement that will occur as the concrete is placed. Any deviations from the original submitted clearances must be reported immediately, see Section 4-12.02, *Falsework Openings*.

Do not allow any falsework erection if the actual clearance is less than reported. Report new anticipated vertical clearance restrictions immediately. Falsework erection may commence 15 days after the resident engineer has submitted the new clearances. See Section 4-12.02, *Falsework Openings*.

9-3.20D Post Material and Parameters

Falsework posts must be either:

- Steel with a minimum section modulus of 9.5 in^3 about each axis.
- Sound timber with a minimum section modulus of 250 in^3 about each axis.

When pipe frame or tubular steel components are used in falsework over or adjacent to a roadway or railroad, either as individual posts or as legs in a tower bent, the specified minimum section modulus for steel columns will apply to the post or tower leg, but not to the screw jack extension.

9-3.20E Impact Loads and Mechanical Connections

Refer to Section 4-12.05C, *Impact Loads and Mechanical Connections,* for design considerations. The purpose of these mechanical connections is to resist lateral impact loads from traffic and should be oriented accordingly. Mechanical connections must be installed per the authorized shop drawings and are required at these locations:

- Bottom of posts: The requirements below apply to all posts within the limits shown in Section 4-12.01, *Introduction*, but not less than two posts. Lateral restraints must be effective parallel to and perpendicular to the bent. For a bent in a highway median, restraint must be effective in all four directions:

- Bottom of posts on corbels: Each post must be mechanically connected to its supporting footing or otherwise laterally restrained.
- Bottom of posts on bottom caps: Each post must be mechanically connected to the bottom cap. The bottom cap must be mechanically connected to its supporting footing or otherwise laterally restrained. The bottom cap must have a minimum of two restraints in the perpendicular direction, one near each end, and a minimum of one restraint in the longitudinal direction at one end.

- Top of post: The requirements below apply to all posts within the limits shown in Section 4-12.01, *Introduction*, but not less than two posts. Lateral restraint must be effective in all directions:
  - Each post must be mechanically connected to the top cap or stringer.
- Stringers over roadway: Mechanically connect these stringers to cap or framing:
  - Exterior stringers
  - Stringers adjacent to ends of discontinuous caps
  - Stringers over point of minimum vertical clearance
  - Every 5^{th} stringer
- Stringers adjacent to roadway within the limits shown in Section 4-12.01, *Introduction*:
  - Mechanically connect exterior stringer adjacent to the roadway to cap or framing
- Stringers over railroad:
  - Mechanically connect all stringers to cap
- Stringers adjacent to railroad within the limits shown in Section 4-12.01, *Introduction*:
  - Mechanically connect all stringers within the limits to cap
- Timber bracing within the limits shown in Section 4-12.01, *Introduction*:
  - Bent parallel to roadway or railroad: Bolted connection required on all braces
  - Bent at an angle to roadway: Bolted connection required on all braces within the limits shown in Section 4-12.01, *Introduction*, and at least one brace bolted
  - Bent at an angle to roadway: Bolted connection required on all braces

9-3.20F Lighting at Traffic Openings

The lighting plan may be a separate action submittal or be part of the shop drawings.

The *Contract Specifications,* Section 48-2.01D(3), *Quality Assurance – Falsework Lighting*, section 48-2.02C, *Materials – Falsework Lighting*, and Section 48-2.03E, *Construction – Falsework Lighting,* state the requirements for pavement and portal lighting at traffic openings. Any project specific requirements will be shown on the plans or included in the special provisions.

Falsework lighting must be installed per the authorized lighting plan. All features of the portal illumination, including plywood clearance markers, as well as pavement and pedestrian walkway lighting, if required, must be in place and operational:

- The same night the first post adjacent to roadway, railroad, or pedestrian walkway is erected.
- Immediately after falsework bents are erected adjacent to roadway, railroad, or pedestrian walkways.
- Prior to allowing traffic adjacent to the falsework.

As soon as the falsework is erected, and the lights turned on, the lit falsework opening should be inspected after dark to check the effectiveness of the lighting, and the lights moved or adjusted if necessary to provide uniform illumination. Lighting fixtures must be aimed to avoid glare to oncoming traffic. Inspection at night should continue periodically, as lights may be inadvertently moved or disturbed as construction continues. An inspection during adverse weather, such as rain or fog, is also advisable.

Temporary barrier system and all painted surfaces at the portal opening must be maintained in a clean, white condition. Repainting may be necessary on occasion. Refer to the contract documents for payment of such work.

The *Contract Specifications,* Section 48-2.03E(1), *Falsework Lighting – General,* do not permit closing of traffic lanes for routine maintenance of the lighting system on any roadway having a posted speed limit above 25 miles per hour.

9-3.21 Cal/OSHA Requirements

The Cal/OSHA Construction Safety Orders require the contractor to obtain a permit to construct or remove falsework or shoring that is more than three stories high. This requirement is discussed in Chapter 2, *Review of Shop Drawings*.

The Cal/OSHA Construction Safety Orders §1717, *Falsework and Vertical Shoring,* requires all falsework or vertical shoring systems to be inspected and certified prior to concrete placement. The certification must be in writing, available on site, and must state that the falsework, as constructed, substantially conforms to the working drawings and that the materials and workmanship are satisfactory for the purpose intended.

For falsework or shoring which exceeds 14 feet in height, measured from the top of the lower cap to the superstructure soffit, or where the length of an individual span exceeds 16 feet, or where provision is made for the passage of vehicular or railroad traffic through the falsework or shoring, the required inspection and certification must be made by a civil engineer registered in the State of California, or by his authorized representative.

For all other falsework, the inspection and certification may be made by any one of the following:

- A civil engineer registered in the State of California
- For shoring systems, a manufacturer's authorized representative
- A licensed contractor's representative qualified in the usage and erection of falsework and vertical shoring

Arranging for the required inspection and certification is the contractor's responsibility. When the falsework design is such as to require inspection and certification by a registered civil engineer, it is the contractor's engineer who assumes this responsibility.

Inspection and certification of the falsework pursuant to the requirements in Article 1717 of the Construction Safety Orders does not relieve the contractor of any of his responsibilities under the contract for falsework construction, nor does it relieve the structure representative of his responsibilities with respect to contract administration. Even though the falsework is certified by the contractor's engineer or by other appropriate authority, the structure representative must satisfy himself that the falsework has been constructed in conformance with the authorized shop drawings before permitting the contractor to place concrete.

9-3.22 Field Changes

The falsework must be constructed per the authorized shop drawings. Per the *Contract Specifications,* Section 5-1.23B(2), *Shop Drawings*, any changes require that the revised drawings be submitted for review in the same manner as the original drawings.

In some cases, the change may be small and can be shown on a simple sketch; however, the sketch must be signed and stamped by a civil engineer registered in the State of California. Calculations are required in all cases.

Contractually, the review time for resubmittal due to field changes is the same as for the original submittal; however, it is SC practice to give high review priority to resubmittals during falsework construction.

Work shown on a revised shop drawing or sketch may not begin until that drawing has been authorized.

9-3.23 Adjustments

Falsework adjustment includes any adjustment or grading.

Particular attention should be given to falsework bents where adjustment is provided at the bottom of the posts. Since any differential vertical movement of posts within a bent may induce undesirable stresses into the frame, the diagonal bracing should be inspected after the falsework is adjusted for evidence of deflected braces and/or distortion at the connections.

Jacks used for grading or adjusting the falsework must be plumb and not extended beyond the distance recommended by the jack manufacturer. The load should be centered over the jack e.g. cap beam web should line up with the center of the jack piston.

Proper bracing must be in place during jacking operations, including additional temporary bracing as required by the shop drawings. Release of falsework bracing must follow the authorized procedure shown in the falsework submittal. When cable bracing is being adjusted, devices such as pork-chops and come-alongs must be used to control the tensioning and de-tensioning of the cables. Releasing cable clips without controlling the tension in the cable is not acceptable.

9-3.24 Metal Shoring Systems

9-3.24A Introduction

This chapter describes the general inspection procedure for metal shoring systems. The term "metal shoring system" describes falsework consisting of individual components that may be assembled and erected in place to form a series of internally braced metal towers of any desired height. The tower legs, directly, or through a cap system, support the main load carrying members and transmit the load to a stable foundation.

Refer to Section 7-4, *Metal Shoring Systems,* for additional information.

9-3.24B Inspection

The safe load carrying capacity of all commercially available shoring systems is based on the use of new components, or used components in good condition, properly erected in conformance with the manufacturer's recommendations. Therefore, proper inspection is of particular importance to verify the adequacy of the completed system. Following is a list of items to be inspected and things to consider:

- The shoring must be installed per the authorized shop drawings and per the manufacturer’s recommendations.
- Shoring components should be inspected prior to erection.
- Any component that is heavily rusted, bent, dented, or otherwise defective, should be rejected.
- Any fabricated unit in which individual members are bent, dented, twisted or broken, or where the welded connections are cracked or show evidence of re-welding, should be rejected.
- Shoring towers must be installed plumb on level foundations. Shoring must be plumb in both directions. Refer to technical data sheets issued by the manufacturer for the maximum allowable deviation from true vertical. If this deviation is exceeded, the shoring must be readjusted to meet the limit.
- A base plate or shore head device should be used at the top and base of all tower legs. All base plates and shore heads must be in firm contact with the footing at the base and the cap at the top.
- Screw jack extension devices may be used at the top of all tower legs. All extension devices must be in firm contact with the cap at the top. Screw jacks will not be allowed at the bottom of shoring towers.
- Shore heads and extension devices must be axially loaded, since shoring components are not designed to resist eccentric loads.
- Vertical components should fit together evenly, without any gap between the upper end of one unit and the lower end of the other unit.
- Base plates, shore heads, and screw jack extension devices must fit into the tower legs.
- Any component that cannot be brought into proper contact with the component into or onto which it is intended to fit should not be used.
- All locking devices on frames and braces must be in good working order. Coupling pins must bring the frame or panel legs into proper alignment and pivoted cross braces must have the center pivot in place.
- Shoring components should be identifiable by paste on stickers or by alpha-numeric stamped impressions.
- Commercial shoring systems used for falsework are reviewed and authorized based on a particular system from specific manufacturers. Various systems may have many similar components, but they are not intended to be interchangeable

between systems. Field engineers should verify that the system furnished is the system shown on the shop drawings and further, that all system components are part of the authorized system. Intermixing of components of various systems is not acceptable.

9-3.24C Letters of Certification

These certifications are required for falsework construction:

- The *Contract Specifications,* Section 48-2.01C(1), *Falsework – Submittals – General,* requires the contractor to submit a letter of certification, which certifies that all components of the manufactured assembly are used in accordance with the manufacturer's instructions.
- In addition, the *Contract Specifications,* Section 48-1.01D(2), *Temporary-Structure Engineer,* and the Cal/OSHA Construction Safety Order §1717(c)(1), *Falsework and Vertical Shoring – Inspection,* require another certification, which certifies that the falsework (which the shoring is part of) is constructed as shown on the authorized shop drawings before concrete is placed.

9-3.25 Manufactured Assemblies

The term *manufactured assembly* means any commercial product, the use of which is governed by conditions and/or restrictions imposed by the manufacturer. Manufactured assemblies routinely used in falsework construction include products such as jacks, hangers, clips, brackets, and similar hardware products, as well as all types of manufactured shoring systems. When authorized for use, such products may be incorporated into the design.

The *Contract Specifications,* Section 48-2.01C(1), *Falsework – Submittals – General,* require the contractor to furnish a written certification stating that all components of the assembly are used in accordance with the manufacturer's recommendations.

When a manufactured assembly is used in the falsework, the contractor must furnish a written certification stating that all components of the assembly are used in accordance with the manufacturer's recommendations. A separate certification is required for each product or device used in the falsework. See Section 9-3.26B, *Manufactured Assemblies*.

9-3.26 Falsework Certification

9-3.26A Falsework

The *Contract* Specifications*, Section* 48-1.01D(2), *Temporary-Structure Engineer,* require that the civil engineer registered in the State of California who signs the shop drawings must certify that the falsework is constructed as shown on the shop drawings before concrete is placed. This certification includes all falsework components, such as soffit forms, stringers, caps, post, pads, bracing, connections and all manufactured assemblies, such as overhang brackets and shoring towers. The certification must be in writing, and it must state that the falsework, as constructed, conforms to the shop drawings and that the materials and workmanship are satisfactory for the purpose intended.

Arranging for the required inspection and certification is the contractor's responsibility. It is the engineer who signed the shop drawings who assumes this responsibility.

9-3.26B Manufactured Assemblies

The *Contract Specifications,* Section 48-2.01C(1), *Falsework – Submittals – General,* requires the contractor to submit a letter of certification, which certifies that all components of the manufactured assembly are used in accordance with the manufacturer's instructions. This certification is in addition to the certification by the civil engineer registered in the State of California in Section 9-3.26A, *Falsework*.

Arranging for the required inspection and certification is the contractor's responsibility. It is the contractor's engineer or a representative from the manufacturer who assumes this responsibility. However, the structure representative must verify that the manufactured assemblies have been inspected by examining the certificate and noting its existence in the project diary. A copy of the certificate must be placed in the job records.

9-3.27 Bridge Construction Engineer Review

The Bridge Construction Engineer must perform a field review of the installations, together with the structure representative, before concrete is placed. This review typically takes place after the contractor has certified the falsework.

9-4 Concrete Placement

9-4.01 Inspection During Concrete Placement

As concrete is being placed, the falsework should be inspected at frequent intervals. In particular, look for the following indicators of incipient failure:

- Excessive compression at the tops and bottoms of posts and under the ends of stringers. Crushing of wedges. Settlement of sand jacks.
- Movement or deflection of diagonal bracing. Distortion at connections. Pulling of nails.
- Tilting or rotation of joists or stringers. Excessive deflection of any horizontal member.

- Posts or towers that are bowing or moving out of plumb.
- Excessive settlement as indicated by tell-tales.
- The sound of falling concrete or breaking timbers. Any unusual sound.

The *Contract Specifications,* Section 48-2.03C, *Falsework – Construction – Erection,* limit falsework settlement to a maximum of ±3/8-inch deviation from the anticipated settlement shown on the shop drawings. The movement of the tell-tale must be inspected regularly during the pour. If the tell-tale movement exceeds the maximum allowable, the pour must be stopped, and the contractor must apply corrective measures. Concrete placement must not be resumed until the engineer is satisfied that further settlement will not occur. Settlement due to soil compression may continue for some length of time, even though the load is not increased.

If inspection reveals members in distress such as crushing at joints, rotation or tilting of vertical members, or any similar indication of incipient failure, all concrete placement must be stopped immediately, and the falsework strengthened by the installation of supplementary supports, or by some other means. Refer to the SC *Concrete Technology Manual* for a discussion of the factors to be considered when it becomes necessary to install an emergency construction joint.

For continuous steel or precast concrete girders the *Contract Specifications*, Section 51-1.03D(2), *Concrete Bridge Decks,* requires the portion of deck over the supports to be placed last. Verify that the deck placement plan shown on the project plan or on the authorized shop drawings is implemented by the contractor, including the location of all the construction joints.

Section 2-4.01, *Initial Review,* requires that if a concrete placing schedule is not shown on the contract plans, the shop drawings must include a superstructure placing diagram showing the proposed concrete placing sequence and/or the direction of pour, whichever one is applicable, and location of all construction joints.

If falsework bents are located near existing roadways or railroads it is likely that the soil in the area is stiffer and the bents in this area will pick up more load. Although these bents have been designed for an increase in load, it is prudent to pay close attention to these bents during the pour.

9-4.02 Inspection After Concrete Placement

Falsework inspection should not stop with concrete placement but should continue periodically until the falsework has been completely removed.

One important, and often overlooked point, is the danger of rain and curing water softening the falsework foundation. Some means should be provided to prevent curing water from reaching and soaking the foundation material beneath the falsework pads.

The contractor should provide for drainage of rain or curing water that accumulates in the box girder cells. Such water in the cells could easily overstress the falsework or, if deep enough, the permanent structure as well. If the water is allowed to drain through the soffit drain locations, ensure the path of drainage will not adversely affect the system. The contractor must comply with the requirements in the authorized Water Pollution Control Plan (WPCP) or Stormwater Pollution Prevention Plan (SWPPP) when curing concrete with water.

9-4.03 Deck Shrinkage

Continuing inspection is particularly important in the case of post-tensioned structures because of the redistribution of dead load forces that occurs following the deck concrete pour. As the newly placed deck concrete shrinks during the curing period, the downward force exerted on the falsework by the bridge superstructure can be re-distributed. The increase is greatest near the center of the structure span, and typically reaches its maximum from four to seven days after the deck concrete is placed.

The effect of deck shrinkage is of greater concern in cast-in place prestressed structures than in conventionally reinforced concrete structures because post-tensioned structures have relatively little rigidity until they are stressed.

The effect of deck shrinkage is not addressed in the specifications; however, field engineers should be aware of the potential shrinkage and look for locations where the falsework may be adversely affected.

9-5 Removal

9-5.01 Introduction

The *Contract Specifications,* Section 48-2.03A, *Falsework – Construction – General,* require the use of construction methods, which include temporary bracing when necessary, to withstand all imposed loads and to prevent overturning or collapse of the falsework during erection, construction, and removal. The means by which the contractor complies with this specification requirement is commonly referred to as the erection plan and removal plan.

Before falsework removal begins, the removal plan, as described in the authorized shop drawings, should be discussed with the contractor's field representative who will be responsible for supervising the removal. The purpose of this requirement is to verify that the removal plan is appropriate for the site and conditions to be encountered, and that all persons involved with the work, both the contractor and State, are familiar with the removal plan.

The *Contract Specifications,* Section 48-2.03D, *Falsework – Removal,* discusses falsework removal. Removal is not allowed over traffic per the *Contract Specifications,* Section 48-2.03A, *Falsework – Construction – General*.

In general, the falsework must remain in place for a specified time period, or until the concrete attains a specified strength, or for cast in-place prestressed construction, until stressing (but not grouting) is completed.

Continuous structures have the following additional requirements. The release of falsework supporting a given span cannot begin until all required work, excluding concrete above the bridge deck and grouting of prestressing ducts, has been completed in that span and in the adjacent spans over a length equal to at least 1/2 of the length of the span where falsework is to be released. See Figure 9-8, *Falsework Release of Continuous Bridges*. The reason for the restriction is that in continuous concrete bridges the bending moment in the finished bridge is reduced due to adjacent spans acting like counterweights. Therefore, placing half of the adjacent span concrete, **L/2**, will keep the positive and negative moments in span A close to design dead load moments.

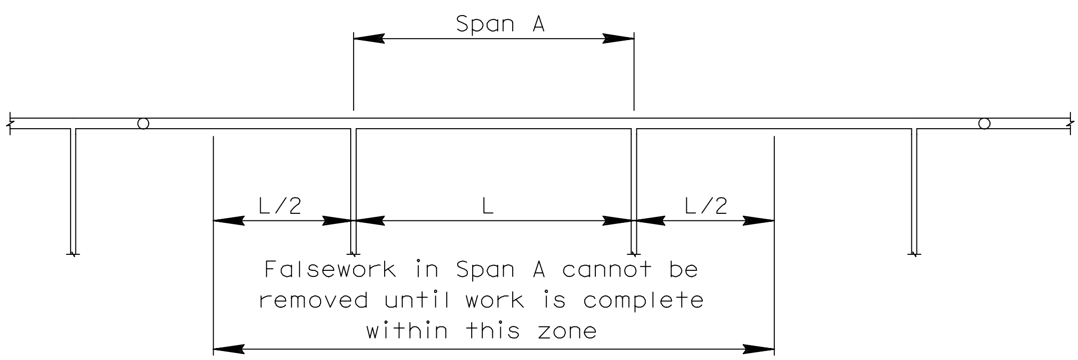


Figure 9-8. Falsework Release of Continuous Bridges.

Releasing falsework in the span adjacent to the short side of the hinge is not allowed until all work at the hinge is complete. Release of falsework in the span adjacent to the short side of the hinge would cause rotation of the hinge and induce excessive dead load moments in the bridge elements. Proposals to provide alternative loads at the hinge or alternative support to the adjacent span to allow release of the falsework in the span adjacent to the short side of the hinge should be discussed with the bridge designer.

9-5.02 Removal Procedure

Falsework removal often presents a greater challenge than erection because the new bridge reduces the available space, hence it must be carefully performed to ensure both worker and public safety. The *Contract Specifications,* Section 48-2.01C(2), *Falsework – Submittals – Shop Drawings* , require the contractor to include a removal plan on the shop drawings. The plan must show the methods and procedures to be employed and any temporary bracing required.

The stability of the system depends on the interaction of many component parts. As falsework components are removed, unbalanced and/or eccentric loadings may occur, and the use of jacks to unload portions of the falsework may induce forces that exceed those considered in the original design. No stabilizing component should be removed without considering the effect of its removal on the stability of the falsework still in place.

Since the falsework removal plan must be shown on the shop drawings, it is necessary for the falsework designer to develop the falsework removal plan many months (even years on very large projects) before the actual removal will take place, and thus its appropriateness may be affected by conditions and circumstances that were not anticipated. In view of this reality, prior to the start of any removal, the structure representative and field engineers are to meet with the contractor to review the removal plan. The review should consider the general appropriateness of the removal method in light of the actual site conditions and should include a discussion of the removal sequence and equipment to be used, the number and responsibilities of the workers involved, and public and worker safety.

The contractor must designate an employee who will be in charge of the falsework removal work and who will be present at the work site while the work is in progress. Additionally, the structure representative must assign a field engineer to be present whenever falsework is being removed. However, falsework removal, like all other contract work, is the contractor's operation, and it is the contractor's responsibility to perform the work in a safe manner and in accordance with the authorized removal plan.

Some contractors use cables attached to winches set on the bridge deck to lower elements of the falsework system. While this is a simple and generally satisfactory removal method, the weight of the winch plus the weight of the suspended falsework may produce a relatively large, concentrated load. Before such removal plans are authorized, the structure representative should be certain that the winch load is distributed over the deck in a manner that prevents overstressing of the permanent structure. In some cases, it may be appropriate to discuss the distribution method with the bridge designer.

All bracing must remain in place until the falsework is removed per the removal plans on the authorized shop drawings. If a contractor wants to remove some bracing or other portions of the falsework during the curing period prior to the bridge being self-supported, the procedure must be clearly shown on the authorized shop drawings.

9-5.02A Removal with Winches or Similar Systems

The *Contract Specifications,* Section 48-2.03D, *Falsework – Removal*, requires falsework removal systems employing methods of supporting falsework by winches, hydraulic jacks with prestressing steel, HS rods, or cranes must be supported by an independent support system when the falsework is over vehicular, pedestrian, or railroad traffic. When traffic is detoured for lowering falsework the independent support system is not required.

Falsework must never be lowered over live traffic, see the *Contract Specifications,* Section 7-1.04, *Public Safety*. The remaining falsework must be inspected before opening to traffic.

High strength rods are typically used as an independent system. All falsework must be tight against the soffit and no loose soffit material suspended over the traffic or construction.

The following are some restrictions on the location and use of winches:

- Winches installed on the deck must be plumb within 2% or as noted on the authorized plans. This can be achieved by installing full length shims at a minimum of three locations under the winch frame beams. The shims can result in higher concentrated loads and the contractor must verify that the load will not damage the deck.
- Restriction on winch orientation with respect to bridge centerline is as follows:
    - When the winch nose is over the edge of deck then the skew in plan view is very restrictive.
    - When the winch nose is at the bridge overhang then rear winch support must be on the exterior girder.
    - When the winch nose is over the bay then the winch can be placed at any angle except that the rear winch support must not be placed on the bridge overhang.
- The rod and wire rope must have a softener at the winch cable hole.

9-5.03 Stage Construction

When continuous cast-in-place prestressed structures are constructed in stages, the stage construction sequence will require some load supporting elements of the falsework system to remain in place for an extended period of time. For such structures, falsework removal involves special considerations.

For any given construction stage, the initial stressing will transfer the superstructure dead load from the center of the spans toward the points of support. This redistribution of dead load forces will decrease the load applied to the falsework near the center of the continuous spans. The load being carried by falsework near the center of a suspended span will be decreased as well; however, the load on the falsework supporting the hinge or construction joint will be increased by dead load transfer.

For continuous prestressed structures, the specified sequence of falsework removal will require certain elements of the system to remain in place. All components of such falsework, including diagonal bracing, must remain in place, even though the falsework may have been partially unloaded by the prestressing operation. This procedure is necessary because, with the passage of time, the redistributed dead load will be carried back toward the center of the span as superstructure dead load deflection takes place.

For continuous prestressed structures, all elements of the falsework system that are not required by the specifications to remain in place should be completely removed. If the falsework cannot be removed within a reasonable time, any components remaining in place should be unloaded. This procedure is necessary to prevent overloading of partly disassembled falsework still in place under the deflecting superstructure.