CDOT Construction Manual

SECTION 600
MISCELLANEOUS CONSTRUCTION

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SECTION 601
STRUCTURAL CONCRETE

601.1 GENERAL REQUIREMENTS

Section 601 of the *Standard Specifications* governs the construction requirements for major concrete structures such as bridges, retaining walls, and box culverts. Acceptability depends on the quality incorporated in the following distinct operations:

1. formwork, falsework, and framing;
2. reinforcing material and placement;
3. concrete mix materials, design, and production;
4. concrete placement and consolidation;
5. concrete finishing; and
6. concrete curing.

The Contract governs each of these operations in detail. Most problems encountered can be traced to materials and work that do not conform to specified requirements.

601.1.1 Completed Bridge Inspection

When construction of a bridge or overhead sign is completed, contact the Bridge Management Systems Engineer at (303) 757-9188 to schedule an inspection.

601.1.2 Vertical Clearances

The Project Engineer will verify the vertical clearance measurements for all bridges and overhead signs and report the findings to the Staff Bridge Branch and Staff Maintenance Oversize/Overweight Permits Office if less than 16 feet six inches. See Appendix D for guidance on measuring and reporting vertical clearances.

601.2 FORMWORK AND FALSEWORK

Falsework is used to support loads, including formwork, until the structure becomes self-supporting. Falsework design and construction are the Contractor's responsibility.

601.2.1 Form Lumber

To produce a clean, uniform finish on exposed concrete surfaces, acceptable form lumber must be used. Compliance will help ensure the desired surface appearance of the finished structure. Attempts to cover up surface blemishes resulting from the use of marginal form lumber will not produce results equal to those that can be obtained from using acceptable form lumber. In addition, check that exterior corners are formed with a chamfer strip or other suitable means to produce smooth, even edges.

601.2.2 Bracing Considerations

The Contractor is responsible for providing adequate bracing of all formwork, and CDOT personnel cannot dictate construction methods. This poses a dilemma during construction, because inadequate bracing can sometimes cause bulges in abutments, wing walls, and retaining walls that, although undesirable, can be construed acceptable. Closely inspect all forms and bracing and accept the work only if it is clear that the Contractor could not have reasonably anticipated the situation. Doing so will help ensure the provision of a quality structure.

601.2.3 Foundation Systems

Adequate foundation systems must be provided to support the weight of falsework and construction loads. This is particularly important during the construction of concrete box girders and pier caps where segmental pouring sequences are employed. Partially

completed structural elements cannot be expected to carry the weight of concrete used in subsequent pours, and adverse cracking will generally occur if falsework settles.

601.2.4 Falsework Drawing Certification

The Contractor's Professional Engineer shall determine the need for falsework drawings, as per subsection 601.11 of the *Standard Specifications*. Prior to placement of any concrete supported by falsework, the Contractor's Professional Engineer shall prepare and submit a letter of falsework certification to the Contractor. The Contractor shall submit the certification letter to the Project Engineer. The certification letter must contain the following information:

1. project number,
2. project code,
3. project location,
4. date,
5. Contractor's name,
6. name of Contractor's Professional Engineer,
7. structure identification,
8. description of portion of structure supported by falsework,
9. statement of certification
10. Professional Engineer's Colorado PE license number, and
11. drawings stamped "Approved for Construction".

The certification letter must be signed and dated by the Contractor's Professional Engineer. The statement of certification in the body of the letter will be as follows:

> *I hereby certify that falsework materials and construction have been inspected and that all falsework design, materials, and construction conform to the requirements of the Contract and are safe for the placement of concrete.*

Note that a separate certification letter is required prior to each concrete pour that is supported by falsework.

601.2.5 Inspection Considerations

Before the concrete pour, thoroughly inspect formwork for trueness to line and grade, warping, smoothness of form faces, condition of form ties, proper bracing, tightness of joints, and cleanliness of forms (e.g., shavings, sawdust). Consider the following additional guidelines:

1. Falsework Drawings. Where determined necessary by the Contractor's Professional Engineer, verify that the falsework drawings are stamped with the registered seal of the Professional Engineer and approved and signed by the Contractor.

2. Letter of Falsework Certification. Verify that the Contractor has submitted a proper letter of falsework certification. See Section 601.2.4 for additional information.

3. Form Supports. Forms must be adequately supported and sufficiently rigid to minimize excessive deflection and distortion.

4. Concrete Finish/Surface Texture. Check that the surface of the forms complies with specified requirements for concrete finish and surface texture.

5. Form Release Agent. Ensure that the proper treatment (i.e., oil or form release agent) is applied to the forms prior to the placement of reinforcement.

6. Form Tightness. Form sections should be drawn tight to minimize mortar leaks at joints.

7. Metal Forms. Where metal forms are used, check sheet thickness and form design for compliance to ensure that forms will remain true to shape during the pour. Verify that form joints are properly aligned. The use of metal forms should produce a smooth concrete surface finish.

8. Chamfer Strips. Check that the specified types of chamfer strips have been properly placed in the corners of forms.

9. Form Ties. Where metal form ties are used, verify compliance with respect to type and number. The number of ties used should be sufficient to minimize bulging. Do not permit the use of twisted wire loops as form ties.

10. Omitted Backforms. The omission of backforms requires approval by the Project Engineer.

11. Embedded Materials. Ensure that all materials that will be embedded in the concrete (e.g., conduits, drains, utility blockouts, anchoring devices) are placed in the proper location and adequately secured.

12. Form Cleaning. Verify that the inside surfaces of the formwork are cleaned of all dirt, mortar, and foreign material.

13. Reuse of Forms. Where form panels such as plywood are to be reused, closely inspect the panels for acceptability before they are reused. Do not allow the reuse of unsuitable form materials.

601.3 CONCRETE PRODUCTION

601.3.1 Load Tickets/Mixer Truck Certification

Subsection 601.06 of the *Standard Specifications* requires the Contractor to furnish a load ticket (i.e., delivery ticket) with each load of concrete delivered to the project. The load tickets are used to verify compliance with specifications and to ensure that quality concrete is delivered to the appropriate location on the project.

Upon receipt of the first load, verify that the class of concrete delivered conforms to specified requirements and check that the information provided on the load ticket is accurate and complete. At the end of each day, obtain the load tickets from the Contractor

and verify that the concrete meets specified requirements for the work in progress. Note that different classes of concrete may be specified for different structural elements. Perform verification checks as needed throughout the workday to ensure compliance. For bridge deck concrete, pay particular attention to the maximum allowable substitution of fly ash for cement.

Subsection 601.07(c) 3 requires the Contractor to provide a Concrete Truck Mixer Certification that shows the various pick-up and throw over configurations and wear marks so that wear on the blades can be checked. This certification shall be completed whenever the Contractor purchases a mixer truck. The Contractor shall provide the Engineer a copy of this certification with the correct date and current Project Number for each project. The Contractor will be required to complete a new certification only if the flights are changed and the wear marks are different than when the original certification was completed.

601.3.2 Deviation From Specifications

The Contract specifies many requirements for concrete production, which should be strictly and uniformly enforced to ensure that quality materials and workmanship are incorporated in the structure. Any consideration to accept out-of-specification material must be based on sound engineering judgment to specifically address the problem encountered in the field and must have the approval of the Project Engineer. Always document the extent and basis of any deviation from specifications.

601.4 CONCRETE PLACEMENT

Consider the guidelines in the following Sections when inspecting the placement of structural concrete. See Section 601.7 for guidelines on placing concrete for bridge decks.

601.4.1 Before Placement

Use the following inspection guidelines before the concrete is placed:

1. Mix Design. Know the requirements of the designated concrete class, and check that the Contractor has obtained an approved mix design. Ensure that the type of fly ash to be used has been approved. Know the requirements for slump, air, and admixtures, including type and quantity.

2. Pouring Schedule/Sequence. The Project Engineer is responsible for approving pouring sequences and procedures. Know the pouring schedule from central or transit mixers.

3. Truck Mixer Certification. Check that the Contractor has provided a properly complete Form 46 – Concrete Truck Mixer Inspection Certification for each truck mixer used on the project.

4. Time and Weather Requirements. Check the specified time limitations and requirements for placing concrete during both hot and cold weather conditions. Verify that the Contractor is adequately prepared to protect fresh concrete from damage due to inclement weather (e.g., rain storms, freezing temperatures).

5. Formwork. Check lines, grades, and clearances of formwork, reinforcing steel, and embedded fixtures for compliance. Verify that all dirt, chips, sawdust, water, and other foreign materials have been removed from formwork. Wood forms should be thoroughly moistened with water prior to the concrete pour. See Section 601.2 for additional guidance on formwork and falsework.

6. Drainage and Weep Holes. Check drainage and weep holes for proper location and elevation.

601.4.2 During Placement

Consider the following inspection guidelines during the placement of concrete:

1. Load Tickets. Check the information presented on load tickets as discussed in Section 601.3.1. Verify compliance with the mix design.

2. Mix Proportion Changes. Consult the Materials and Geotechnical Branch regarding any changes to mix proportions.

3. Adding Water. Ensure that the quantity of water added to the concrete mix at the site is properly recorded. Verify compliance with specified procedures for adding water (e.g., mixer drum revolutions, water/cement ratio).

4. Mixer Revolutions. Check that mixer revolutions are performed at mixing speed.

5. Chutes and Troughs.Verify that chutes or troughs are used properly.

6. Segregation. Check that the Contractor's method of placing concrete minimizes segregation.

7. Construction Joints. Verify that construction joints are properly formed at the correct location. Check that construction joints are cleaned and maintained free of debris and loose material.

8. Tell-tales. Check forms for obvious signs of weakness, such as panel bulges and settlement. Monitor tell-tales for settlement beyond acceptable limits, and required immediate corrective action.

9. Pour Sequence. Verify conformance with the designated concrete pour sequence.

10. Reinforcing Steel. Monitor the operation for reinforcing steel displaced by workers or concrete pours. Check that proper cover and clearance is maintained. Prior to placement of additional concrete, verify that extraneous mortar is cleaned from exposed reinforcing steel.

11. Reinforcement Dowels. Check that reinforcement dowels are properly installed at the correct locations.

12. Time Limitations. Monitor the operation to ensure that specified time limitations are not exceeded during concrete placement.

13. Consolidation. Check that vibrators provide adequate consolidation, thorough but not excessive. Do not permit vibrators to be used to move concrete along the forms.

14. Concrete Placed Under Water. Determine and verify the requirements for placing concrete under water.

601.5 CONCRETE FINISHING

Project Inspectors should closely monitor the finishing operation to ensure that all specified finishing requirements are being met. Various classes of concrete finish may be specified for any given structure, and the designated finish must be applied properly at the designated location. Do not approve a structure until the finishing operation has been thoroughly inspected and found acceptable. A structure's appearance is only as good as the quality incorporated in the surface finish. Consider the following guidelines:

1. Form Removal. Check that forms are removed at the proper time. The concrete must be allowed to cure to a strength that will allow the structural member to support itself without damage when formwork and falsework are removed. Minimum strength criteria and number of days required before removal of forms will be specified in the Contract.

2. Temperature Considerations. Where a structural coating is designated, verify that the concrete surface temperature is within allowable limits before application.

3. Joints. Pay particular attention to construction and expansion joints during the finishing operation. Joint cavities must be maintained free of all mortar and loose concrete.

4. Bridge Decks. See Section 601.7 for guidance on finishing concrete bridge decks.

5. Surface Preparation. Verify that exposed surfaces are thoroughly cleaned by water and/or sand blasting at the proper time and that all irregular projections are removed. Check that all cavities, honeycomb spots, and broken edges are properly cleaned, saturated with water, and pointed and trued with the specified mortar mixture. Check that mortar patches are cured as specified.

6. Types of Surface Finishes. Verify that the designated class of finish is properly applied at the correct location. Although a Class 1 finish is not a comprehensive treatment, it is just as important as other surface treatments. Class 1 finishes are applied immediately after form removal. Before the application of a Class 5 finish or a structural coating, the concrete surface must been allowed to cure as specified. Where a structural coating is designated, check that the coating material and color have been approved, and verify the application rate and number of coats for compliance.

601.6 CONCRETE CURING

The requirements for the allowable methods of curing structural concrete are defined in the *Standard Specifications* and must be strictly enforced. Closely monitor the operation for compliance to all specifications. The surface of the concrete must be maintained in a moist condition for the minimum curing period, which includes the period during which the finishing operation is performed. Check that that Contractor is adequately prepared to protect the concrete and maintain the surface in a moist condition, especially during hot, sunny weather. Consider the following guidelines:

1. Temperature Requirements. Know the requirements for cold-weather concreting. Concrete must be maintained at the minimum specified temperature for the minimum number of curing days.

2. Curing Method. Verify that the Contractor's proposed curing method has been approved for the project.

3. Curing Compound. Ensure that the curing compound has been approved for use on the project, and verify the application rate for conformance.

4. Bridge Decks. See Section 601.7 for guidance on curing concrete bridge decks.

601.7 CONCRETE BRIDGE DECKS

The following Sections specifically address the construction of concrete bridge decks. Sections 601.1 through 601.6 provide additional information that should be considered for structural concrete work.

601.7.1 Pre-Pour Conference

A Structural Concrete Pre-Pour Conference will be held prior to the concrete deck pour to discuss project requirements with the Contractor. The Agenda for the Pre-Pour Conference is presented in Appendix A. During the various stages of the project, it is important to maintain communications with Contractor personnel (e.g., Superintendent, Foremen, Material Testing Supervisor) that have been established at the Conference.

601.7.2 Stay-in-Place Forms

Consider the following where stay-in-place steel forms are used in bridge deck construction:

1. Erection Drawings. Ensure that the Contractor has submitted erection drawings, and verify that materials and installation are in compliance with these drawings.

2. Form Connections. Verify that form connections are made in compliance with specified requirements.

3. Welding Considerations. Monitor the operation to ensure that welding arcs do not come into contact with steel girder flanges.

Problems with forming concrete decks on precast prestressed concrete girders are typically due to inadequate haunch height. The haunch is the distance from the top of the girder to the bottom of the bridge deck. The haunch is specified by the designer on the plans and is designed to accommodate girder camber, deck geometry, and forming of the deck. It allows for the girder deflections due to the weight of the slab (dead load deflections).

Girder camber is due to the force of the tensioned prestressing strand and the time dependent effects of creep and shrinkage. Creep and shrinkage are a function of the actual concrete mix placed in the girder. Camber in a girder cannot be reliably predicted, since it is not known during design what the girder's age will be at the time of erection, the creep and shrinkage characteristics of the concrete mix, the concrete strength when the prestressing force is applied to the girder, and how these factors will interact.

Inadequate haunch height problems generally have been the result of:

1. The fabricator not monitoring the camber growth of the girders and taking corrective action when necessary, i.e. weighting the girders down.

2. The designer not allowing adequate tolerance for girder camber when specifying the haunch height.

3. The girders sitting on the bridge substructure for extended periods of time before the deck is placed.

4. The designer not making an allowance for the bridge deck geometry when determining the haunch height, for example, the effects of a vertical curve or the deck cross slope.

During construction a number of different problems can develop that result in a difference between the haunch height specified on the plans and the actual haunch height in the field.

For example:

1. Less camber than predicted or failure to consider the effects of a crest vertical curve during design leads to a deeper haunch which can:

    a. Increase the dead load on the girders and subsequently create additional dead load stress or deflection that the girder was not designed for.

    b. Increase the height of the haunch which probably was not planned for by the Contractor and is often discovered after the girders are erected. This often leads to conflicts and discussions about payment and time requirements for additional work. It may require ordering new forming materials.

2. More camber than predicted or failure to consider the effects of a sag vertical curve during design leads to a thinner haunch which can result in:

    a. The inability to attain the minimum concrete bearing thickness under the ends of the precast concrete deck panels when the panels are used for deck forming.

    b. Girders projecting into the deck, reducing the deck thickness over the girders and complicating the support of deck forming systems.

3. More camber than predicted due to:

    a. The fabricator failing to support girder segments stored in the yard at the bearing seat locations at the end of the girders, or

b. The fabricator failing to weight the girders down, when there is an especially long period between girder fabrication and erection.

See the standard note on CDOT's prestressed girder worksheets for more information on the remedial action required by the Contractor to prevent excessive camber growth (B-616-BT,BX,SL, and U).

4. More or less camber than predicted due to bearing seats constructed at an elevation lower or higher, respectively, than that shown in the plans. As specified in subsection 601.12(l) of the Standard Specifications,– the Contractor shall provide an as constructed survey of abutments and piers prior to girder erection. Conducting this survey is important to predicting problems with haunch depth and allowing for any necessary adjustments prior to girder erection.

When problems arise, discuss the options with the Contractor, the bridge designer, the roadway designer, and the Area Engineer.

Options that may be considered:

1. Raising or lowering the grade of the bridge deck and approach roadway to accommodate the actual girder cambers, if possible.

2. Reducing the bearing thickness under the precast panels by using a grout as the panels are placed.

3. When metal stay-in-place deck forms are used, letting the girder project up into the deck and reduce the clearance between the bottom mat of steel reinforcement and the girder. In some cases they may sit directly on the girder.

4. When precast box girders are placed side by side, there can be differences in camber between adjacent girders. This can result in a thinner slab or thicker slab than required on the plans at various locations and the clearance between the reinforcement mat and the tops of the girders will vary. This will require variable height chairs for reinforcement support.

601.7.3 Finish and Placement Considerations

To provide a smooth, uniform deck finish, it is important to balance the placement and finishing operation with the delivery of a uniform concrete mix. The delivery rate should be governed by the quantity of concrete that the Contractor's force and equipment can properly place and finish. The rate of placing and finishing should never be adjusted to accommodate a faster delivery rate. A proper balance will minimize frequent stops in the finishing operation, which usually creates humps in the deck. In addition, pay particular attention to slump and air content, because these factors greatly influence mix workability and consistency.

601.7.4 Concrete Placement Considerations

601.7.4.1 Before Placement

Consider the following guidelines before the concrete bridge deck pour begins:

1. Pre-Pour Conference. Verify that the Pre-Pour Conference has been held (see 601.7.1). Review the conference minutes, and check that the minutes have been updated, as needed, before each pour.

2. Temporary Traffic Control. Check that all provisions for protecting vehicle and pedestrian traffic have been adequately addressed.

3. Safety. Check that all safety items including handrails and toe rails are installed properly to protect workers and the traveling public.

4. Reinforcing Steel. Check the reinforcing steel for compliance immediately prior to the concrete pour.

5. Deck Machine Support. Verify that the deck machine is properly supported beyond the edge of the bridge deck.

6. Finishing Equipment. Verify that the screeding and finishing equipment has been checked for trueness. See Section 601.7.5 for additional information on finishing bridge decks.

7. Dry Run. Monitor the dry run of the finishing machine to ensure that the required thicknesses and clearances will result.

601.7.4.2 During Placement

Consider the following guidelines during the placement of bridge deck concrete:

1. Reinforcing Steel. Randomly check and document clearances of reinforcing steel.

2. Mortar Roll. Check for the proper quantity of mortar rolling ahead of the screed. A loss of roll will usually create a low spot, which will lack good consolidation.

3. Vibrators. Check that mechanical vibrators are being properly used to adequately consolidate the concrete.

4. Hand Work. Monitor the hand work used during the operation. Hand work should be kept to a minimum.

5. Slab Thickness. Check slab thickness for compliance using the stabbing method.

6. Finishing Machine. Verify that the finishing machine is providing a uniform, sealed surface finish with minimal ridges and voids. See Section 601.7.5 for additional information on finishing bridge decks.

7. Water. Ensure that the quantity of water applied for the purpose of finishing is the minimal required and that application is performed using an approved fog spray.

8. Slab Surface. Before the concrete takes its initial set, check the deck slab for irregularities, and verify that the Contractor is performing straight-edge testing, as specified. Ensure that the deck surface conforms to the requirements for pavement smoothness.

9. Joints. Monitor the operation to ensure that joints are properly constructed at the correct location. Where expansion joints are installed, consider the following:

    a. Angles. Angles must be accurately set with respect to cross-section, grade, and curbing.

    b. Anchor Bars. Check that anchor bars are correctly set and attached to angles.

    c. Compression Joint Sealer. Verify that the compression joint sealer is installed in conformance with specified requirements.

    d. Finger-Type Expansion Joint Devices. Where designated, check the vertical and horizontal alignment of the devices, and ensure that they are installed parallel to grade without lateral contact between fingers.

601.7.4.3 Bond of Cast-in-Place Concrete Deck to Precast Elements

The top surface condition of precast prestressed concrete girders and deck panels will affect the bond of cast in place concrete to these elements. Since this is a mechanical bond, factors such as surface roughness, dirt or debris on the surface, surface water, the substrate concrete's moisture condition, and consolidation of the deck concrete placed on the precast elements all can affect the bond. These factors also apply to the bond of thin concrete overlays to existing decks on bridge deck rehabilitation projects. Delamination at this interface can lead to deck failure.

When precast prestressed concrete deck panels, girders, or both are used, inspect these elements and have the Contractor remove all dust, dirt, water, and other

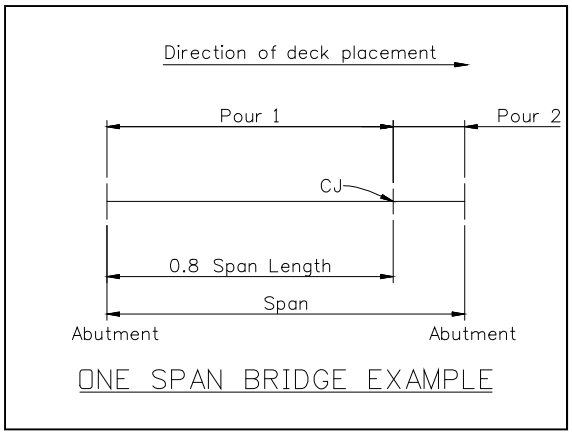
deleterious substances from the top surface prior to placing the deck concrete. The bond of the cast-in-place concrete to the precast members is dependent on the cement paste flowing into the surface irregularities (pores) of the substrate concrete. Thus, any material that covers or fills these small voids or pores will inhibit the bond of the concrete and could lead to delamination and premature failure of the deck.

601.7.4.4 Bridge Deck Construction Joints

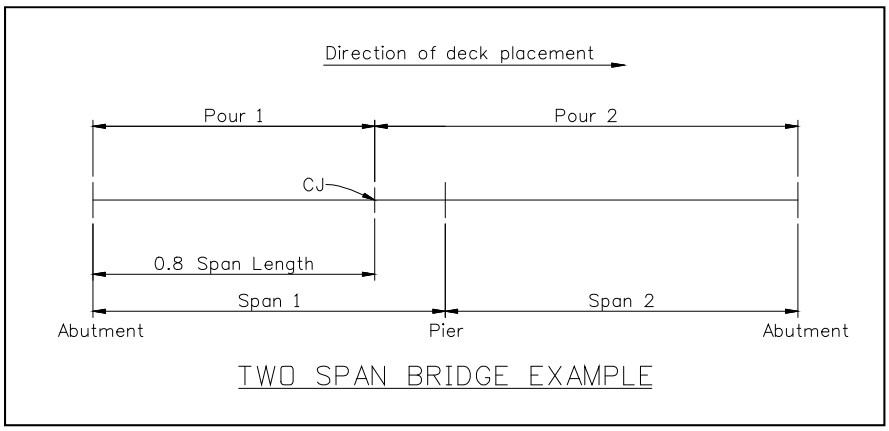
Construction joints (CJ) in bridge decks are used for various reasons, for example: to reduce the size of a deck placement or when an emergency bulkhead is needed to suspend a large deck pour. Ideally, construction joints should be located to allow the girders in a span to deflect and the ends to rotate under the weight of the entire deck. When CJ are not placed at correct locations, girder end rotation and deformation are restrained by the hardened concrete. Therefore, in the process of placing the deck on precast prestressed concrete girders, the ends of the girders in the next span should not be restrained until about 80% of the next span is placed. To approximate these conditions, a construction joint can be placed at about 80% ± 10% of the span length as shown in the following examples.

During a deck placement (See subsection 601.12 of the Standard Specifications), the leading edge of the fresh concrete should be kept parallel to the substructure so that the girders are loaded evenly during the placing and screeding operations. Construction joints should be placed parallel to the substructure. Construction joints should be cleaned of surface laitance, curing compounds, and other foreign materials before fresh concrete is placed against the surface of the joint.

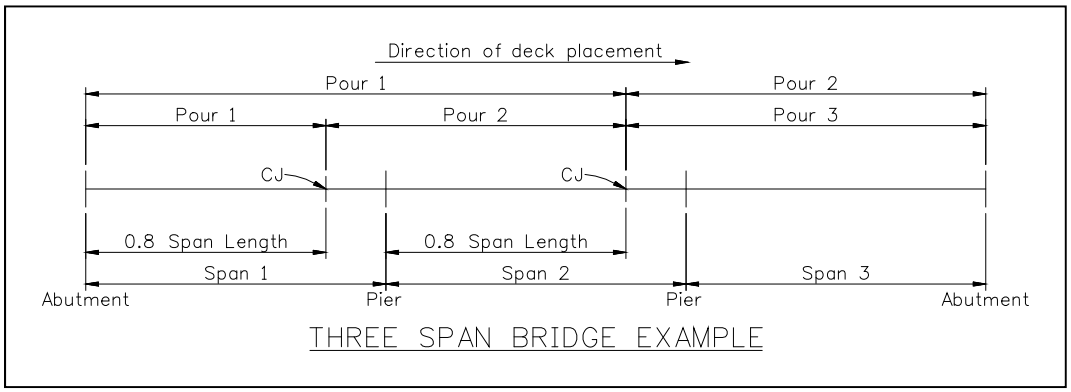
See Structural Concrete Pre-Pour Conference in Appendix A for the construction joint locations.



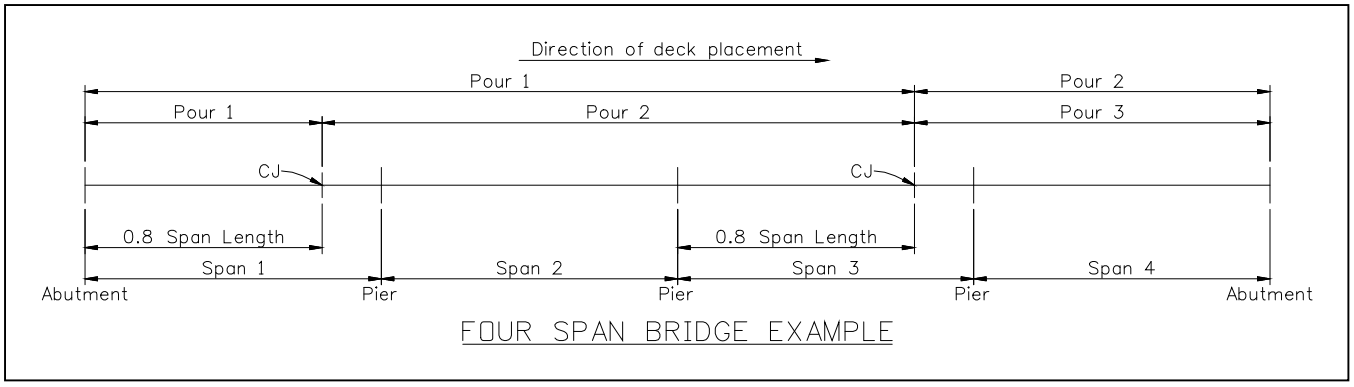
ONE SPAN BRIDGE EXAMPLE



TWO SPAN BRIDGE EXAMPLE



THREE SPAN BRIDGE EXAMPLE



FOUR SPAN BRIDGE EXAMPLE

601.7.5 Concrete Finishing Considerations

601.7.5.1 Before Finishing

The Department requires the use of self-propelled mechanical finishers for all concrete bridge decks. The mechanical finisher is usually supported by a rail support system that is attached to the bridge deck, which transfers the load to the outside girders. If improperly installed, the use of a rail support system on welded plate or wide flange girders can cause thin decks or thick overhang sections, primarily due to girder rotation and overhang settlement. To prevent this condition, adequate cross-bracing must be installed between the outside and intermediate girders. Where rail support systems are installed, check that the spacing of the rail supports is sufficient to carry the load of the finishing operation without causing undue girder rotation or overhang settlement. In addition, check that the rail supports have been properly adjusted for the required alignment and grade. This adjustment check is typically performed using a string line to verify the grade at various locations along the deck while the mechanical finisher is moved into position.

601.7.5.2 During Finishing

Consider the following guidelines during the finishing of concrete bridge decks:

1. Hand Finishing. Because the use of self-propelled mechanical finishers is required for all concrete bridge decks, CDOT expects a higher quality surface in terms of smoothness and uniformity and a strict conformance to designated lines and grades. Therefore, hand finishing should only be permitted where it is necessary to remove surface irregularities such as:

    a. holes and depressions resulting from test procedures,
    b. surface tears caused by the screed, and
    c. minor incidental deformities.

2. Plastic Turf Drag. When the final riding surface is the concrete surface a plastic turf shall be dragged longitudinally over the full width of bridge deck after a seamless strip of burlap or other approved fabric has been dragged longitudinally over the full width of bridge deck to produce a uniform surface of gritty texture. Verify the proper dragging of a seamless strip of turf over the deck surface. Check that the drag material is maintained clean and free from encrusted mortar.

3. Grooving/Surface Texturing. Where designated for decks that will not receive a bituminous overlay, verify that the deck surface is properly textured.

601.7.5.3 After Finishing

Consider the following guidelines after the finishing operation:

1. Surface Check. Before the concrete takes its initial set, verify that all joints are tested with a straight edge and properly corrected. Check the entire slab surface for trueness, as needed, using a string line or a straight edge.

2. Joint Edges. Verify that joint edges are rounded with an approved radius hand tool, and that any tool marks on the adjacent surface are removed by brooming.

3. Surface Protection. Ensure that the finished surface is properly protected from damage due to traffic.

601.7.6 Concrete Curing Considerations

Immediately after the concrete is placed and finished, the deck will be cured and protected in accordance with specified requirements, including any *Special Provisions*. Consider the following guidelines:

1. Curing Method. Verify that the method of curing has been approved and is following immediately behind the finishing operation without damaging the designated surface finish.

2. Deck Cracking. Cracks allow moisture and de-icing chemicals to penetrate the deck slab, and extensive cracking may affect the durability of the structure. Crack width is usually measured by inserting a wire gauge in the cavity. Contact the Staff Bridge Branch at (303) 757-9309 where crack widths of 0.02 inches or larger are observed. Where crack widths greater than 0.035 inches are found, ensure that the Contractor immediately repairs the cracks in accordance with subsection 601.15(i) of the *Standard Specifications*.

601.7.7 Approach Slabs

For joint or tied approach slabs, use the guidelines for bridge deck construction to inspect formwork, reinforcement, mix production, concrete placement, and the finishing operation. The inspection of approach slabs should be performed with the same diligence as for the bridge deck.

SECTION 602
REINFORCING STEEL

602.1 GENERAL

The design strength of reinforced concrete structures cannot be fully realized unless the specified reinforcing steel is placed as designated in the Contract. The type and size of reinforcing steel; bar location, spacing, and clearance; and the bond developed between the concrete and the bar surface are critical factors to consider during inspection.

602.2 INSPECTION GUIDELINES

602.2.1 Before Construction

Consider the following guidelines before work involving reinforcing steel for structural concrete and concrete bridge decks begins:

1. Mill Test Reports. Upon delivery, compare bar bundle tags with Mill Test Reports to ensure that bar size, material grade, and coating meet specified requirements. Spot check bar identification markings for proper steel grade.

2. Certificates of Compliance. Verify that Certificates of Compliance have been received.

3. Bar List. Verify that the Contractor's Bar List conforms to the Contract with respect to bar size, quantity, and bending details.

4. Bar Condition. Check reinforcing bars for mud, oil, rust, and detrimental scale. Concrete will only bond with a clean bar surface. In addition, check bars for straightness, and ensure that they are protected from damage. Ensure that any damage to epoxy coating is adequately repaired.

5. Bar Bending. Become familiar with the bar bending details. Where field bending is required, ensure that the proper procedures are being followed, and verify if the application of heat is permissible.

6. Additional References. As needed, consult the *Concrete Reinforcing Steel Institute Manual of Practice* for recommended placement practices.

602.2.2 During Construction

Consider the following guidelines during the placement of reinforcing steel for structural concrete and concrete bridge decks:

1. Bar Alignment and Spacing. Check that bar alignment and spacing conforms with the Contract. Verify that all bars and other embedded items are correctly placed so that the concrete can be adequately consolidated.

2. Bar Clearance. Check bar clearance and depth of concrete cover for compliance. Ensure that the proper minimum clearance is obtained between the top mat of deck bars and the surface of the concrete.

3. Bar Splicing. Check bar splices to ensure that they are the proper length for the type and size of bar placed. Note that epoxy-coated bars require longer splices than uncoated bars. Verify that bar splices are correctly staggered.

4. Bar Supports. The type, number, and spacing of supports must be adequate to minimize sagging, displacement, and damage of reinforcing bars. Plastic or epoxy-coated supports are required for epoxy-coated bars.

5. Securing of Bars. To minimize displacement, bars must be securely tied. Verify that the bars are tied at all intersections or as otherwise designated. For bridge decks, check that the upper mat of bars is properly tied to the lower mat. Do not permit welding of bars except as noted in the Contract. Note that the use of coated ties is required for epoxy-coated bars.

6. Post-Tensioned Concrete. Adjustments made to reinforcement in post-tensioned concrete require approval by the Project Engineer.

7. Optional Form 279 (see Appendix B) can be used to document quantities of reinforcing steel for payment purposes.

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SECTION 603
CULVERTS AND SEWERS

603.1 GENERAL

The acceptability of culvert and sewer installations depends on the extent to which material and construction conform to the Contract. Many factors must be considered during inspection, including:

1. structure alignment, elevation, and grade;
2. alignment of upstream and downstream channel, where applicable;
3. camber and end treatments;
4. bed preparation and condition and uniformity of bedding material;
5. backfilling method and material (see Section 206); and
6. embankment material and construction.

Culvert and sewer designs are typically based on the results of preliminary data collection and field investigations. Although adequate designs will be specified, it is not uncommon to discover situations that were not found during the field investigation or considered during design. Project Engineers and Project Inspectors should continuously monitor the construction operation and be watchful for situations that may warrant consideration of complete or partial redesign work.

603.2 INSPECTION GUIDELINES

603.2.1 Before Construction

Review the Contract for the location, type and size of culverts, and bedding required. Consider the following:

1. Pipe Material. Upon delivery, verify receipt of proper material certifications. Inspect pipe and coating material for cracks, defects, and damage that may have occurred during shipping. Verify that smooth lined pipe is being used for irrigation and storm drain systems. Check pipes for proper:

    a. class, type, and size;
    b. thickness, gauge, and schedule;
    c. coating and lining, and
    d. lengths of sections.

2. Safety Considerations. Review the safety requirements for trenching operations and confined space entry. Do not enter manholes, inlets, vaults, trenches, or other confined spaces without taking the proper safety precautions.

3. Staking. Check that manholes, inlets, and pipes have been properly staked. Verify that staked locations and elevations are appropriate for existing field conditions.

4. Utilities. Verify that the Contractor has located all underground utilities. Ensure that all conflicts have been resolved.

603.2.2 During Construction

Consider the following guidelines during the construction of culverts and sewers:

1. Grade Stakes. Frequently check grade stakes for errors.

2. Excavation. Know the requirements for pipe installation in new embankments. Check excavation for correct depth, width, and alignment. Verify that the trench bed has been properly graded and compacted. Where rock is encountered during excavation, enforce the minimum depth of removal below grade.

3. Bedding. Check the type and depth of bedding for conformance.

4. Placement. Verify that pipe placement begins at the downstream end. Check that the entire length of pipe rests in contact with the bedding material at the proper flow line. Perform frequent alignment and elevation checks. Be exacting on sanitary sewer grades and flow-line smoothness.

5. Pipe Jacking. Where pipe jacking is required, verify the proper proportioning of the grout mixture. Check the roadway surface for signs of upheaval or failure, and require immediate corrective action. Where jacking is designated, proposed alternative methods require written approval by the Project Engineer.

6. Pipe Joints. Check the direction of joint laps for conformance. The bell or grooved end of concrete pipe or the outside lap of metal or plastic pipe must be placed in the upstream direction. Check that joints are properly sealed or banded and snug. Verify that joints are grouted, where required.

7. Lift Holes. Ensure that all lift holes are properly plugged.

8. Pipe Damage. Check in-place pipe for damage prior to backfilling and again before accepting the work. Ensure that any damage to coating or lining is properly repaired.

9. Pressure Testing. Prior to backfilling, check that storm drain and sewer lines have been pressure tested for water tightness as specified.

10. Backfilling Operation. Check the backfill material for conformance. Verify that the backfill material is being placed and fully compacted in lifts of the required thickness. This operation must be performed equally and simultaneously on both sides of the pipe. Note that the required compaction must be obtained prior to placing successive lifts. Observe the operation to ensure that the method of compaction does not cause pipe damage or displacement.

603.2.3 After Construction

Prior to acceptance, verify that the pipe is properly cleaned and in good repair. Trenches in roadways must be properly resurfaced before opening to traffic.

SECTION 604
MANHOLES, INLETS, AND METER VAULTS

604.1 GENERAL

Section 604 of the *Standard Specifications* governs the material and construction requirements for concrete manholes, inlets, and meter vaults. Unless the type is specifically designated, these items, or portions thereof, may be precast or cast-in-place. See Section 601 for information on reinforced concrete structures and bridge decks, and Section 602 for information on reinforcing steel.

604.2 INSPECTION GUIDELINES

604.2.1 Before Construction

Prior to starting work on drainage structures, review the Contract. Verify existing drainage conditions, and check that the structures are staked at the proper location and elevation. Consider the following:

1. Safety. Review safety requirements for trenching operations and confined space entry. Do not enter manholes, inlets, vaults, trenches, or other confined spaces without taking the proper safety precautions.

2. Precast Structures. Upon delivery of precast structures, verify receipt of proper material certifications. Check the type and dimensions of precast items for conformance. Where applicable, check the spacing of stair rungs for compliance. Pay particular attention to defects and damage that may have occurred during shipping.

3. Cast-in-Place Structures. Where cast-in-place structures are used, check forms and reinforcing steel for proper condition and dimension. Check the Contractor's Bar List.

604.2.2 During Construction

Consider the following during construction of manholes, inlets, and meter vaults:

1. Pipe Invert and Flow Line. Check pipe invert and flow-line elevations.

2. Manholes. A smooth flow line must be provided between manholes and pipes. Check that a good union with pipes is achieved. Where precast sections are used, check that neat joints are constructed. Verify the proper use of brick and mortar to make field adjustments.

3. Inlets. Check for proper dimension, formwork, concrete placement, and curing.

604.2.3 After Construction

Verify that all drainage structures are cleaned of any debris prior to accepting the work. Consider the following:

1. Grates. Check grates for acceptability with respect to type, dimension, orientation, and galvanization.

2. Manhole Covers. Check the type and dimension of manhole covers for compliance. Where located within pavements, check the slope and elevation of covers.

3. Mortar/Grouting. Verify that any needed mortar repairs and grouting around pipe are properly performed.

SECTION 605
SUBSURFACE DRAINS

605.1 GENERAL

Subsurface drains are installed to remove water from the roadway prism. Several different types may be designated. Underdrains may be installed to lower a high-water table, to intercept and dispose of water seeping into the roadway from sources outside the roadbed, or to intercept and control water seepage from the backslope. Edge drains are typically installed parallel to and near the edge of pavement to intercept water that seeps through the pavement surface courses.

605.2 INSPECTION GUIDELINES

605.2.1 Before Construction

Various types of pipe material may be designated for subsurface drainage. Know the locations where the designated types of pipe are to be installed, and consider the following:

1. Safety. Review safety requirements for trenching operations. Do not enter trenches or other confined spaces without taking the proper safety precautions.

2. Material Considerations. Upon delivery, verify receipt of proper material certifications. Check pipe materials for proper type (e.g., perforated, non-perforated), material grade, schedule, and diameter. Where corrosion resistant pipe is designated, pay particular attention to the specified material requirements. Check filter fabric material for compliance.

3. Staking. Check the location and elevation of staking for conformance.

4. Field Adjustments. Be alert for adjustments to underdrain locations that may be performed to enhance the functionality of the system.

605.2.2 During Construction

During the construction of subsurface drainage systems, consider the following guidelines:

1. Trench. Check trench location and shape for compliance. Perform grade checks regularly.

2. Bedding. Verify that the proper type of bedding material is being used. Check the depth of bedding for conformance.

3. Perforated Pipe. Verify that perforated pipe is being used at the proper location and that the pipe is being placed correctly with regard to the orientation of the perforations.

4. Joints. Verify that pipe sections are being securely fastened using the proper method of connection (e.g., connecting bands).

5. Filter Fabric. Verify that the proper type of filter fabric is being correctly placed. Watch for tears and contamination of the fabric material.

6. Filter Material. Check that the filter material is clean and uncontaminated. Ensure that the filter material is corrected where contamination such as dirt, clay, and vegetation is observed.

7. Backfilling. Verify that the backfill material is as specified and the backfilling operation does not damage the filter fabric.

SECTION 606
GUARDRAIL

606.1 GENERAL

Where guardrail and concrete barrier rail systems are warranted, they are installed to prevent errant vehicles from leaving the traveled way and moving into fixed objects, steep slide slopes, and opposing traffic. Different types of designs exist to address specific conditions.

606.2 INSPECTION GUIDELINES

606.2.1 Before Construction

See Section 210.2.1 and consider the following guidelines before installing guardrail and concrete barrier rail systems:

1. Materials Considerations. Check the type of rail system for conformance, including rail sections, hardware, and posts.

2. Location. Verify stake locations. Check lateral offset, longitudinal length, termini location, post spacing, rail curvature, parabolic flares, and trench width, where applicable.

606.2.2 During Construction

See Section 210.2.1 and consider the following guidelines during the construction of guardrail and concrete barrier rail systems:

1. Guardrail Post Installation. Unless designated otherwise, guardrail posts may be driven in place, set in dug holes, or set on a concrete base. Check post spacing, elevation, and alignment regularly. Where posts are driven, watch for irregular movement, possibly indicating an underground obstruction. Check driven posts for damage (e.g., distortion, burring). Where posts are set in dug holes, watch for overdrilling and require backfilling and compaction as needed to adjust depth and provide a firm foundation. After setting, verify that backfill material is placed and compacted in layers around posts. Check that all posts are set firm and plumb and that they are within tolerance of the required alignment and elevation.

2. Cutting of Wood Posts. Where wood posts are cut in the field, verify that the exposed surface is properly treated.

3. Installation of Rail Sections. Check that all fittings and metal plates are securely placed in the correct position. Check that rail sections are properly lapped in a smooth, continuous installation. Check that all bolts are drawn tight. Check the rail height and rail face (i.e., with respect to lateral offset and alignment) for conformance and any needed adjustment.

4. Concrete Barrier Rail. Concrete barrier rail may be either precast, slipformed, or cast-in-place. Check the trench lines and grades for conformance and ensure that the base is properly compacted and watered before the barrier is placed. At transitions, check connection hardware for conformance and ensure that it is properly installed. Verify that cast-in-place and precast barriers are given a Class I finish and that slipformed barriers are given a vertical broom finish. Check that lift holes are properly filled and sealed. Ensure that the barrier is checked with a straightedge in the longitudinal direction and corrected where out of tolerance.

5. Terminals and Transitions. Pay particular attention to the construction details for end treatments, median terminals, and rail transitions (e.g., post type, post spacing, number of rail sections, lapping direction, splices, method of connecting, fastener type, reflector tab location). Specialized hardware and designs are commonly used at these locations and require close inspection prior to acceptance.

6. Dissimilar Metals. Where dissimilar metals contact each other, ensure that the surfaces are separated by an approved protective coating.

7. Traffic Considerations. Where the facility will be maintained open to traffic, it is good construction practice for the installation of rail sections to closely follow the installation of guardrail posts. At the end of the workday, check to ensure that the termini of exposed rail sections are treated as specified.

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SECTION 607
FENCES

607.1 GENERAL

Fences are generally placed within the CDOT right of way.

607.2 INSPECTION GUIDELINES

607.2.1 Before Construction

Consider the following guidelines before the installation of fencing begins:

1. Agreements. Check the right of way agreements for special fence requirements.

2. Material Considerations. Know the required type of fencing and gates. Check material certifications for compliance and document material condition. Check the weight, length, and coating of steel posts and the preservative treatment, straightness, and size of wood posts for acceptability. Verify that barbed and woven-wire fabric rolls are tagged with the required information. Check hardware for conformance. Concrete used for fence installation will comply with the requirements of Section 601 of the *Standard Specifications*. The use of field-mixed concrete requires previous approval.

3. Staking. Check that the staked alignment is approximately six inches inside CDOT right of way unless otherwise specified and that the post spacing is properly marked.

4. Temporary Fence. Verify if temporary fence is required (e.g., stock control, pedestrian safety, wetlands protection).

607.2.2 During Construction

Regularly check line, grade, and post spacing, and consider the following guidelines during the installation of fencing:

1. Posts. Check that posts are set at the specified depth and elevation. Verify that metal posts are set to face the correct direction.

2. Corner and Line Brace Posts. Check for properly located corner and line brace posts. Verify that line braces have been installed where needed for grade changes.

3. Concrete Curing. Concrete must be allowed to set sufficiently around posts and braces. Verify that the concrete has been permitted to gain the required strength before the fabric or wire is stretched.

4. Wire/Fabric. Know which side of the post the fence fabric or wire is to be installed. Check that the fence fabric or wire is properly stretched and fastened.

5. Sound Barrier. Where sound barriers are installed, verify that components are tightly abutted.

6. Vegetation Protection. Verify that plastic fencing is installed around vegetation that is to be protected.

607.2.3 After Construction

Ensure that no advertising tags or signs are placed on fencing or within the right of way.

SECTION 608
SIDEWALKS AND BIKEWAYS

608.1 GENERAL

Sidewalks and bikeways will either be concrete or bituminous paved facilities, as designated in the Contract. They are constructed on a solid foundation, typically bed course material, that has been properly graded and compacted.

608.2 INSPECTION GUIDELINES

608.2.1 Before Construction

608.2.1.1 Subgrade

Check the cross-slope, elevation, and alignment of the subgrade for compliance. Where bed course material is required, ensure that the required type and depth of material is properly placed, shaped, and compacted. Check for soft spots, and enforce the Contract provisions with respect to needed repairs. Do not permit construction on a frozen base. Freeze-thaw cycles tend to loosen a compacted base. Recheck base density after freezing and thawing.

608.2.1.2 Curb Ramps

Review the location and construction details of curb ramps that are designated in the Contract. Pay particular attention to the slope and surface finishing requirements of curb ramps. Detectable warnings are typically required to meet ADA requirements, and field adjustments may be needed to meet slope requirements. Review the locations of drainage structures to ensure that no new drainage structures are aligned with curb ramps.

608.2.1.3 Concrete Materials and Equipment

Where concrete will be used for sidewalks and bikeways, check that the concrete complies with the specified class and that the mix design has been approved (see Section 601). Check for concrete coloring agents if required for curb ramps. Ensure that the specified sampling and testing requirements are being met. Where reinforcing steel is required, check to ensure that the reinforcement is of the proper type and size (see Section 602). Check the type, number, and condition of equipment that will be used to place, consolidate, finish, and cure concrete. Where forms are used, ensure that they are in good condition and of the proper type and dimension. Where slipforming is used, check the slipforming equipment for acceptability. Ensure that the Contractor has adequate materials on hand to properly cure and, as needed, protect the concrete during cold weather.

608.2.1.4 Bituminous Materials and Equipment

Where bituminous materials will be used for sidewalks and bikeways, check materials for conformance and that the mix design has been approved. Ensure that the specified sampling and testing requirements are being met. Check the type, number, and condition of equipment that will be used to place and compact the mix. Where it is impractical to use standard paving equipment, ensure that the Contractor's proposed alternative methods have been approved. See Section 401 for additional guidance.

608.2.2 During Construction

608.2.2.1 Concrete Sidewalks and Bikeways

Consider the following guidelines during the construction of concrete sidewalks and bikeways:

1. Forms. Where forms are used, check that they are set to the proper line and elevation with respect to grade stakes and that they are firmly staked into

position. Pay particular attention to how forms are set with respect to locations of inlet sections, curb ramps, and driveways, and require adjustments where needed. Ensure that forms are set to accommodate drainage. Prior to placement of concrete, verify that forms are treated with an approved release agent.

2. Reinforcement. Where reinforcing steel is required, check spacing, clearance, and supports for acceptability.

3. Moistening of Subgrade. Ensure that the subgrade has been thoroughly moistened before the placement of concrete.

4. Placement and Consolidation. Check for the proper placement and consolidation of concrete. Where slipforming is used, check that the grade has been trimmed to the correct line, cross-slope, and elevation. Check grade stakes, grade line, and electronic controls for proper adjustment, including locations of inlet sections, curb ramps, and driveways. Regularly check alignment, elevation, and cross-slope during slipforming, and ensure that the extruded section conforms to typical section, especially the pan (i.e., spill or catch).

5. Joints. Check that transverse expansion joints and saw cuts are located and constructed properly. Joint types and locations should match those in adjacent concrete. Ensure that approved expansion material is placed to full depth in the joint reservoir. Verify that edging is performed where required. Construction joints shall be formed around all appurtenances, such as manholes and utility poles that extend through the sidewalk.

6. Finishing. Check the acceptability of the surface finish. Pay particular attention to texturing requirements (e.g., curb ramps). The finishing operation ideally should be accomplished without the use of additional water.

7. Curing. Verify that concrete is properly cured for the specified curing period. Where curing compound is used, check that it is of an approved type and that the rate and time of application are acceptable. Ensure that the Contactor complies with the provisions for concrete protection during cold weather.

8. Protection. Verify that the Contractor protects the concrete sidewalks and bikeways for the specified time period.

9. Form Removal and Backfill. Form removal and backfill must not be started until the concrete has reached sufficient strength to withstand damage. Ensure the edges are adequately shouldered. Watch for damage to the concrete during the backfill operation.

608.2.2.2 Bituminous Sidewalks and Bikeways

Check the alignment, elevation, depth, and cross-slope of the bed course material and ensure that it has been thoroughly compacted. Verify that the correct mix is being used. Where tack coat is specified, check that a proper type of bituminous material is being applied at the specified rate. Monitor the operation for proper mix placement and ensure that full compaction is being achieved. After construction, check that the edges are adequately shouldered. See Section 401 for additional guidance.

SECTION 609
CURB AND GUTTER

609.1 GENERAL

The treatment of the foundation and forms for curb and gutter systems greatly affects the quality of the final product. Substandard work generally produces curb and gutter systems that promote standing water and deterioration of the roadway structure.

609.2 INSPECTION GUIDELINES

609.2.1 Before Construction

Before construction begins, ensure that the base has been properly prepared (see Section 608.2.1.1). Where concrete curb and gutter is specified, check the concrete class and review Section 608.2.1.3 for additional materials and equipment considerations. Where bituminous curb is specified, verify mix design approval and that the curb machine is of an approved type. Review Section 608.2.1.4 for additional guidance.

609.2.2 During Construction

609.2.2.1 Concrete Curb and Gutter

Check that forms are rigidly braced at the correct line, grade, and depth. Require correction of any weakness found in formwork. Verify that forms have been set correctly to accommodate all drainage per typical section (e.g., pan constructed to spill or catch). Where reinforcement is required, check for proper type and placement. Watch for proper placement and consolidation of concrete. Check joints for proper type and location, including mortared joints where applicable. Check length of sections and finish of

joints upon form removal. Verify surface finish and timely application of curing compound. See Section 608.2.2.1 for additional guidance.

609.2.2.2 Bituminous Curb

Check the location and layout for compliance with the drainage requirements of the Contract. Monitor placement to ensure that the curb machine is forming a uniform and compact curb shape at the correct alignment. Ensure that the proper type and rate of tack are applied in only the area where curb is to be placed. Check for the proper application of a fog coat after the curb is placed. Know if the curb is to receive paint or seal, and check for a clean and dry surface. Verify that temperature requirements are met.

609.2.3 After Construction

Ensure that the Contractor takes adequate precautions to protect concrete from cold weather conditions. Verify that forms are not removed and the backfill operation is not begun until the concrete has gained sufficient strength to prevent damage from the operation. Upon removal of forms, inspect the concrete curb and gutter for honeycombed areas and require proper repair work to be performed.

SECTION 610
MEDIAN COVER MATERIAL

610.1 GENERAL

Median cover material will generally be comprised of a concrete, bituminous, or stone material. The quality of the finished product depends greatly on the attention given to ensuing a properly prepared base. Construction requirements for median cover material are specified in Section 608 of the *Standard Specifications*.

610.2 INSPECTION GUIDELINES

The inspection guidance provided in Section 608.2 generally applies to concrete and bituminous median cover. In addition, consider the following:

1. Herbicide Treatment. Prior to herbicide treatment, ensure that the Region Maintenance Noxious Weed Coordinator has been notified of the location and time of application. See Section 217.2 for additional guidance on herbicide treatment.

2. Pattern and Color. Check for the correct pattern and color of application.

3. Stone Material. Check for the correct type, size, and depth of stone material.

4. Plastic Sheeting. Where plastic sheeting is required, verify it is of the correct type and thickness.

5. Expansion Joint Material. Ensure placement is in accordance with the Contract.

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SECTION 611
CATTLE GUARDS

611.1 GENERAL

Cattle guards may be either precast or cast-in-place. The Contract will designate the location and type to be constructed. Each cattle guard must be constructed in accordance with the details shown in the Contract.

611.2 INSPECTION GUIDELINES

Cattle guards must be carefully constructed to the specified grade and cross-slope to provide a smooth riding surface and a well-drained facility. Ensure that bumps, ponding, and other errors in elevation are properly corrected. Consider the following guidelines:

1. Material Certification. Ensure that all required material certifications have been obtained and that they reflect proper materials.

2. Concrete Foundation. Ensure that the concrete foundation is placed, finished, and cured in accordance with the requirements of Section 601 of the *Standard Specifications*. See Section 601 for additional guidance.

3. Wings. Timber and steel materials that are used in wings of cattle guards must conform to the respective requirements of Section 508 and Section 509 of the *Standard Specifications*. Ensure that timber posts are the correct size and treated in accordance with specified requirements. Check steel for proper welding and painting.

4. Backfill. Ensure that backfill material is properly placed and compacted to the correct grade and cross-slope.

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SECTION 612
DELINEATORS AND REFLECTORS

612.1 GENERAL

Delineators and reflectors are supplemental traffic control devices that delineate the alignment of the roadway during hours of darkness and inclement weather. Delineators and reflectors are especially advantageous during inclement weather because they remain visible where the road is wet or covered with snow. Installation must always conform to Contract requirements.

612.2 INSPECTION GUIDELINES

612.2.1 Before Construction

Before delineators and reflectors are installed, consider the following:

1. Delineators. Know the type and color of delineators required, and ensure compliance with specified requirements.

2. Reflectors. Check reflectors for guardrail and concrete barrier for compliance with respect to type, color, and dimension. Verify that containers are marked with the CDOT pre-inspection stamp or that samples have been submitted to the Materials and Geotechnical Branch and found acceptable.

3. Condition. Inspect delineator and reflector materials for damage and reject as necessary.

612.2.2 During Construction

Consider the following guidelines during installation of delineators and reflectors:

1. Location and Spacing. Verify that delineators and reflectors are being laid out and installed at the correct location and spacing, especially with regard to curves and roadside obstacles. The Contract will generally designate spacing criteria in a tabular format.

2. Delineators. Delineator posts may be driven or set in drilled holes. Check for damage during installation, and ensure that posts are set stable and plumb. Check mounting height and lateral clearance for acceptability. Angular placement shall be according to Standard Plan S-612-1. Ensure that the proper number and color of reflectors are affixed to each delineator post.

3. Base Anchoring. Ensure the anchoring depth can be achieved. If the minimum anchor depth cannot be obtained, the anchor shall be embedded in concrete.

4. Reflectors. Verify that reflectors are properly mounted on guardrail and concrete barriers. Check the location and mounting height for acceptability. Ensure that the proper number and color of reflectors are installed. Pay particular attention to the direction and orientation of reflectors during installation.

SECTION 613
LIGHTING

613.1 GENERAL

The materials and construction requirements for lighting will be governed by the Contract and Section 613 of the *Standard Specifications*.

613.2 INSPECTION GUIDELINES

613.2.1 Before Construction

Before lighting work begins, consider the following:

1. Preconstruction Conference. If a lighting plan is included in the Contract, the Contractor is required to supply at the Preconstruction Conference a list of all material and equipment to be incorporated in the work. The Contractor must coordinate with the local utility company to ensure system compatibility and to plan for required utility connections and any needed utility relocations or adjustments.

2. Materials Considerations. Check the type, dimension, coating, and condition of all lighting materials including light poles, arms, luminaires, galvanized fastener hardware, breakaway bases, conduits, cables, pull boxes, and expansion fittings. Ensure that required material certifications have been submitted.

3. Screw-In Foundations. If screw-in foundations will be used, ensure that the required Soil Test Reports have been received from the Contractor and found acceptable. Screw-in foundations are permitted only for specific soil conditions. Check to ensure that all material certifications have been submitted. Know the manufacturer's recommended installation procedures.

4. Concrete Foundations. Where concrete foundations will be used, they may be either precast or cast-in-place. Check concrete materials for conformance. Check that foundation locations and dimensions conform to designated requirements, and ensure that a solid and properly compacted foundation subgrade is provided. See Section 503 for additional guidance.

5. Layout and Obstructions. Review the general layout of the work for acceptability, and verify that the Contractor has accounted for underground obstructions and overhead lines (e.g., power, telephone, cable television).

6. Conduit and Cable. The location of conduit runs will be established during construction with consideration to existing and future installations. Know the requirements for conduit placed under roadway sections. Know circumstances that require pull boxes (e.g., wire splices, conduit ends and angles). Know if jacking of conduit is required.

613.2.2 During Construction

Consider the following guidelines during the installation of highway lighting:

1. Screw-In Foundations. Where screw-in foundations are permitted, verify that the Contractor is following the manufacturer's recommended installation procedures.

2. Concrete Foundations. Where concrete foundations are used, ensure that they are properly poured or placed. Pay particular attention to reinforcement, curing, and backfill requirements.

3. Light Poles. Ensure that the Contractor installs light poles and luminaires in accordance with specified requirements and the manufacturer's installation guidelines. Check that light poles are set plumb at the correct location. Verify the proper installation and location of breakaway bases. Require that any coating damage is properly repaired.

4. Pull Boxes. Verify that pull boxes are being installed at the correct location and at the proper grade.

5. Trenches. Check trench depth and shape for compliance. Watch for obstructions. Ensure that the correct material and procedures are being employed for the backfill operation.

6. Jacking. Check the clearance from roadway of jacking pits to ensure the specified minimum is not encroached. Do not permit the use of water to aid jacking.

7. Expansion Fittings. Check that conduit expansion fittings are properly installed on bridges.

613.2.3 After Construction

Check backfilled trenches for settlement and the correct operation of lights at night prior to project acceptance. Check for tagging of all electrical conductors in boxes. Check that a plastic envelope containing the cabinet drawings, line diagram, luminaire schedule and list of all system components is mounted to the inside of the lighting cabinet door.

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SECTION 614
TRAFFIC CONTROL DEVICES

614.1 GENERAL

Traffic control devices must be installed in compliance with the requirements of the Contract. Contact the Region Traffic Engineer for any needed assistance. See Section 630 for guidance on temporary traffic control in construction zones.

614.2 HIGHWAY SIGNS

614.2.1 Before Construction

Before the installation of highway signs, consider the following guidelines:

1. Class III/Special Signs. Verify that the detailed layouts for Class III and special signs have been furnished to the Contractor.

2. Material Certifications. Verify that material certifications have been received.

3. Permanent Barricades. Verify if permanent barricades are required.

4. Timber Posts. Prior to installation, inspect timber posts for acceptability. Check the certified grading stamp on the posts for proper inspection agency, species, and grade (see Grade Stamps of Accredited Lumber Agencies in Appendix D).

5. Steel Posts. Check steel post certifications, welding, and coating for acceptability.

6. Hardware. Inspect fastening hardware prior to installation. Verify that bolt heads and washers match the background color of panels and legends, as appropriate. Check that anchor bolts and washers are galvanized.

7. Sign Location. Inspect staked sign locations for compliance to the Contract. Check for obstructions to sign visibility. When inspecting sign staking, consider placing signs behind guardrail where appropriate.

8. Sign Panels. Check for closure strip on vertical seams. Verify that the back side of all panels is stamp dated. Verify if masking of sign legends is required.

614.2.2 During Construction

Verify that highway signs are installed in accordance with the Contract and the *Manual of Uniform Traffic Control Devices*. Ensure that removal and installation of signs follow a logical sequence to maintain traffic safety.

614.2.2.1 Post Installation

Consider the following guidelines during highway sign post installation:

1. Footings. Ensure that concrete, reinforcing steel, and backfill for footings conform to specified requirements.

2. Posts. Check for correct type and size of posts. Verify if modifications to existing posts are required.

3. Plate Bolts. Check torque on breakaway plate bolts and fuse plate bolts.

4. Breakaway Assembly. Check ground level with reference to the top of the footing. Clearance of the breakaway assembly is critical. Check breakaway holes for spacing and diameter on six inch by six inch timber posts.

5. Vertical Alignment. Ensure that all posts are plumb.

6. Post Embedment. Verify that post embedment is proper for the post size.

614.2.2.2 Sign Panels

Consider the following guidelines during sign panel installation:

1. Illumination. Verify if sign illumination is required.

2. Sign Panels. Check for correct type and size of panels. Verify if modifications to existing sign legends are required. Inspect for cleanliness and general appearance.

3. Angular Placement. Inspect the angle of sign placement to the roadway for compliance.

4. Height and Clearance. Check for proper height above edge of traveled way and proper vertical and horizontal clearance of sign panel.

614.3 OVERHEAD SIGN STRUCTURES

614.3.1 General Considerations

Overhead sign structures have a substructure component constructed of reinforced concrete, and a superstructure component typically constructed of structural steel. In most cases, the substructure is a drilled caisson with anchor bolts that project from the top of the foundation to connect with the superstructure. Drilled caissons are designed to provide support for the overhead sign from structurally stable soil. It is essential that the anchor bolts are accurately located, have the proper orientation, and project the specified length from the top of the foundation. It is important to examine the proposed overhead sign location for acceptability and inspect the soil conditions to ensure they are as described in the Caisson Drilling and Installation Notes in the Contract.

614.3.2 Shop Drawings/Fabrication Inspection

Shop drawings are required for sign structures. The Project Engineer will send the drawings to the Staff Bridge Branch according to Section 105.2.3. Upon receipt of the drawings, the Staff Bridge Branch will forward them to the Project Structural Engineer for review. Once reviewed and accepted, the drawings will be returned to the Staff Bridge Branch for distribution to the Fabrication Inspector and Project Engineer. Because the Fabrication Inspectors only perform random inspections, upon receipt of the reviewed drawings, the Project Engineer will perform a thorough field inspection of the fabricated structure and report the fabrication's acceptability on CDOT Form 157 – Field Report for Sample Identification or Materials Documentation. The Project Inspector must have a thorough understanding of shop drawings, and the drawings must be readily accessible at all times. Whenever the Contractor is working, the Project Inspector should actively monitor erection and assembly to ensure compliance and immediately report significant problems. Significant problems warrant stoppage of work until the structure's design engineer can review the situation and evaluate solutions. Disassembly may be necessary.

614.3.3 Substructure Considerations

Before construction, ensure that the ground surrounding the substructure is well-drained and that the overhead sign will have a minimum vertical clearance required above the finished roadway surface. The inspection guidance provided in Section 614.4.3 for traffic signal substructures is also applicable to overhead sign substructures. Consider the following additional guidelines:

1. Anchor Bolts. Ensure that anchor bolts are accurately located, have the proper orientation, and project above the top of the drilled caisson concrete the specified length. For bridge type overhead signs, verify that anchor bolts are placed such that the distance between drilled caissons, as referenced between the centerline of anchor bolt groups, complies with that specified on the shop drawings.
2. As-Constructed Survey. The Contractor is required to perform an As-Constructed Survey of the substructure as soon as practical after it has been completed. The

requirements for the As-Constructed Survey are defined in the notes on the plan sheets for the overhead sign.

614.3.4 Superstructure Considerations

Bolted connections are used to connect the superstructure to the substructure and to fasten structural elements within the superstructure itself. Bolts must be tightened as specified without gaps between connection plates and without overtightening. Consider the following during erection of overhead sign structures:

1. Bolt Tightening. Verify that bolts in field splices are tightened in an incremental and progressive manner. This must be performed while the splice connections are not carrying load. To create this no-load condition, a crane will be necessary to lift fabricated components during tightening.

2. Overtightening. Do not permit the overtightening of bolts to close non-designated gaps or where such action will distort steel components.

3. Adjustment and Leveling. Once erected, the anchor nuts and leveling nuts may require adjustment to level the sign. When assessing the need for leveling, no external support should be attached to the superstructure; however, during adjustment, a crane will be necessary to lift the superstructure. Verify that the leveling nuts are in contact with the base plate before releasing the overhead sign from the crane and tightening the anchor nuts.

4. Field Welding. Unless otherwise designated, field welding is not permitted.

614.4 TRAFFIC SIGNAL SYSTEMS

614.4.1 General Considerations

The supports for traffic signals have a substructure component constructed of concrete, a superstructure component constructed of structural steel, and an electrical system component. The substructure is designed to provide support from structurally stable soil. It is important to examine the proposed location for acceptability and inspect the soil conditions to ensure they are as described in the notes in the Contract. The following types of support systems are typically installed for traffic signals:

1. Span Wire. In span-wire installations, the strain pole is typically placed in a drilled hole, and concrete is poured around the pole for support. Span wire is then strung between the poles once the concrete has hardened.

2. Mast Arm. In mast-arm installations, the substructure is typically a drilled caisson with anchor bolts projecting from the top of the caisson. It is essential that the anchor bolts are accurately located, have the proper orientation, and project from the top of the caisson the specified length. The pole of the superstructure is connected to the anchor bolts of the substructure using bolted connections. Bolted connections are also used to connect the mast arm to the pole of the superstructure. It is important that all bolts are tightened as specified without overtightening and without gaps or spaces between connection plates.

614.4.2 Shop/Working Drawings

The type of drawing submittal necessary is specified on the traffic signal plan sheets.

614.4.3 Substructure Considerations

614.4.3.1 Before Construction

Thoroughly review the Contract and consider the following before construction of the substructure begins:

1. Soil. Verify that the soil surrounding the substructure location is well-drained. Bogs and sloughs are undesirable locations, especially where the lower portion of the superstructure will be in a wet or frequently moist environment. Prompt notification is required if such conditions are found to ensure that the design engineer can consider alternatives to resolve the problem.

2. Vertical Clearance. Verify that the proposed location will accommodate the minimum required vertical clearance above the roadway surface. Provide immediate notification if encroached, because the design engineer will need to evaluate alternatives such as relocating the substructure or raising its elevation.

3. Survey References. Verify that the Contractor has established adequate survey referencing to locate the center of the bolt circle and pole. Multiple survey reference points are preferred.

4. Utilities. Verify that the Contractor has staked known utility locations, resolved utility conflicts, and coordinated any needed adjustments or relocations.

614.4.3.2 During Construction

Section 503 provides inspection guidance that is applicable to the construction of traffic signal substructures. Consider the following additional guidelines:

1. Drilling Auger. Check the auger diameter used for boring the foundation hole for acceptability.

2. Drilling Operation. During the drilling operation, inspect the soils and provide immediate notification of any discrepancies with the soil notes in the Contract so that the design engineer can assess the situation and consider any needed alternatives. Check the depth of the hole of compliance, and verify that all loose material is removed. On span-wire installations, ensure that crushed rock is placed in the bottom of the hole as specified.

3. Reinforcing Steel. Verify that the reinforcing steel complies with the requirements of Section 602 of the *Standard Specifications*. Check bar arrangement and spacing for compliance. Do not permit the welding of reinforcing steel.

4. Concrete Placement. Verify that concrete material and placement, respectively, complies with the requirements of Section 601 and subsection 503.07 of the *Standard Specifications*.
5. Anchor Bolts. Verify that anchor bolts are accurately located, have the proper orientation, and project above the top of the drilled caisson concrete the specified length. Do not permit the welding of any attachments to anchor bolts.

6. Concrete Curing. Ensure that the concrete at the top of the drilled caisson is cured in accordance with subsection 601.13 of the *Standard Specifications*.

7. Cover Plate. Ensure cover plates are installed when the pole is erected to prevent intrusion by wildlife.

614.4.4 Superstructure Considerations

614.4.4.1 Span-Wire Installations

For span-wire installations, ensure that the strain pole and span wire are installed in compliance with the Contract. The span wire should not have more than a five percent sag after loading. Upon completion, ensure that the Contractor furnishes the requisite As-Constructed Plans.

614.4.4.2 Mast-Arm Installations

Bolted connections are used to connect the pole to the substructure and to connect the mast arm to the traffic signal pole. Bolts must be tightened as specified without gaps between connection plates and without overtightening. To ensure adequate vertical clearance, the traffic signal pole must be placed such that it is plumb when deflected by the load it carries. Verify that the leveling nuts are in contact with the base plate before the anchor bolt nuts are tightened, and ensure that anchor nuts and leveling nuts are tightened according to the notes in the Contract (see Section 614.3.4). Upon completion, verify that the Contractor furnished the required As-Constructed Plans.

614.4.5 Electrical Considerations

614.4.5.1 Before Construction

Verify that all Certificates of Compliance for materials have been received and checked and that the Contractor has furnished the required list of materials and equipment and schematic wiring diagram. Where applicable, verify that provisions have been met to properly coordinate new traffic signals with existing systems.

614.4.5.2 During Construction

The Region Traffic Engineer may be contacted for inspection assistance. During electrical work traffic signal systems, consider the following:

1. Conductors. Verify that the correct number of active and spare conductors has been provided. Ensure that the end of each run is taped until connected. Do not permit the splicing of conductors outside of specified areas (e.g., pull boxes, handhole locations).

2. Wire Slack. Verify that the proper slack is provided at pull boxes and handhole locations.

3. Control Cable. Check that the control cable is properly tagged and identified and that its ends are taped until connected. In span-wire installations, verify that the control cable is properly attached to the span wire by cable rings spaced a maximum of one foot apart. There should be no sag in the control cable.

4. Vehicle Detector Loops. Verify that vehicle detector loops are of the proper type and are installed in conformance with the requirements of the Contract. Check the depth of the detector for compliance and verify that saw cuts are properly filled after installation.

5. Pull Wire. Verify that pull wire has been placed in all new conduit and in existing conduits, if cable is added or replaced. Ensure that there is a minimum of two feet of pull wire doubled back at each termination.

6. Bonding and Grounding. Verify that all bonding and grounding are in compliance with Article 250 of the National Electrical Code.

7. Controller Cabinet. Verify that the controller cabinet is of the proper type and ensure that it is mounted to provide a clear view of the intersection when the cabinet door is open.

8. Pre-emption Equipment. Verify the proper location and installation of any required pre-emption equipment for emergency pre-emption or railroad coordination.

9. Signal Heads. Verify that traffic signal heads, pedestrian signal heads, and pushbuttons are of the proper type and installed in compliance with the Contract. Pay particular attention to mounting height and orientation with respect to driver and pedestrian approaches. Verify that signal heads are covered until the system is operational.

10. Signal Lamps. Verify that the traffic signal lamps are of the proper type and wattage.

614.4.5.3 After Construction

Consider the following after the installation of traffic signal systems:

1. Backfilling and Patching. Where required, verify that trenches are properly backfilled and the roadway surface is properly patched.

2. As-Constructed Plans. Verify that the Contractor has furnished the required As-Constructed Plans.

3. Testing. Before accepting the system, ensure the Contractor performs a five-day functional test and that any needed adjustments are performed.

4. Diagrams. Verify that the controller diagram and intersection-phase diagram are placed inside the controller cabinet.

5. Manufacturer Guarantee. Verify that the Contractor has furnished the manufacturer guarantee for the signal equipment.

6. Local Agency. Where applicable, verify that the Local Agency has been notified to accept operation of the signal system.

7. Cleanup. Verify that the area is left in an acceptable manner and know the disposition of any material or equipment removed from the job site.

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SECTION 615
WATER CONTROL DEVICES

615.1 GENERAL

The construction of water control devices is discussed in Section 603 of the *Standard Specifications*. Erosion control devices (e.g., Embankment Protector Type 3 and Type 5) are generally constructed with materials such as dry or grouted rubble, concrete, bituminous, riprap, and geotextile fabric, as discussed in their respective Sections of the *Standard Specifications*. The material is placed on the embankment as an apron for protection against water runoff.

615.2 INSPECTION GUIDELINES

Inspection guidelines for water control and erosion control devices are presented in the Section of the *Manual* for which the material applies. Consider the following additional guidelines:

1. Slide Headgates and Automatic Drain Gates. Check for correct sizes and verify that the gates have been approved for use. Check for proper coating.

2. Embankment Protectors. Check that embankment protectors are located according to the Contract and cover an area sufficient to provide adequate runoff protection. Verify if curbing is required.

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SECTION 616
SIPHONS

616.1 GENERAL

Siphons are generally used in conjunction with irrigation systems where it is necessary to pipe water from one side of the roadway to the other and where the ditch line is higher than the elevation of the roadway to be crossed. To provide sufficient cover material over the pipe, a siphon is used.

616.2 INSPECTION GUIDELINES

616.2.1 Before Construction

Upon delivery, inspect all materials for damage. Verify items such as pipe and valves are of the proper type and size. Ensure that any required material certifications have been obtained.

616.2.2 During Construction

Watch for damage to materials (e.g., crushing of pipe) during installation and consider the following:

1. Grade. Check for reversed siphon grade.

2. Drain Valves. Verify the proper installation of drain valves and ensure that they are accessible after installation.

3. Drainage. Proper provision for drained water to escape is required.

4. Trash Guards. Where required, verify the proper installation of trash guards and ensure that the specified coating is properly applied.

5. Watertight Test. Test for a watertight installation before backfilling.

616.2.3 After Construction

Prior to acceptance, inspect siphons for proper operation.

SECTION 617
RESERVED

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SECTION 618
PRESTRESSED CONCRETE

618.1 GENERAL

Prestressed concrete members differ from conventionally reinforced concrete members in that the concrete member is stressed prior to loading. This pre-compression is achieved through the action of high-strength steel bars or stranded wire that are placed within the structural members. Prestressed concrete members are used to minimize tension in structural elements, thus allowing the use of minimum concrete material.

Prior to fabrication of prestressed members, contact the Staff Bridge Fabrication Inspection Unit (303) 747-9193.

See specification Section 618 for pre erection requirements and see Appendix A for the pre-erection conference agenda.

618.1.1 Pre-tensioning / Post-tensioning

The prestressing force may be applied before the concrete is placed or after the concrete has cured. Consider the following:

1. Pre-tensioning. Pre-tensioning is the method of applying the prestressing force before placing the concrete. The bars or wire strands are anchored by a continuous bond throughout the length of the structural element, unless debonded.

2. Post-tensioning. Post-tensioning is the method of applying the prestressing force after the concrete has cured. In post-tensioning, the bars or wire strands are mechanically anchored at each end of the member.

618.1.2 Creep and Camber

Creep is the shortening of a girder after it is prestressed. The actual shortening is slight and occurs rapidly, tapering off over a period of about two months. Because the prestressing force is applied eccentrically, a noticeable uplift, or camber, will occur, which is anticipated during design. However, if the girder cambers beyond tolerable limits, corrective action will be necessary.

618.1.3 Precast Girders

Precast girders are fabricated on a flat surface at the precast yard and shipped to the bridge site for erection similar to steel girders. The girders will camber when the prestressing force is applied (see Section 618.1.2). Be aware that girder age and storage conditions can produce additional camber that may render the girder unacceptable.

618.1.4 Cast-In-Place Girders

Concrete box and “T” girders are typically cast-in-place and post-tensioned in the field. During construction, galvanized rigid ducts are cast into the girder webs. Once cured, the wire strands are pulled through the ducts to prestress the member. Because these girders are produced in the field, the forms and falsework must account for deflections due to dead load and prestressing.

618.1.5 Segmental Construction

The use of precast or cast-in-place post-tensioned segmental structures is generally limited in application to side hill bridges and viaducts. Such structures are generally long in span with limited access area, thus requiring gantries or heavy cranes for

construction and erection. Bars, wire strands, or a combination of both may be used to impart the prestressing force in segmental members.

In precast applications, the members are match cast to produce a bridge that conforms to the required geometry, but the prestressing is performed in the field. Contrary to conventional girders, segmental members must accommodate both heavy construction and final service loads, and special construction techniques are employed to provide stability. It is therefore important to thoroughly study the Contract and the fabrication drawings. If the Contract designates the prestressing force required only for the final service load, the fabrication drawings must define that force needed to accommodate both construction and service loads. Note that superstructure camber has already been developed in member segments during match casting but may be adjusted between segments with shims during erection.

618.2 INSPECTION GUIDELINES

618.2.1 Precast Girders

Inspection work is to be performed by Fabrication Inspectors from the Staff Bridge Branch. Maintain a close liaison with Fabrication Inspectors to coordinate delivery and follow through on any repair work prior to final acceptance of the girders.

618.2.1.1 Before Construction

Before precast girder construction begins, thoroughly review the Contract, shop drawings, and job safety requirements. Consider the following:

1. Construction Procedures. Review the prestressing procedures with the Contractor. Check the Contractor's field sheets for compliance. Pay particular attention to strand elongation and tiedown details.

2. Concrete Mix. Verify acceptability and approval of the aggregate source and concrete mix design.

618.2.1.2 During Construction

Consider the following during precast girder construction:

1. Reinforcement/Embedments. Inspect reinforcing cages and embedments for proper assembly and placement in forms.

2. Forms and Prestressing Steel. Inspect forms and prestressing steel for cleanliness and proper dimensions. Observe the tensioning procedure and verify compliance with the shop drawings.

3. Concrete Placement. Inspect concrete placement, form vibration, and curing method for acceptability.

4. Tensioning. Ensure that the concrete has attained the proper strength prior to tensioning.

618.2.1.3 After Construction

To maintain the integrity of the final product, it is important that the precast girders be properly handled and stored. If the girders are tipped or dropped, they may split apart or become otherwise damaged. After precast girder construction, consider the following:

1. Shipping/Erection. Review the methods of shipping and erecting the girders with the Contractor. A Pre-erection conference will be held prior to installation; erection agenda is in Appendix A.

2. Camber. Check the camber in the girders. Excessive camber may cause the girder flange to project into the deck slab, interfering with the concrete deck panel

or placement of reinforcing steel. Notify the Staff Bridge Branch immediately in such situations.

618.2.2 Cast-In-Place Girders

Coordinate with the Materials and Geotechnical Branch for the QA testing of materials used for cast-in-place girders. The Project Engineer and Project Inspectors are responsible for the inspection of all girder construction in the field.

618.2.2.1 Before Construction

Before cast-in-place girder construction begins, thoroughly review the Contract, shop drawings, and job safety requirements. Pay particular attention to the blockout dimensions and anchorage clearances noted on the shop drawings. Consider the following additional guidelines:

1. Prestressing Construction Procedures. Review the prestressing procedures with the Contractor and become familiar with the equipment and materials to be used. The Staff Bridge Branch will provide assistance for personnel unfamiliar with post-tensioning.

2. Concrete Mix. Verify acceptability and approval of the aggregate source and concrete mix design.

3. Prestress Strand Sample. Obtain samples of the wire strand material that will be used for prestressing well in advance of the post-tensioning operation. Forward the sample to the Materials and Geotechnical Branch for testing.

618.2.2.2 During Construction

Consider the following during cast-in-place girder construction:

1. Forms. Inspect forms for cleanliness and proper dimensions.

2. Grouting Ports and Vents. Verify that grouting ports and vents will remain accessible after concrete placement.

3. Concrete Placement. Ensure that concrete placement complies with specified requirements. Check for proper vibration of concrete around and under anchorages to eliminate voids.

4. Ducts. Verify that ducts are blown clear immediately after the concrete is placed. Ensure ducts and/or tendons are installed at the proper locations and without any wobble.

5. Prestressing Steel. Ensure that exposed prestressing steel is protected from dirt and debris when threaded through ducts in the field. If not immediately tensioned, also ensure that it is adequately protected from adverse weather conditions.

6. Construction Joints/Anchorage Zones. Construction joints should be located well away from anchorage zones and anchorage zone reinforcement. Verify that all anchorage zone reinforcement is placed in accordance with the Contract and shop drawings and reviewed by the Project Structural Engineer.

7. Concrete Curing. Check the curing of concrete for compliance, and ensure that the concrete attains proper strength prior to staring the prestressing operation.

618.2.2.3 During Prestressing

Review the sequence of operations with the Contractor, and be concerned with safety. Stay away from the backside of the ram, dead-end anchorages, and above the anchorage during the prestressing operation. The prestressing operation will elongate the steel strands in the members as the jacking force is applied. The jacking force is applied by a ram that is equipped with a dial gauge, graduated in pounds per square inch. This dial

gauge is used to indirectly monitor the amount of jacking force applied. A calibration curve is provided with the dial gauge, which is calibrated for the ram. Use this curve to convert the jacking force (e.g., P(JACK) to an associated reading on the dial gauge. Monitor strand elongation as follows:

1. Find the strand elongation length on the shop drawings. The actual stand elongation will vary from what has been calculated if the physical properties of the strand are different than those assumed in the calculations. The following equation is used as a basis to adjust the strand elongation:

   $e = PL/(AE)$

   where:

   e = strand elongation (inches)
   P = force applied to the strand (kips)
   L = length of strand (inches)
   A = area of the strand (square inches)
   E = Modulus of Elasticity of the steel strand (kips/ksi)

   Moving P and L to the other side of the equation, the expression becomes: $PL = eAE$.

   The subscript 1 is added to the right side of the equation to denote the assumed strand physical properties and becomes:

   $P_1L_1 = e_1A_1E_1$.

   Similarly, in a second equation, the subscript 2 is added to denote the actual strand physical properties and the equation becomes:

   $P_2L_2 = e_2A_2E_2$.

   Since P_1L_1 equals P_2L_2 the two equations can be set equal to each other:

$e_1A_1E_1 = e_2A_2E_2$.

Solving for e_2 yields:

$e_2 = e_1A_1E_1/A_2E_2$

A_1 = 0.153 square inches for 0.5 inch strand and A_1 = 0.217 square inches for 0.6 inch strand. The shop drawings will show the size and strand area assumed. The value assumed for E_1 will also be shown on the shop drawings. The values for A_2 and E_2 will be reported on samples from each heat of strand submitted to the Materials and Geotechnical Branch for testing.

2. Before the Strand Elongation is measured, the strand is usually jacked to 20 percent of P(JACK). This is done to remove slack in the strands. The measured strand elongation is reduced by the same percentage (20 percent).

3. Measure the strand elongation as follows:

   Mark a strand in a tendon 10 inches from the end of the ram (find a part of the ram that does not move as the reference point and measure from there). A permanent black felt tip marker can be used to make the mark.
   Monitor the dial gauge reading as the jacking force approaches P(JACK).

At P(JACK), measure the distance to the mark made on the strand from the reference point. This distance, less the dead end anchor set, should be equal to or greater than the strand elongation calculated in Step 2 above. If the elongation is not what is expected, carefully check the calculations and measurements to verify that the strand elongation is in fact short.

If the measured strand elongation varies more than seven percent from the calculated strand elongation or if the elongation measurements are erratic, examine the prestressing operation for possible problems. If the problem cannot be solved in the field, contact the Project Structural Engineer or the Staff Bridge Branch for assistance. Do not

permit the protruding strands to be cut until the strand elongation has been verified and all problems have been properly addressed.

618.2.2.4 After Prestressing

Check that tendons are grouted as soon as practical after prestressing. All grouting ports and vents must be operating properly to ensure full-length grouting. The prestressing and grouting for all tendons in a particular bridge must be completed before the work is accepted.

618.2.3 Segmental Construction

In advance of segment casting, discuss the inspection requirements for segmental structures with the Fabrication Inspectors from the Staff Bridge Branch (303) 757-9193 The Project Engineer and Project Inspectors are responsible for the inspection of all erection and/or site fabrication.

618.2.3.1 Before Construction

Before segmental construction begins, thoroughly review the Contract, shop drawings, and job safety requirements. Pay particular attention to the blockout dimensions and anchorage clearances noted on the shop drawings. Check gantry drawings and precast form drawings to ensure they will accommodate variables due to roadway curvature, tapered webs, and slabs within the elements. Consider the following additional guidelines:

1. Construction Methods. Review the prestressing procedures and erection sequence with the Contractor. Verify that equipment is available to transport and erect the segments. Become familiar with all equipment, forms, and other items involved in the fabrication and prestressing of the bridge.

2. Concrete Mix. Verify acceptability and approval of the aggregate source, concrete mix design, epoxy bonding agents, and other materials used in the work.

3. Inspection Scheduling. Coordinate the inspection schedule with the casting and erection sequence that has been established by the Contractor.

618.2.3.2 During Construction

Be concerned with safety. Stay away from the back of jacks during the prestressing operation. Periodically check work platforms, gantries, and highlines for safe operation. Consider the following additional guidelines:

1. Forms. Inspect forms for cleanliness and proper alignment and dimensions.

2. Concrete Placement. Verify concrete placement for compliance and ensure that the concrete is properly vibrated.

3. Ducts. Verify that ducts are blown clear immediately after concrete is placed. Check duct and/or tendon installation for proper location and stability (i.e., no wobble). Check ducts for leakage and verify that any repair work will withstand the forces imparted by concrete placement and vibration.

4. Prestressing Steel. Verify that the Contractor protects the prestressing steel from corrosion and damage prior to prestressing and grouting.

5. Concrete Curing. Ensure that the concrete has attained proper strength prior to beginning the prestressing operation.

6. Strand Elongation. Check ram gauge readings and strand elongation as described in Section 618.2.2.3. Because of the highly mechanized casting operation of segmental construction, automatic procedures may need to be established to record readings for documentation purposes.

7. Grouting. Verify that tendons are grouted in accordance with the shop drawings.

8. Epoxy Joint Material. Inspect the mixing of epoxy joint material and its application to ensure complete coverage and proper curing.

9. Segment Alignment. Check the segments for proper line and grade as they are erected. Checkpoint elevations on a particular segment will vary as additional segments are added; however, tabulated data will be made available by the Contractor to recheck points as the construction progresses. If alignment begins to deviate from the tabulated data, verify that the alignment is properly corrected.

618.2.3.3 After Construction

The stressing and grouting of tendons in the bridge must be completed before the work is accepted. Inspect the final structure to verify that all temporary supports have been removed, all chipped corners, tie rod holes, etc., have been patched and that bearings and expansion devices are functioning properly.

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SECTION 619
WATER LINES

619.1 GENERAL

If work on water lines will be performed by the Contractor under Item 619, the local utility company shall be contacted to ensure that the installation is in compliance with local standards and specifications.

619.2 INSPECTION GUIDELINES

619.2.1 Before Construction

Before construction, inspect the acceptability of all materials to be used in the work. Verify that required material certifications have been received.

619.2.2 During Construction

Review the safety requirements for trenching operations and verify compliance. Regularly check the depth and width of trenches for uniformity and conformance to designated dimensions. Consider the following:

1. Pipe Support. Ensure that the pipe is uniformly supported throughout its entire length.

2. Joints. Verify that joints are constructed in an approved and acceptable manner.

3. Alignment. Alignment must be true. Alignment deviation is limited to plus or minus 0.3 foot per 100 feet.

4. Kickers. Ensure that kickers are used and properly placed to reinforce sharp bends.

5. Watertight Test. Prior to backfilling, test to ensure that the lines are watertight.

6. Backfill. Ensure that backfill is placed in uniform lifts of the specified thickness and thoroughly compacted.

619.2.3 After Construction

Prior to acceptance, inspect water lines for proper operation. As needed, coordinate inspection with the local utility company.

SECTION 620
FIELD FACILITIES

620.1 GENERAL

The Contractor is required to furnish field offices, sanitary facilities, and field laboratories, as designated in the Contract or as otherwise directed. These facilities will be maintained operational by the Contractor during construction and subsequently removed upon completion of the project or as otherwise directed by the Project Engineer.

620.1.1 Trailer Shortages

If field facilities cannot be furnished as specified, the Contractor should immediately notify the Project Engineer so that alternatives can be considered (e.g., use of larger trailers, reconfiguring trailer interiors, use of building facilities). The Project Engineer is responsible for evaluating the acceptability of alternate field facilities. Although the selected alternative should satisfy the intended function of the specified facility, it is important to remain flexible and reasonable in working with the Contractor. Price reductions, if warranted, should be applied judiciously based on the extent of deviation from the intended functionality. Alternate field facilities should be considered on a project-by-project basis and such considerations must not establish a convenient precedent for unreasonably deviating from specified requirements on future projects. The Area Engineer in the Contracts & Market Analysis Branch may be contacted for guidance.

620.2 INSPECTION GUIDELINES

Note and document the date of arrival of all field facilities on the project. Check that the facility dimensions and furnishings conform to the requirements specified in the Contract. Verify that the facilities are serviced by the Contractor and maintained in a satisfactory

condition. Document on Form 105 – Speed Memo the date and condition of the facility when removed from the project.

SECTION 622
REST AREAS AND BUILDINGS

622.1 GENERAL

The material and construction requirements for rest areas and buildings are detailed in Section 622 of the *Standard Specifications*. The Contractor is responsible for all required permits, pre-inspections, and final inspections in accordance with governing Federal, State, and local laws and ordinances.

622.2 INSPECTION GUIDELINES

Inspection of building, heating, plumbing, sanitary, and electrical installations must be performed by qualified building inspectors charged with these duties. The Notice Of Compliance achieved in the design phase for buildings will list the individuals who are required to perform the inspections for the building work. This will not be a list of CDOT employees or consultants, but rather it will be a list of non-CDOT government agency inspectors and other such certified inspectors. CDOT's inspectors should perform their own inspections in conjunction with the certified building inspectors as outlined below.

622.2.1 Underground Pipe

622.2.1.1 General Considerations

For underground pipe installations, see Section 603 and consider the following general guidelines:

1. Existing Utilities. Watch for conflicts with existing utilities and systems.

2. Trench. Check the pitch, line, and grade of the trench or bed before the pipe is placed and after completion of each pipe section.

3. Pipe Installation. Ensure that the pipe is installed in accordance with the manufacturer's installation recommendations, and consider the following:

    a. Pipe Cleanliness. Check for cleanliness of pipe sections and joints during placement and after completion. Pay particular attention to the cleanliness of joints.

    b. Pipe Base. Pipe should be placed on a uniform, firm, and stable base.

    c. Obstructions. Check for pipe plugs, debris, and other obstructions in the pipe.

622.2.1.2 Water Lines

For water lines, see Section 619 and consider the following guidelines:

1. Grade Lines. Grade lines should avoid high points where practical. Where high points occur, vacuum and relief valves may be necessary. Check the specified requirements.

2. Pipe Support. A properly installed water line does not move. Check blocking, movement at joints, bends, dead ends, and hydrants. Check wedging at all fittings.

3. Water Line Sterilization. Ensure that the sterilization of the water line is performed as specified. Consider the following:

    a. Main Flushing. The water line main is to be thoroughly flushed with water until all entrained mud and debris have been removed.

b. Sterilizing Agent. Check that a sterilizing agent is added to the water line at the specified dosage. Ensure that the agent remains in the line for the minimum specified period.

c. System Flush. Ensure that the entire water line system is thoroughly flushed to remove the sterilizing agent.

622.2.1.3 Sanitary Sewer Lines

For sanitary sewer lines, see Section 603 and consider the following:

1. Spigot End of Pipe. Check that the spigot end of pipe is pointed downstream.

2. Conflicts with Water Lines. Check the distance separating water and sewer lines. Installation of sewer lines must be below the elevation of the water line, unless special construction techniques are employed at crossings.

3. Grade/Manholes. Check that a uniform grade is maintained between manholes. Ensure that the top elevation of the manhole is readily accessible.

4. Clean-Outs. Check that a clean-out is placed every 100 feet at an angle pointing downstream.

622.2.1.4 Pipe Joints

Check the tightness of joints frequently during placement of pipe, and do not permit pipes to be joined in mud and water. Where flexible joints are used, check the acceptability materials, and consider the following:

1. Flexible Gaskets. Check the placement and positioning of flexible gaskets.

2. Lubricant. Check that a lubricant is properly applied at flexible joints.

3. Hydrostatic Test. Verify that a hydrostatic test is performed as soon as practical after placement.

622.2.1.5 Copper Pipe

Check the acceptability of the pipe and fittings supplied. Check for good workmanship (e.g., good bends, no burrs, clean pipe, pleasing location and placement).

622.2.2 Masonry and Tile

622.2.2.1 General Considerations

Consider the following guidelines during inspection of masonry and tile work:

1. Temperature. Verify that the ambient temperature is at or above the minimum temperature specified.

2. Leads. Verify that the Contractor erects leads at corners and jambs. Masons must use levels to check plumbness and to set string lines between leads.

3. Cutting. Check that the cutting of block and tile was done using a masonry saw. Blocks should be dry cut.

4. Wall Insulation. Verify the proper placement of wall insulation. Watch for broken and compressed insulation.

5. Horizontal Joint Reinforcement. Check that joint reinforcing is provided at designated locations (e.g., at courses designated on plans [usually 16 inches], under sills, over lintels, overlap reinforcement by six inches, and use prefabricated “T” and “L” sections at corners and intersecting walls).

6. Vertical Reinforcement (concrete block walls). Check size of rebar, lap and location of vertical reinforcement. Grout all cells with vertical reinforcement after masonry wall has attained sufficient strength to resist grout pressure. Vertical reinforcement should be tied to reinforcement extending from foundation as per plans. Vertical reinforcement is usually at sides of all openings, exterior corners, and 32 inches on center.

7. Bond Beams. Check that bond beams are provided at designated locations (e.g., under sill, above lintel level, top of wall, intermediate locations).

8. Door and Window Frames. Check that anchors are provided at each jamb. Verify that hollow door frames are filled with mortar.
9. Embedded Items. Check that embedded items (e.g., sleeves, electrical conduit, heating ducts, recessed items) are installed properly as masonry is erected, not cut in afterwards. Check mechanical and electrical drawings for proper locations.

10. Caulking. Verify that frame openings are properly caulked.

11. Wall Bracing. Incomplete walls are not self-supporting. Check that they are properly braced to resist wind pressure.

622.2.2.2 Mortar Considerations

Verify that mortar is allowed to take its initial set before masonry joints are tooled. A good guideline is to use the “thumb-print" rule before tooling is performed. If masonry units move after the mortar takes initial set, require removal and resetting using fresh mortar. Consider the following additional guidelines:

1. Excess Mortar. Unless otherwise directed, verify that excess mortar is removed from the face and joints of brick and block before mortar takes its initial set. In insulated walls, verify that excess mortar is removed from the backside of masonry units. Check for excess mortar accumulation in the bottom wall cavity.

2. Proportioning. Mortar must be accurately proportioned and have all admixtures included. Check proportioning at least once a week and whenever mortar tenders are changed.

3. Re-temper. Mortar must not be re-tempered.

4. Mechanical Mixers. Mechanical mixers should be used on all but the smallest jobs.

622.2.2.3 Bricks and Concrete Block

Check bricks and concrete block for chips, cracks, and defects prior to installation and consider the following:

1. Placement. Undue shifting or realignment of brick or block is not permitted. During placement, consider the following:

    a. Joints. Joints should be filled solidly as brick or block is placed.

    b. Placement Method. "End buttering" (i.e., placing mortar on brick or block) or "pick and dip" (i.e., simultaneously picking up brick or block with one hand with mortar on trowel in the other) is acceptable. Throwing of mortar to fill joints after brick or block is laid (i.e., slushing) is unacceptable.

    c. Mortar Bond. Check to ensure that mortar bond is not broken between newly laid brick or block joints. It is advisable to wait 24 hours to grout cells and to fill bond beams.

2. Structural Header Courses/Metal Ties. Verify that structural header courses and metal ties are installed between the face and back of masonry units. Check that metal ties are of the specified shape and size and placed at the proper spacing.

3. Joints. Check that all exposed joints are of uniform width.

4. Expansion Materials. Check the quality and location of expansion materials.

5. Brick Cleaning. Final clean-up of brickwork should be in accordance with the specifications. Check for loose bricks.

6. Anchors and Ties. Ensure that anchors and ties are installed as the work progresses.

622.2.2.4 Structural Glazed Tile

Check that joints in glazed tile are not be more than 0.25 inches in width. Verify that tile faces are cleaned with a clean, damp rag as the work progresses. Upon completion of walls, check that all tile surfaces are washed with soap powder and clean water. Stiff fiber brushes should be used, not metal brushes or acid solutions.

622.2.3 Building Infrastructure

622.2.3.1 Carpentry

Check acceptability of lumber grade and dimensions. Verify good craftsmanship and that the carpentry work meets governing building codes.

622.2.3.2 Roofing

Review safety requirements and consider the following:

1. Materials. Ensure that specified materials are being used.

2. Roof Surface. Verify that the roof is dry, smooth, firm, and free of dirt, projections, and foreign materials.

3. Flashing. Check flashing at all projections through roofing. Check for vented nailers at vertical leg of base flashing.

4. Drains and Vents. Verify that drains and vents are unplugged.

5. Roof Drains. Check roof drains for proper location and elevation. Also check that roof drains are properly flashed, clean, and provided with grating.

6. Temporary Protection. Verify that wood runways are used for wheelbarrow traffic to protect roof sections.

7. Sheet Metal. Verify that construction and installation of sheet metal complies with the Contract and shop drawings. Check fabrication for good workmanship.

8. Corrugated Roofing. Check material before and after installation for defects and damage. Reject defective materials.

622.2.3.3 Doors and Windows

The installation of doors and windows must comply with the Contract and shop drawings. Consider the following:

1. Materials. Check materials for defects, warps, and buckles. Reject substandard materials.

2. Operation. Check doors and windows for proper operation.

3. Alignment. Check each door and window to see that it is plumb, square, and level.

622.2.3.4 Caulking, Glass, and Glazing

Consider the following during caulking, glass, and glazing work:

1. Grooves. Check that grooves are of sufficient depth and cleaned of mortar, dust, and foreign matter before caulking.

2. Caulking. Verify that caulking is uniform and relatively smooth without smearing.

3. Glass. Check the type and thickness of glass for acceptability. Verify that all glass surfaces are cleaned of labels, paint, putty, and other defacements.

4. Mirrors. Check mirror installation for compliance with the Contract and shop drawings. Verify that a concealed, non-tamperable mounting of mirrors is provided. Verify that mirrors are at designated height and properly centered with respect to fixtures. Ensure that mirrors are cleaned of labels, paint, putty, and defacements.

622.2.3.5 Ceramic Tile

Check size, color, and pattern of ceramic tile for acceptability and consider the following:

1. Tile Setting. Inspect tile setting for:

    a. straight, level, perpendicular, and uniform 1/16-inch joints;
    b. firmness of set; and
    c. damaged or defective tiles.

2. Floor Tile. Check the laying of floor tile for:

    a. cleanliness of subfloor, spread of adhesive, and initial set time;
    b. cutting, trimming, setting, and fitting of tile; and
    c. grouting and cleaning.

622.2.3.6 Toilet Partitions

Verify that toilet partitions are installed according to the manufacturer's instructions. Check for neat and accurate workmanship. Watch for unacceptable cutting and drilling of partition panels. Consider the following:

1. Partition Placement. Check the acceptability of partition fitting, jointing, and anchoring. Check that the assembly is straight, plumb, and level.

2. Partition Damage. Reject partition units that are dented, punctured, deeply scratched, or otherwise damaged. Slight mars, abrasions, and scratches may be touched up if they can be repaired to match undamaged parts.

3. Hardware and Accessories. Check the proper installation of all hardware and accessories.

622.2.3.7 Plumbing and Sprinkling Systems

See Section 603, Section 619, and Section 623 and consider the following:

1. Material Damage. Check pipes and fittings for damage. Reject damaged materials.

2. Trench. Inspect each length of pipe and fitting as it is lowered into the trench. Report all ground water conditions. Subsection 623.23 of the *Standard Specifications* requires a pressure and coverage test. It is critical to pressure test the system before it is backfilled. Also, the system should be run for a few days before the sod and plants are placed to troubleshoot the system and give the vegetation a good start.

3. Pipe Caps/Plugs. Verify that caps or plugs are placed on open ends of pipe where work is halted at the end of the day or where future connections are to be made.

4. Material Submittals. Check that required material certifications, samples, and approvals have been received prior to material installation.

5. Sleeves. Check the number and size of sleeves in floors and walls for acceptability before the floors are poured and during wall erection.

622.2.3.8 Soil, Waste, Drain, and Vent Piping

Check the following related to soil, waste, drain, and vent piping:

1. Pipe and Fitting Material. Check the acceptability of all pipes and fittings. Pay particular attention to the type, weight, and coating, if required.

2. Pipe Slope and Alignment. Check pipe slope and alignment for correctness.

3. Pipe Bedding and Cover Material. Verify that pipe bedding is at the proper grade and thoroughly compacted. Do not permit boulders to remain in bedding or cover material. Verify that pipe cover material is placed in uniform layers and thoroughly compacted.

4. Floor Drains. Check that floor drains are of the proper type and size and are equipped with sediment baskets or backwater valves. Verify that the floor pitches toward the drain.

5. Roof Drains. Check that roof drains are of the proper type and size. Verify that the roof drains are set at or slightly below the low points of the roof.

6. Sewer Pipe Bends. Do not allow perpendicular bends in the horizontal plane of sewer lines upstream from the septic tank.

7. Supports and Anchors. Check all supports and anchors for acceptability.

8. Pipes Under/Through Structures. Check the placement of pipes under and through footings and foundations to ensure that settlement will not affect pipes.

9. Vent Pipes. Check that all buildings and septic tanks have vent pipes.

622.2.3.9 Water Piping

Check water supply pipes from the outside service lines to the building for proper type, size, location, and elevation and interference with other underground utilities. Check clearance between water and sewer lines for acceptability and consider the following:

1. Frost Line. Check that pipes outside the building are below the frost line.

2. Non-Potable/Sewer Conflicts. Do not permit cross connections between potable and non-potable water supply or sewer drains.

3. Hangers. Check hangers for proper type, spacing, and secure anchorage.

4. Threaded Pipe. Do not allow the use of wicking in threaded pipe.

5. Pipes and Fittings. Check for proper type and weight of pipes and fittings. Check for the inappropriate use of galvanized and brass or copper pipe and fittings in the same run.

6. Fixtures. Check fixtures for complete trimming, fitting, and shut-off valves. Check fixtures for blemishes and the rigidity of fixtures.

7. Protection of Fixtures. Ensure that fixtures are properly protected during building construction. Prohibit the use of fixtures until the plumbing system is tested.

8. Accessory Equipment. Check that accessory equipment is of the proper type and installed in accordance with the Contract.

9. Controls/Regulators. Check for the proper installation of controls and regulators.

10. Flexible Connections/Vibration Eliminators. Check for the proper installation of flexible connections and vibration eliminators.

11. Testing. Prior to testing, check that all diaphragms and internal valve parts can withstand the test pressure without damage; otherwise, have them removed before the test is begun.

12. Final Cleanup. Check that all grease, paint spots, and debris are removed.

13. Final Adjustments. Check for the proper final adjustment of all fixtures, devices, and controls.

14. Operating/Maintenance Instructions. Check that the operating and maintenance instructions are posted where required.

622.2.4 Electrical System

622.2.4.1 General Considerations

The final inspection and permitting of electrical systems will require the services of a master electrician. Such assistance should be requested promptly from such authorized individuals. Consider the following:

1. *National Electrical Code*. The electrical installation must conform to the latest edition of the *National Electrical Code* and applicable State and local ordinances.

2. Materials and Equipment. Check materials and equipment for compliance with the Contract and approved shop drawings when they are delivered to the job. Examine equipment for damage due to shipping.

3. Permits. Verify that all required permits have been properly posted.

4. Grounding. All grounding must be in accordance with the latest edition of the *National Electrical Code* and approved by a State electrical inspector.

5. Conduit and Wire Size. Know if the conduit system is to be installed concealed or exposed. Check that the size of conduit and wire meet the minimum specified requirements.

6. Buried Conduit. Where designated, ensure that buried electrical conduit is placed and approved before the floor slab is poured. Where required, verify that the exterior of buried conduit is painted with a bituminous-based paint.

7. Conduit Damage. Inspect for damage and deformation of conduit during installation.

8. Conduit Bends. Check the number of bends in conduit to verify that it does not exceed the maximum in a single run.

9. Conduit Alignment. Verify that exposed conduit runs are installed parallel or perpendicular, as appropriate, to walls and structural members. Check that vertical conduit runs are plumb. Exceptions may be necessary due to obstructions or space limitations.

10. Pulling Wire. Observe pulling of wires and cables and watch for damage to sheaths, jackets, and insulation.

11. Panelboard Directories. Verify that panelboard directories are complete and correctly identify the circuits and equipment served.

622.2.4.2 Lamps and Lighting Fixtures

For the inspection of lamps and lighting fixtures, consider the following:

1. Material Damage. Check fixtures for chipped porcelain, cracked glass and plastic, bent louvers, and the overall finish.

2. Lamp Wattage. Check that the lamp wattage is of the correct rating.

3. Lamp Type. Check ballasts for fluorescent and mercury vapor lamps to ensure suitability for circuit voltage and high-power factor type. Determine if the slow, rapid, or instant start feature is specified and installed.

4. Fixture Alignment. Installation should be plumb and have good horizontal and vertical alignment.

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SECTION 623
IRRIGATION SYSTEM

623.1 GENERAL

The work for irrigation systems generally consists of constructing a pressurized irrigation mainline and lateral transport lines that provide coverage to the limits shown in the Contract. The Contractor will establish the exact locations to fit field conditions and receive approval from the Project Engineer prior to construction. The construction of irrigation systems must conform to all applicable State and local codes.

623.2 INSPECTION GUIDELINES

623.2.1 Before Construction

Ensure that all equipment and materials to be installed are new. Verify that equipment to be installed conforms to the list of equipment submitted and approved.

623.2.2 During Construction

During the construction of irrigation systems, consider the following:

1. Staking. Verify that staked locations are approved. The Contractor must protect stakes during construction.

2. Trenches. Check trench bottoms for a flat grade that will support the pipe evenly. Verify that the depth will provide for the specified minimum cover. For mainline pipe, ensure that the bottom of the trench is flat, and excavation and backfill conform with Sections 206 and 703 of the *Standard Specifications*.

3. Pipe. Check pipe for correct size and proper identification markings. For mainline pipe, check that type of pipe fitting conforms to the specified type in relation to the size of pipe (i.e., solvent weld or rubber gasket). Check that pipe ends are taped during installation to protect against entry of foreign material.

4. Sleeve Pipes. When installing sleeves, check that the location of the sleeve is recorded in the As-Constructed Plans and marked with magnetic tape for future location.

5. Mainline Low Points. Ensure that drain valves are placed at low points along the mainline.

6. Clearance. Check for specified clearances between line crossings.

7. Kick Blocks. Ensure that kick blocks are installed as required.

8. Wiring. Check wire for correct color code. Check that wire is located properly in the trench. Where more than one wire is placed in a trench, check that the wires are correctly taped together. Check that wire is placed at least at the minimum depth.

9. Underground Marking Tape. Ensure that underground marking tape is placed with mainline pipe that does not have control wire in the same trench.

10. Valve Boxes. Check valve boxes for proper markings on the cover and for installation to the correct grade.

11. Pressure Test. Verify that a pressurized or volumetric test for mainline leakage is performed prior to backfilling joints and fittings.

623.2.3 After Construction

After the construction of an irrigation system, consider the following:

1. Coverage Test. The Contractor is required to perform the coverage test in the presence of the Project Engineer. Verify that adjustments are performed.

2. As-Constructed Plans. The Contractor will provide detailed As-Constructed Plans of the irrigation system.

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SECTION 624
DRAINAGE PIPE

624.1 GENERAL

This specification allows the Contractor to choose any pipe material allowed in Table 624-1 for the pipe class specified in the contract. The Contractor shall state at the Pre-Construction Conference which pipe material was chosen. Construction requirements are the same as for section 510 or 603 as applicable. Refer to those sections for further guidance.

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SECTION 625
CONSTRUCTION SURVEYING

625.1 GENERAL

Construction surveying shall be performed in accordance with Section 625 of the *Standard Specifications* and the *CDOT Survey Manual*.

625.2 – 625.10 RESERVED

625.11 3D ENGINEERED CONSTRUCTION SURVEYING (3DECS)

Your project may be one that the Resident Engineer or Project Manager determined meets the criteria for providing three dimensional modeling data to the contractor to be used for bidding and construction. To determine if yours is such a project, check the Project Special Provision, *Revision of Section 102 – Project Plans and Other Data* and see if it includes the statement that such documents are available.

The Contractor may use the data from these files to create efficiencies during construction. The primary benefits are less staking and improved efficiency of earthwork operations. The data can be input directly into heavy machinery enabling the machinery to make automatic adjustments, or the data can be provided to the operator enabling the operator to make the machine adjustments.

Chapter 6 of the Survey Manual has been modified for projects in which the Contractor chooses to use 3D Engineered Construction Surveying (3DECS). There should be discussions at the Pre-survey Conference regarding use of 3DECS.

The CDOT Standard Specification Section 625 and the Survey Tabulation Sheet have been modified such that should the Contractor choose to use 3DECS, less staking is required. Less staking will make it more difficult for CDOT to check the work, but minimal staking is still required. Should you feel you need more surveying to check the

work, you can require more staking per Standard Special Provision, *Revision of Section 105 – Construction Surveying* where we pay the contractor an hourly rate for additional surveying.

SECTION 626
MOBILIZATION

626.1 GENERAL

Mobilization is governed by Section 626 of the *Standard Specifications*. Item 626 – Mobilization is automatically calculated by the Department's construction management software.

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SECTION 627
PAVEMENT MARKING

627.1 GENERAL

Pavement marking material and construction requirements are detailed in Section 627 of the *Standard Specifications*, and placement must be in conformance with the manufacturer's recommendations, the *Manual of Uniform Traffic Control Devices*, and the *CDOT M&S Standard Plans*.

627.1.1 Surface Preparation and Payment Considerations

Preparation of the pavement surface prior to applying extruded thermoplastic, epoxy, and preformed tape is required and should be performed in accordance to the manufacturer's recommendations. This cleaning shall remove oil, dirt, dust, grease, and similar foreign materials, and payment is generally included under the pavement marking item. Because of the much greater effort required to remove existing markings from both asphalt and Portland cement concrete pavements, their removal is generally specified as a separate item of work and paid for independent of the pavement marking item.

627.2 INSPECTION GUIDELINES

627.2.1 Before Construction

Before applying pavement markings, consider the following:

1. Pavement Marking Plan. If the Contract does not include a pavement marking layout, verify that the Contractor has provided a layout of existing conditions for approval and modification.

2. Control Points. Check control points for correct size and placement to ensure compliance with the pavement marking plan.

3. Conflicts. Verify that there are no conflicts between typical section, pavement marking plan, or existing markings.

4. Material. Confirm the type of material (e.g., paint, thermoplastic, epoxy, and tape) to be installed. Ensure that the material to be installed meets specifications.

5. Surface Preparation. Ensure the surface is properly cleaned and free of moisture, grease, oil, dirt, and laitance. Check the need for primer, sandblasting, waterblasting, grinding, or grooving.

6. Temperature. Check that air temperature complies with the specifications and manufacturer's recommendations.

7. Signing Conflicts. Check for conflicts with highway signing.

627.2.2 During Construction

During the placement of pavement markings, perform regular checks to ensure that the surface is clean and dry. Regularly check completed lines for good workmanship and straightness. Consider the following additional guidelines:

1. Application Procedures. Check application procedures for compliance with the manufacturer's recommendations.

2. Application Rate. Check application rate of paint, thermoplastics, and epoxies for compliance. The Contractor may use a meter or dip their tanks for measurements before and after striping. Verify the application rate is correct by measuring the area striped and calculating the minimum and maximum rate allowed in the spec.

3. Beads. Check that the application rate of beads complies with specified requirements.

4. Protection. Make sure that adequate cones are used to prevent tracking by vehicular traffic.

5. Full-Compliance Markings. Verify the proper application of full-compliance markings at crossovers, detours, and no-passing zones.

6. Conflicting Pavement Markings. Check that conflicting or confusing pavement markings are properly removed. Removal should be done by waterblasting to help prevent “ghosting” of the removed pavement markings.

7. Epoxy Pavement Marking. Verify that Certificates of Compliance have been received and consider the following:

    a. Curing. Check for proper curing of epoxy marking material.

    b. Component Ratio. Ensure that proper equipment is on hand that is capable of metering components at the correct ratio and able to maintain the material at the correct temperature.

    c. Thickness. Check that the correct thickness of material is applied.

8. Thermoplastic Pavement Marking. Ensure that suitable equipment is on hand to provide proper extrusion, heating, mixing, and control of the flow of material. Consider the following:

    a. Alignment and Size. Ensure that a continuous uniformity in stripe dimensions and alignment is maintained.

    b. Thickness. Check that the correct thickness of material is applied.

9. Preformed Pavement Marking. For the application of preformed pavement markings, consider the following:

    a. Existing Pavement. When placed on existing cold pavement, check for a clean, dry, and properly prepared surface. Verify if sandblasting is required. Ensure that primer has been properly applied. Check for appropriate splicing sequence and roller weight.
    b. Inlay. For hot bituminous inlay placement, ensure that the material is applied in the proper location and sequence on the new mat. Check that the pavement surface is at the recommended temperature to obtain complete inlay.

10. Pavement Marking Tape. Where pavement marking tape is used, ensure that the tape is in conformance with the Contract and is suitable for temporary use. Consider the following:

    a. Tape Application. Ensure that the tape is clean and pressed down until it completely adheres to the surface. Check for correct lengths and intervals and that locations are according to plan or as directed.

    b. Tape Removal. Ensure that temporary tape is removed prior to subsequent lifts of hot bituminous pavement.

SECTION 629
SURVEY MONUMENTATION

629.1 GENERAL

Survey monumentation shall be performed in accordance with Section 629 of the *Standard Specifications* and the *CDOT Survey Manual*.

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SECTION 630
CONSTRUCTION ZONE TRAFFIC CONTROL

630.1 GENERAL

Coordination and advance planning by the Contractor, Traffic Control Supervisor, and the Project Engineer are required to provide for the safe and efficient maintenance and protection of traffic during construction. Every reasonable and practical effort should be made to reduce hazards and inconvenience to the traveling public and to adequately protect project personnel at the site. The Traffic Control Plan and Method of Handling Traffic must address the items shown in subsection 630.10 of the *Standard Specifications*.

CDOT and Contractor personnel must continually monitor the construction area and immediately report potentially hazardous situations for correction. The topic of construction zone traffic control will have been thoroughly addressed at the Preconstruction Conference.

630.2 TRAFFIC CONTROL REVIEW PROGRAM

630.2.1 Overview

The Traffic Control Review Program has been established to provide assistance in administering the traffic control aspects of a construction project. The Traffic Control Review Program relies on the experience and expertise of the Resident Engineer to assist Project Engineers. The Traffic Control Review Form is used to document the results of the Traffic Control Review.

630.2.2 Implementation Procedures

The objective of the Traffic Control Review Program is to obtain an "in compliance" or “yes” response to each question posed on the Traffic Control Review Form. The following procedures are used to implement the Traffic Control Review Program:

1. Traffic Control Review Frequency. The Project Engineer and the Resident Engineer will perform a joint Traffic Control Review once each calendar year for each active construction project.

2. Substitution of Reviewer. The Region Program Engineer may appoint a qualified substitute to the Resident Engineer to participate in the Traffic Control Review; however, the substitute will not be assigned to the project being reviewed.

3. Traffic Control Review Form. The Traffic Control Review Form will be used to document the results of the Traffic Control Review. A copy of each completed form will be maintained in the project files. Contact the Project Development Branch for blank copies or an electronic version of the Traffic Control Review Form. See Appendix B for an example of a properly completed Traffic Review Form.

4. Deficiency Corrections. All deficiencies noted during the Traffic Control Review will be immediately reported to the Contractor for correction. The maximum time period for correction is 24 hours.

630.2.3 Inspections During Non-Working Hours

The Traffic Control Review Program requires night inspections of traffic control. The following guidelines have been established to ensure State-wide uniformity:

1. Traffic Control Supervisor Inspections. The Project Engineer is responsible for ensuring that the Traffic Control Supervisor inspects for compliance the work zone traffic control during non-working hours, including nights and weekends.
2. CDOT Inspections. The Project Engineer, or a qualified CDOT employee, should make at least one nighttime inspection upon implementation of a new Method of Handling Traffic that includes nighttime traffic control devices.

630.2.4 Review of Method of Handling Traffic

The Project Engineer is responsible for reviewing the Contractor's Method of Handling Traffic. Check that the Method of Handling Traffic complies with the requirements of the *Manual of Uniform Traffic Control Devices*, *CDOT M&S Standard Plans*, and the project's Traffic Control Plan. Verify that the Method of Handling Traffic provides adequate protection for workers, motorists, pedestrians, and bicyclists. Consider the following:

1. Contractor Review. Verify that the Method of Handling Traffic has been reviewed and initialed by the Contractor.

2. Speed Reduction. If a speed reduction is requested, check that the Method of Handling Traffic complies with the conditions of the approved CDOT Form 568 – Authorization and Declaration of Temporary Speed Limits.

3. Emergency Vehicle Access. Ensure that there is an adequate plan for emergency vehicle access.

4. Unnecessary Devices/Flaggers. Do not approve a Method of Handling Traffic that includes unnecessary devices or flaggers. Part 6 of the *Manual of Uniform Traffic Control Devices* specifies the type, number, location, and arrangement of devices and flaggers that are acceptable for use in construction applications. Occasionally, Contractors will propose more devices and flaggers than are warranted, making a false assumption that such practice will provide additional safety. On the contrary, such practice can be a detriment to safety for an increase in cost. Too many devices and flaggers can cause confusion, render other control measures

ineffective, and exacerbate the hazard potential. If a Contractor insists on using unnecessary traffic control, contact the Region Traffic Engineer or the Safety and Traffic Engineering Branch for immediate assistance.

5. Pedestrian and Bicycle Traffic. Verify that the Method of Handling Traffic adequately provides for pedestrian, bicycle, and other non-vehicular traffic. Check that bicycle and recreational trail detours have been correctly identified and signed.

6. Access/Crossovers. Verify that the Method of Handling Traffic adequately provides access for construction and maintenance traffic, including turnaround locations. Ensure that median crossings and crossovers comply with the requirements of the Contract.

7. Restrictive Clearances. Where the Method of Handling Traffic includes detours and construction activities at bridge structures, the Project Engineer will verify that the appropriate signing has been provided and check for restrictive vertical and lateral clearances (see Appendix D). Consider the following:

    a. Vertical Clearance. If a vertical clearance of less than 16 feet six inches is necessary, verify that the condition is appropriately signed and notify Craig Smith (craig.smith@state.co.us) and Dan Wells (dan.wells@state.co.us) in the Maintenance and Operations Branch immediately by electronic mail. The subject line of the message should read “RESTRICTION ALERT.” Include the following information in the body of the message:

        i. highway number,
        ii. beginning mile post for the restriction,
        iii. ending mile post for the restriction,
        iv. direction of travel that is restricted,
        v. restriction description (e.g., vertical, lateral),
        vi. beginning date and approximate time of restriction, and
        vii. name and phone number of contact for the project restriction.

Note that the ending date of the restriction is an approximation. Although, the restriction will not be removed from the report until notification of the end of the project, an estimate assists the permit writers in answering queries about the restriction.

b. Lateral Clearance. If a restriction to the existing lane width or shoulder is necessary, immediately notify the Maintenance and Operations Branch by electronic mail as previously discussed for vertical clearance restrictions.

c. Advance Notice. Provide the Maintenance and Operations Branch with as much advance notice as possible to allow them to properly notify permit holders. As soon as the Contractor provides any indication that height or width restrictions will be necessary, immediately use the notification procedures contained in Construction Manual subsection 630.2.4, number 7, paragraphs a. and b. Additionally, notify the Maintenance and Operations Branch when the restriction may be lifted.

Vertical and horizontal clearance restrictions and the notification process must also be discussed at the Preconstruction Conference.

For Local Agency projects, the Local Agency Project Manager must make the required notification to the CDOT Maintenance and Operations Branch as described above, and must also send a copy of the notification to the CDOT Resident Engineer.

630.2.5 Responsibilities of the Traffic Control Supervisor

The Traffic Control Supervisor is an individual other than the Contractor Superintendent and must have a current Flagger's Certificate and certification from the American Traffic Safety Services Association or the Colorado Contractors Association. The following is presented to assist the interpretation of subsection 630.10 of *Standard Special Provision, Revision of 630 – Construction Zone Traffic Control* and to ensure statewide uniformity in administration. The Traffic Control Supervisor is responsible for the following:

1. Method of Handling Traffic. The Traffic Control Supervisor will prepare, revise as needed, and implement each Method of Handling Traffic in accordance with the Traffic Control Plan. Each Method of Handling Traffic must designate the traffic control operations and devices necessary for its respective phase of construction. The Method of Handling Traffic must be submitted on 8.5-inch by 14-inch or 11-inch by 17-inch paper for convenient use by project personnel. The Traffic Control Supervisor will provide multiple copies of the Method of Handling Traffic for distribution to the Contractor and all subcontractors that are involved in the construction phase. See Section 630.2.4 for guidance on reviewing Methods of Handling Traffic.

2. Communications. The Traffic Control Supervisor will provide Traffic Control Management on a 24-hour-per-day basis. The required minimum level of communications include:

    a. Contractor. The Traffic Control Supervisor will communicate with the Contractor to determine what traffic control measures need to be provided by subcontractors and material suppliers.

    b. Local Agencies. The Traffic Control Supervisor will inform local police and fire agencies of any lane closures or delays. Regular updates are required as operations change.

    c. Emergency Contact Numbers. The Traffic Control Supervisor will provide emergency contact numbers of Contractor and CDOT personnel to local police and fire agencies. This allows the proper project personnel to be notified in case of an emergency on the project during working or non-working hours.

    d. Response Time. During non-working hours, the Traffic Control Supervisor, or designee, will respond to the site within 45 minutes of notification; however, if not certified, a certified respondent must arrive at the site within two hours of initial notification.

3. Inspections. The Traffic Control Supervisor, or certified designee, will inspect traffic control devices on each calendar day that they are in use, masked, or turned away from traffic. These inspections will include at least one night inspection per week. Verify that the proper type and number of traffic control devices are located and arranged as designated on the active Method of Handling Traffic. Check devices for damage, undesirable relocation, and acceptable visibility. Ensure that lights and flashing beacons are functioning properly. Supervise the cleaning of devices as frequently as necessary to preserve legibility and retroreflectivity. All devices must be cleaned a minimum of once every two weeks.

4. Traffic Control Inspection Diary. The Traffic Control Inspection Diary must be signed by the person that conducted the inspection (i.e., Traffic Control Supervisor or certified designee). The Traffic Control Inspection Diary must contain a statement certifying that all traffic control devices are clean and properly maintained and include the following information:

    a. date and time of inspection;
    b. project number;
    c. list of flaggers and hours;
    d. uniformed traffic control hours used;
    e. Method of Handling Traffic used;
    f. weather conditions;
    g. interference with normal traffic flow,
    h. detours in use;
    i. work performed by Contractor, subcontractors, or utility companies;
    j. location of flagging stations and flagging hours,
    k. problems encountered and corrections made;
    l. crashes or other incidents involving the traveling public;
    m. types and quantities of traffic control devices used;
    n. maintenance or cleaning performed on the traffic control devices; and
    o. any unusual conditions, significant delays or problems encountered during the day.

5. Project Meetings. The Traffic Control Supervisor will attend all project scheduling meetings. This will help ensure that the Traffic Control Supervisor is properly informed of the planned operations so that an appropriate Method of Handling Traffic can be developed. Any conflicts in traffic control between subcontractors should be addressed at project scheduling meetings.

6. Relief Flagging. The Traffic Control Supervisor will not act as a flagger, except in emergency situations or when it is necessary to relieve the stationed flagger for a period of a half hour or less (e.g., lunch breaks, rest periods). Relief flagging will be performed only when such action will not interfere with the normal duties of the Traffic Control Supervisor; otherwise, another certified flagger must be provided.

630.2.6 Flagger Certification

All flaggers on CDOT projects must possess a Flagger's Certification Card in accordance with subsection 630.14 of the *Standard Specifications*. Subsection 630.14 requires that all flaggers on CDOT projects be properly certified, having successfully passed the Department's minimum training requirements within two years of starting work on the project. The Department's minimum training requirements are defined in *CDOT Procedural Directive 306.1 – Flagger Training and Certification Program*. Note that CDOT does not certify non-CDOT employees for flagging duties. The certification requirements include reviewing the latest edition of the *CDOT Flagger's Training Manual*, viewing a flagger training video, and obtaining a passing score of at least 80 percent on a Flagger Proficiency Test, which must be administered by a Registered Flagger Proctoring Agency. Contact the Project Development Branch for a list of Registered Flagger Proctoring Agencies. Public or private entities desiring to become a Registered Flagger Proctoring Agency may contact the Department as follows:

Colorado Department of Transportation
Safety and Traffic Engineering Branch
Work Zone Safety Program
Attn: Work Zone Safety Coordinator
4201 E. Arkansas Ave.
Denver, CO 80222
(888) 639-3271
dot_cdot_flagger@state.co.us

630.3 INSPECTION GUIDELINES

Use the Traffic Control Review Form to inspect the construction zone traffic control provided by the Contractor, and consider the guidelines presented in the following Sections.

630.3.1 Traffic Operations and Project Documents

Verify that the following documents are available at the project site:

1. *Manual of Uniform Traffic Control Devices*. Check that a current version of the *Manual of Uniform Traffic Control Devices* with up-to-date Federal Highway Administration revisions and current CDOT supplement is readily available.

2. Plans. Verify the availability of the Traffic Control Plan sheets, *CDOT M&S Standard Plans*, and detour plan and profile sheets, where applicable.

3. Method of Handling Traffic. Inspect traffic control operations for compliance with the approved Method of Handling Traffic. Verify that each Method of Handling Traffic addresses the following (see Section 630.2.5):

    a. approved by Contractor and CDOT for each construction operation,
    b. tabulation of traffic control devices and flaggers,

c. match CDOT Form 568 for location and approved speed limitations,
d. provide for emergencies, special events, and non-vehicular traffic,
e. provide for access, median crossings, and turnaround locations.

4. Flagger Certifications. Ensure that current and proper certifications from the American Traffic Safety Services Association or the Colorado Contractors Association are provided for the Traffic Control Supervisor and all flaggers. See Section 630.2.6 for additional information on flaggers.

5. Emergency Contacts. Verify that 24-hour Contractor emergency phone numbers are provided for the Traffic Control Supervisor and response personnel. Ensure that the appropriate Contractor and CDOT numbers are given to the Local Agency. As needed, contact the Local Law Enforcement Agency and request copies of any crash reports involving work zone traffic control. Review the crash reports and determine if improvements are warranted.

6. Speed Reductions. Verify that a CDOT Form 568 – Authorization and Declaration of Temporary Speed Limits has been approved for requested speed reductions, and ensure the a copy of the approved form is retained in the project files.

7. Traffic Control Review. Verify that a Traffic Control Review is performed at least once per calendar year.

630.3.2 Traffic Control Supervisor

Verify that the Traffic Control Supervisor is available on the project as required, is appropriately dressed (e.g., reflectorized clothing at night), and making and documenting periodic project inspections, day and night, as required (see Section 630.2.5). Consider the following:

1. Project Documents. Check that the Traffic Control Supervisor has a copy of the documents presented in Section 630.3.1.

2. Certifications. Know if an American Traffic Safety Services Association or a Colorado Contractors Association certification will require renewal during the course of the project. Ensure that the Traffic Control Supervisor has a current flagger certification if used as a relief flagger (see 630.2.6).

3. Inspections. Ensure that night inspections are being conducted and properly documented. Check that device cleaning and maintenance activities are being properly documented.

4. Daily Diary. Verify that the Traffic Control Supervisor is submitting a daily diary. Check that the diary properly reports problems and unsafe conditions, crashes, flagging and device quantities for the active Method of Handling Traffic, including any changes. Verify that discrepancies, as noted in the diary, have been corrected in a timely manner.

630.3.3 Flaggers

During construction, check the following with respect to flaggers:

1. Certifications. Verify that current and proper flagger certifications are provided. Check that the card matches the person. Know if the certifications will require renewal during the course of the project. See Section 630.2.6 for additional information.

2. Dress/Equipment. Check the flaggers' dress and equipment to ensure compliance with the *Standard Specifications* and the *Manual of Uniform Traffic Control Devices*. Pay particular attention to compliance of the following:

    a. Fluorescent orange-red or fluorescent yellow-green hardhat and vest of the proper type of material,
    b. correct size and shape of "Stop/Slow" paddle, and
    c. proper reflectorized clothing and equipment for night operations.

CDOT currently requires all of our CDOT-employed highway construction and maintenance workers, including CDOT flaggers, to wear high-visibility vests and hardhats with background material color either fluorescent orange-red or fluorescent yellow-green as defined in the latest version of the ANSI/ISEA standard (see CDOT Procedural Directive 80.1).

3. Methods. Check that proper flagging methods are being used.

4. Location. Check flagger location as follows:

   a. flagger facing oncoming traffic,
   b. visible to oncoming traffic,
   c. proper distance in advance of the work, and
   d. flagger station illuminated during night operations.

630.3.4 Construction Signing

The American Traffic Safety Services Association publication *Quality Standards for Work Zone Traffic Control Devices* may be used as a guideline when inspecting signing and traffic control devices. Inspect construction signing for proper installation and satisfactory condition. Consider the following:

1. Contract Plans and Specifications. Ensure that signs conform to the Contract, including the *CDOT M&S Standards* and the *Manual of Uniform Traffic Control Devices*. Pay particularly attention to compliance of the following:

   a. size, shape, and color;
   b. retroreflective sheeting; and
   c. appropriate location.

2. Traffic Control Plan/Method of Handling Traffic. Verify that signs and devices conform to the Traffic Control Plan and the active Method of Handling Traffic.

3. Sign Condition. Check that the signs are clean, legible, and in good repair.

4. Breakaway Bases. Check for required breakaway bases on post mounted signs.

   Posts that do not meet these conditions should be rejected and replaced.

   Please see CDOT Standard Plan S-614-5, sheet 1 of 2, for clarity.

5. Temporary Signs. Check that temporary signs are properly weighted, mounted, and at the correct height.

6. Stored Signs. Signs not in use should be properly stored. Check that signs are:

   a. lying flat, including the base;
   b. beyond the shoulder;
   c. outside the normal roadside recovery area; and
   d. not on landscaped areas or sidewalks.

7. Conflicting Signs. Ensure that conflicting permanent signs are properly masked.

8. Retroreflective Sheeting. Confirm that that sign and barricade sheeting placed on the project is in compliance with the *CDOT Construction Zones Retroreflective Sheeting Materials Guide*. The Safety and Traffic Engineering Branch, in conjunction with the FHWA, has developed this publications to facilitate inspection of the proper application of retroreflective sheeting materials on CDOT projects. The publication contains samples of retroreflective sheeting that are approved by CDOT and FHWA and will be updated as needed. Contact the Safety and Traffic Engineering Branch at (303) 757-9654 for additional information.

630.3.5 Traffic Control Devices

Traffic control devices are used to warn the traveling public of hazards, advise them of the proper path through the work zone, delineate areas where they may not operate, and

separate them from construction workers. The effectiveness of these markings depends on their visibility upon installation and throughout the life of the project. Because it is not practical to require new devices to be installed on each construction project, the American Traffic Safety Services Association has published the document *Quality Standards for Work Zone Traffic Control Devices* as guidance to use in assessing the quality of traffic control devices used in construction zones. Copies of this publication can be obtained by contacting the Safety and Traffic Engineering Branch at (303) 757-9654.

Work zone devices designated by FHWA as Category I, II, or III, shall meet NCHRP 350 requirements. Devices designated as Category IV, including but not limited to portable or trailer-mounted devices such as flashing arrow panels, temporary traffic signals, area lighting supports, and changeable message signs, are not required to meet NCHRP 350 requirements.

Except for Category IV devices, the Contractor shall obtain and present to the Engineer the manufacturer's written NCHRP 350 certification for each work zone device before it is first used on the project.

Consider the following during the inspection of traffic control devices:

1. Flashing Arrow Panels. Ensure that flashing arrow panels are in the correct location and functioning properly. Check flashing arrow panels for:

    a. properly working lights in the correct mode,
    b. correct automatic dimming at night, and
    c. correct panel size mounted at the correct height.

2. Channelizing Devices. Ensure that channelizing devices conform to the requirements of the Contract Specifications, *Manual of Uniform Traffic Control Devices*, Method of Handling Traffic, and the project's Traffic Control Plan. Pay particular attention to the following:

    a. correct dimensions in a clean, serviceable condition,
    b. proper retroreflectorized sheeting or collars,

c. correct placement with proper taper lengths and spacing,
d. proper and functioning warning lights that are set in the correct mode, and
e. weighting by acceptable methods.

3. Concrete Barriers. Check that temporary concrete barriers are correctly placed with proper treatment at end sections. Pay particular attention to the acceptability of connecting pins and the color and retroreflectorization of sheeting.

4. Impact Attenuators. Ensure that impact attenuators are properly located and installed according to the Contract and manufacturer's recommendations including:

a. correct weight of proper material placed in each barrel, and
b. provisions for preventing filler material from freezing.

5. Quality Standards. Temporary traffic control devices are subjected to wear during use, storage, shipment, installation, relocation, and removal. A large number of worn devices on a project are unacceptable. The American Traffic Safety Services Association publication *Quality Standards for Work Zone Traffic Control Devices* should be used to assess device quality. Such assessments should be made while the devices are in storage before use on the project, during initial set up, and periodically during the life of the project. Require removal and replacement of unacceptable devices in accordance with subsections 630.02 and 105.01 of the *Standard Specifications*.

6. Flashing Beacons. The S-Standard, S-630-3, requires that flashing beacons utilize a typical 12" signal head lens with a 150 Watt lamp or approved ITE Amber LED. Do not accept an 8" lens with 110 Watt lamps. Although the 8" lens meets the requirements of the MUTCD, it does not meet the requirements of the M&S Standards and is unacceptable for use on CDOT projects.

630.3.6 Temporary Pavement Markings

Ensure that temporary pavement markings meet the requirements of the Method of Handling Traffic, striping plan, and Contract Specifications. Check temporary markings for correct placement in a timely manner, and ensure that conflicting markings have been completely removed.

630.3.7 Pilot Car Operations

Ensure that flaggers and pilot vehicles are properly equipped and located in accordance with the requirements of the *Manual of Uniform Traffic Control Devices*.