SPECIAL PROVISIONS
FOR
ERECTION OF CONCRETE ARCH SPANS

Johnson County
HDP-3715(652)--71-52

Effective Date
April 19, 2016

THE STANDARD SPECIFICATIONS, SERIES 2015, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

156030.01 DESCRIPTION

The erection of the structure and the quality in the field shall be in accordance with the best practice and shall conform to the Standard Specifications, Special Provisions and other contract documents.

A schematic erection sequence is shown on the plans and specified herein. Utilization of this sequence as presented is not mandatory. If the Contractor elects to use the construction sequence shown in the Plans, he shall ascertain for himself the practicality thereof and shall assume complete responsibility for the detailed design of the erection procedure and equipment. The Contractor shall prepare a complete erection method based on the erection sequence chosen. The Contractor shall define and analyze the loads to be supported during erection and shall submit complete detailed working and erection drawings of Contractor's elected erection sequence, including all design calculations, to the Engineer for review.

No work shall be performed above the pier footing on the concrete arch until the Contractor's complete erection sequence is reviewed and approved by the Engineer. Approval of the Contractor’s erection sequence, working drawings and plans shall not relieve the Contractor from his responsibility for performing the work required by the contract documents.

Modifications of the structure for erection purposes will be permitted only with the approval of the Engineer provided it is demonstrated that the details will have no adverse effect on the completed structure. Any additional materials required shall be provided at no additional cost. Complete details and stress computations will be required for all revisions to the Plans. The Contractor shall present for the Engineer's approval all proposed modifications to details shown on the contract drawings. All details and stress computations submitted by the Contractor shall be prepared by a Professional Engineer licensed in the State of Iowa with proven erection engineering experience in complex arch and post-tensioned bridge design and construction.

The safe erection of the bridge is the sole responsibility of the Contractor. Neither the Contractor's use of an erection procedure similar to that shown on the plans, nor the review of the Contractor's erection plans and procedures will relieve the Contractor of this responsibility.

156030.02 ERECTION MANUAL

The Contractor shall prepare a complete Erection Manual which describes each stage of erection in order to complete the construction in accordance with the contract documents. The Erection Manual and all designs and detailing work (working drawings), geometric control and erection sequence stress calculations shall be prepared, approved and signed by a Professional Engineer licensed in the State of Iowa.

The Contractor is referred to the design specifications and loads shown on the plans. When preparing erection design stress calculations for working and erection drawings, consideration shall be given to those forces which are "locked-in" to the structure based on the Contractor's proposed erection sequence.

The following shall be performed by the Contractor and will be subject to the Engineer's approval:

A. General

1. Prior to his analyses, the Contractor shall meet with the Engineer to discuss the proposed erection procedure, erection design criteria, and structure capabilities to support the proposed erection scheme. The Engineer will review the preliminary erection procedure proposal for general compliance with the contract requirements.

2. At the contractor's option, the Contractor's Erection Engineer may provide the results of a preliminary analysis prior to beginning the erection analysis. The preliminary analysis is not required to consider the various stages of erection of time dependent effects.

3. The Contractor's Erection Engineer shall develop an erection analysis that consists of a staged construction computer analysis of the proposed construction sequence. This analysis shall include the step-by-step accumulation of the forces, stresses, and displacements of the structure as it is sequentially erected. The analysis shall consider the effect of any required temporary shoring and the addition and removal of construction loads. Time dependent effects, such as long term losses from concrete creep and shrinkage and steel relaxation, shall be included in the analysis. This analysis shall be used to provide the step-by-step values required in the Erection Manual below.

4. The Contractor's sequence of construction shall ensure the intermediate static and dynamic stability, including wind stability, of the structure for the various stages of the construction.

5. The Contractor shall develop and submit to the Engineer a complete description of, and stress calculations for the proposed process and sequence of erection including the location of falsework supports and/or other temporary works or bracing, and positions and weights of equipment which may be supported by the partially erected structure in sufficient detail to allow review of the effects of the erection procedure on the structure. At no time shall the stresses in the permanent structure be permitted to exceed those permitted by the AASHTO LRFD Bridge Design Specifications. Alternative design codes may be permitted for the design of temporary works with the approval of the Engineer.

6. The Contractor shall submit to the Engineer the detailed design of all erection equipment, falsework, temporary erection towers, cables and bracing and other items as required for erection. It is anticipated that temporary lateral bracing will be required on the floor system and the arch until the deck is composite.

7. The proposed Erection Manual shall include, but not limited to:

- Complete detailed design of:
  - All erection equipment to be used on site

- Falsework
- Erection towers
- Falsework removal plan
- Crane mats and locations
- Temporary bracing
- Temporary bearings (if used)
- Temporary shoring (including global stability analysis)
- Other items as required for construction of the footings, arch rib, tie girder, knuckles, floorbeams, columns and hangers
- Installation procedure and schedules for all temporary falsework, erection towers and other temporary works
- Camber of the concrete arch spans

- Methods and procedures for erection including:
  - Sequence for installing temporary falsework, erection towers and erection jigs.
  - Methods and procedures for casting concrete in the dry.
  - Sequence, methods and procedures of construction of the concrete arch spans including but not limited to the arch ribs, columns, knuckles, tie girders, floorbeams, hangers and slabs.
  - Sequence, method and procedure for removing temporary falsework, post-tensioning and transferring loads to the hangers.
  - Sequence, method and procedure for post-tensioning tendons, stressing and grouting.
  - Details indicating provisions for stability and adjustability of the partially erected arch during the various stages of construction.
  - Sequence, method and procedure for vertical displacements of the tie girder at the abutments.
  - Sequence, method, procedure and load verification method for the hangers' tensioning.
  - Sequence, methods and procedures for temporary shoring.

- Computations shall consist of step-by-step values for, but not limited to:
  - For the proposed erection procedure, provide the calculated shear, moments and axial forces at the arch rib and tie girder work points and locations midway between the work points shown in the Plans. Include forces on the slab, tie girder, knuckles, arch rib, columns, floorbeams, footing and drilled shafts. For the composite floorbeam and tie girder members, keep track of the accumulation of forces on the floorbeam and slab and tie girder and slab separately as the erection progresses.
  - For the proposed erection procedure, provide the service stresses at the work points and the locations midway between the work points shown in the Plans. Include stresses on the slab, tie girder and floorbeams. Keep track of the accumulation of stresses on the floorbeam, tie girder and slab separately.
  - For the proposed erection procedure, provide the primary and secondary post-tensioning tendon stresses at the work points and the locations midway between the work points shown in the Plans.
  - For the proposed erection procedure, provide minimum required concrete strengths for each stage.
  - For the proposed erection procedure, provide the hanger axial force and hanger length calculations.
  - For the proposed erection procedure, provide the minimum and maximum vertical and horizontal reactions at all temporary and permanent supports.
  - For the proposed erection procedure, provide the temporary lateral bracing forces.
  - Verification that the permanent structure is not overstressed during the proposed erection sequence. At no time shall the stresses in the permanent

structure be permitted to exceed those permitted by the AASHTO LRFD Bridge Design Specifications.
- For the proposed erection procedure, provide the camber at the locations shown in the Plans. Provide camber for the tie girder, knuckles, arch rib, columns, floorbeams, footing consistent with proposed erection sequence and the target camber values described below.
- Details of geometric control, anticipated deflections, elevations, and adjustments required shall be shown for each erection stage.
- If the Contractor's proposed erection sequence is different than what is shown in the plans, verification of the erection sequence on the permanent structure shall be required. This would include checking for compliance with AASHTO LRFD design for the strength and service load cases for operating loads at the beginning of service and 30 years after construction.
- Design of any temporary foundations required to support falsework, erection towers and crane mats.
- Design of all temporary falsework, erection towers and temporary bracing and sub sequent temporary connections to the permanent structure.

- Provide complete detailed working and erection drawings for all elements discussed above.

- Provide temperature adjustments where temperature changes the geometry or force distribution for a construction operation.

B. Concrete Construction in the Dry

The Contractor shall submit to the Engineer the detailed design and working drawings of the chosen method to erect the footing and the arch free from river water, debris and other contaminants in accordance with Sections 2403 and 2405 of the Standard Specifications. Methods to construct the concrete in the dry for the footing and the arch may include cofferdams, watertight forms or other suitable methods. The level of flood protection for cofferdams is at the risk of the contractor. Erection equipment, falsework, cofferdam, watertight forms, cables and bracing and other items as required for erection of concrete in the dry shall be included in the submittal.

C. Hangers

1. Based on the Contractor's construction equipment and procedures, the Contractor shall compute and prepare tables of anticipated tension in each hanger at corresponding stages of erection including, but not limited to the stages of self-weight, deck placement and after full dead load including deck, concrete parapets, railings and utilities are imposed. The tables of anticipated hanger tensions and computations shall be submitted to the Engineer as described above.

2. If hanger forces exceed the design forces as shown in the plans, the Contractor shall investigate the adequacy of all hangers, hanger components and anchorages. Cost for any and all additional material required shall be borne by the Contractor.

3. Final hanger adjustment and tension verification per the tolerances listed below, shall be performed after all other dead loads are in place.

D. Slab Pouring Sequence

A bridge deck concrete placement sequence is shown in the plans. An alternate placing sequence may be submitted for review, however the deck stresses must be less than the tension requirement of 0.24*SQRT(f'c) at all stages of construction and 0.0948*SQRT(f'c) at the beginning of service and when the bridge is 30 years old. Deck compression and tension stresses shall be checked for Service I and Service III load combinations in accordance with the design criteria on the plans for final design loads. In either case, the erection plan shall include

the Contractor's proposed deck placement sequence including screed support locations, deck placing sequence, proposed bulkheads, placement rates and the desire for concrete admixtures such as high-range water reducers or retarders.

E. Precast Floorbeams

The Contractor shall handle the precast floorbeams such that they are maintained in an upright position at all times. The precast floorbeams must be picked up at points located no more than 3 feet from the ends. The Contractor is responsible for lifting loops as required for transportation of the precast floorbeams. The Contractor is responsible for floorbeam stability at casting yard, during transportation to the jobsite, and during erection with the final structure. The Contractor shall submit shop drawings showing complete details of the precast floorbeams including reinforcing steel and calculations for determining the required elongations of the prestressing tendons to provide the necessary tensile force.

F. Submittals

1. The Contractor shall submit all components of the Erection Manual sufficiently in advance of the start of construction to allow the Engineer a 60-calendar day review period. The review period shall begin on the day the submittal is received by the Engineer. All submittals not approved and requiring re-submittal shall be subject to the above review time period, with the review time beginning anew for each such re-submittal. Work for the erection of concrete arch spans above the pier footings shall not begin prior to the Erection Manual returned to the contractor as “no exceptions taken”.

2. Computations, working drawings and erection plans shall be submitted in a neat and organized manner which is easy to follow.

3. Review of temporary works is subject to the same review periods as defined for other components of the structure.

156030.03 CONSTRUCTION

A. Submittal Approval Procedure

The proposed erection sequence shall be subject to the following approval procedure:

1. The Engineer will review the preliminary erection procedure proposal for general compliance with the erection requirements outlined in this Special Provision.

2. The Contractor shall develop and submit to the Engineer a complete description of the proposed procedure and sequence of erection. This submittal shall be of sufficient detail to permit review of the erection procedure for the structure as required above.

3. The Contractor shall develop and submit to the Engineer a complete Erection Manual in accordance with the requirements in this Special Provision.

4. After the Engineer reviews the process and sequence of erection, the Contractor shall submit to the Engineer for review, detailed design and details of all falsework, temporary shoring and bracing, temporary anchorages, and other items as required.

B. Geometric Control Plan

The following shall be performed by the Contractor and will be subject to the Engineer's approval.

1. The Contractor shall be responsible for geometric control of construction so that the completed structure will conform to the lines, grades, dimensions and hanger forces shown

on the Plans. The hangers shall conform to the requirements indicated in the Special Provisions for Hanger Assembly.

Camber shall be adjusted by the contractor based on the Contractor's approved erection method. Vertical geometry of the concrete arch spans shall be set such that at 2000 days from beginning of arch erection with the assumed erection scheme concluding with in the contracted project schedule, final theoretical vertical geometry is achieved when considering time dependent effects.

2. The structure shall have a geometric configuration at 50°F normal temperature in general conformance with the dimensions shown on the Plans for the dead load condition. Temperature effects play a role in the structural analysis and geometry control and shall be included.

3. The tolerances for construction shall be in accordance with AASHTO LRFD Bridge Construction Specifications 3rd Edition, with 2015 interims, Section 11 of ACI 117, the Standard Specifications and special provisions. If the tolerances are in conflict, the Special Provisions and Standard Specifications take precedence.

4. Final adjustments shall be made to the hangers to obtain the dead load hanger force within the following tolerances.

- Hangers shall be adjusted for the dead load condition such that each individual hanger shall not exceed ±5% of the hanger dead load computed from approved working drawings. It is possible that one individual hanger may have to be adjusted to lesser tolerances to prevent stress in other hangers from exceeding the ±5% tolerance.

- Pairs of hangers at a single anchor point shall be adjusted such that each individual hanger shall not exceed ±10% of the force in the adjacent hanger.

- The hanger cross sections and geometric lengths shown on the plans are for the convenience of the Contractor only. Final fabrication lengths shall be calculated by the Contractor after erection loads and methods are known and detailed erection stress calculations have been completed. The tolerance in the fabricated length of the hanger in the 20% stressed condition shall be +/-25% of the socket adjustment length as measured from its centermost position.

5. An absolute tolerance in the tie girder elevation at the centerline of bridge span shall be +1 inch, -0 inch provided that the tie girder elevation at other major working point stations (hanger attachment points) shall follow, within a tolerance of ± ½ inch, a smooth parabolic curve passing through the final tie girder elevation at the centerline of bridge.

6. The geometry of the arch rib shall be within +/- ½ inch in any direction but in no case more than a total differential of ½ inch between adjacent arch rib construction joints.

7. Hanger assembly shall be within +/-0.5 degrees of the plane of the arch in any direction.

8. Post-tensioning tendon at all locations shall be within +/- ¼ inch vertically. Lateral location of tendons in the slab shall be within +/- ½ inch. All other locations shall be within +/- ¼ inch laterally. Other post-tensioning tolerance shall be in accordance with section 10.4 of AASHTO LRFD Bridge Construction Specifications.

9. Precast floorbeams shall be set in place with a tolerance of +/- ¼ inch. The placement of the post-tensioning tendons for the cast-in-place portion shall be considered in the orientation of the precast floorbeam. The maximum deviation from the centerline of the

cast-in-place tendon relative to the precast floorbeam shall be +/- 1/4 inch. The tolerances for setting floorbeam and tendon alignment are not additive.

10. Vertical bearing displacements at the abutments caused by jacking shall be within +/- 1/16 inch.

11. The Contractor shall monitor the deflections in the permanent structure caused by the erection process, and report values to the Engineer for evaluation. The procedures are to be listed in the geometric control plan below. The Engineer will be the sole judge of the degree of compliance or the erection process with the requirements specified herein.

156030.04 METHOD OF MEASUREMENT

No separate measurement will be made for Erection of Concrete Arch Spans.

156030.05 BASIS OF PAYMENT

No separate payment will be made for Erection of Concrete Arch Spans. The cost of furnishing all equipment, materials, and labor and performing all work required for erecting the arch spans, as prescribed above and as shown on the plans, will not be paid for separately and all costs shall be included in the contract price bid for Structural Concrete 4500 PSI or Greater.