GENERAL SUBJECT: Post-Tensioned Bridge Structures

SPECIFIC SUBJECT: General Requirements for the Usage, Design and Specification of Substructures Supporting Post-Tensioned Bridge Superstructures

SUPERSEDES: None

DIVISION ADMINISTRATOR APPROVAL: 
/original signed/
Kendal R. Walus, P.E.
State Structure and Bridge Engineer
Approved: December 13, 2016

This Memorandum is effective on December 13, 2016.

REFERENCES:
IIM-S&B-93 Minimum Inspectability Requirements for Post-Tensioned Bridges
IIM-S&B-80 for additional load requirements for post-tensioned elements

GENERAL:
This IIM is not intended to replace AASHTO LRFD Bridge Design Specifications, 7th ed., VDOT 2016 Road and Bridge Specifications, FHWA, Post-Tensioning Institute (PTI), American Segmental Bridge Institute (ASBI) or other VDOT requirements. It is to clarify issues related to post-tensioning, supplement existing requirements, and provide guidance toward designing, and detailing a structure.

DESIGN AND DETAILING:
The bridge substructure and layout shall be developed to minimize long term maintenance and inspection costs for VDOT. Bridge elements shall be designed and detailed to ensure the easiest access for inspection, evaluation, repair and retrofit consistent with ensuring long-term maintenance, inspection and repair of the structure.
SUBSTRUCTURE ELEMENTS:

Post-tensioning shall not be used in substructures, with the exception of post-tensioning in cylinder piles. Concrete cylinder piles shall conform to the Special Provision for Concrete Cylinder Piles for Design-Build and PPTA Contracts.

Substructures supporting post-tensioned superstructures shall comply with the following requirements:

Multi-column piers:
Conventionally reinforced concrete pier columns shall each have a minimum cross sectional area of 19.5 square feet and least dimension of 3'-0" for rectangular column.

Single column piers (hammerhead or flared piers):
The cross sectional area of hammerhead pier columns shall have a minimum dimension of 5'-0" and shall not be less than 50 square foot.

Wall piers (including paired wall piers):
- The minimum wall thickness shall be 3'-0".
- The wall slenderness ratio (b/t)* shall not exceed 15.

H-shaped piers:
- The minimum wall thickness shall be 3'-0".
- The wall slenderness ratio (b/t)* for each wall shall not exceed 15.

Hollow column pier:
- Hollow columns shall be solid from the foundation to either 10'-0" above ground or 10'-0" above Mean Higher High Water, whichever is higher.
- Cross sections above the solid section shall conform to the following in addition to requirements of AASHTO:
  - Wall thickness shall be not less than 1'-3"
  - Wall thickness shall be uniform except that fillets, not less than ½ the thickness of the wall shall be provided in all corners
- Hollow columns shall conform to the inspectability requirements of IIM-S&B-93.

Abutments supporting Post-Tensioned Superstructures:
- Abutments supporting post-tensioned superstructures shall not include post-tensioning.

* Refer to AASHTO LRFD Bridge Design Specifications, 7th ed., Section 5.3 for definitions of b and t.
SPECIAL PROVISIONS and SUPPLEMENTAL (SPECIFICATIONS)

See: Appendix A

CC: Chief Engineer
Division Administrators
District Administrators
District Construction Engineers
District Maintenance Engineers
Assistant State Structure and Bridge Engineers
District Structure and Bridge Engineers
Residency Administrators/Engineers
Structure and Bridge Program Managers
FHWA: Bridge Section
APPENDIX A

Special Provision for Concrete Cylinder Piles for Design-Build and PPTA Contracts

Special Provision for Carbon Fiber Reinforced Prestressed Concrete Piles for Design-Build and PPTA Contracts

Special Provision Copied Note for Stainless Steel Strand for Design-Build and PPTA Contracts
I. DESCRIPTION

The work covered under this section includes the furnishing of plant, labor equipment, appliances and materials and the performance of operations in connection with the installation of prestressed pre-tensioned concrete cylinder piles or prestressed post-tensioned concrete cylinder piles.

The work includes, but is not limited to, furnishing equipment and supporting structure for driving prestressed concrete cylinder piles, of either type, including all material, labor, equipment, and all else necessary to construct any temporary supporting structure necessary or pre-boring necessary for driving prestressed concrete cylinder piles.

II. REFERENCES

2016 VDOT Road and Bridge Specifications
AASHTO LRFD Bridge Design Specifications, 7th Ed. and VDOT Modifications

III. MATERIALS AND FABRICATION

A. General

1. The required overall length of pile shall be achieved either by casting a pre-tensioned pile in one piece to the required length or by post-tensioning short segments into a single pile at the manufacturing plant.

2. Materials shall comply with the latest revisions of the Specifications and tests of ASTM, ACI, and PCI, PTI and the additional requirements shown on the Approved for Construction (AFC) Plans, Specifications, the Supplemental Specifications, and these Special Provisions.

B. Cement

Cement in cylinder piles and buildups shall conform to Section 217 Class A5.

C. Concrete

1. Concrete in cylinder piles and buildups shall conform to Section 217 Class A5.

2. Concrete shall contain either 5.4 gallons per cubic yard of calcium nitrite conforming to Section 215, or 2 gallons per cubic yard of calcium nitrite with granulated iron blast-furnace slag (minimum 40 percent by weight) or silica fume (minimum 7 percent by weight) conforming to Section 215.

D. Post-Tensioning Grout

Cement grout where used in prestressed piles shall be of materials which conform to the requirements stipulated herein for cement, sand, admixtures, and water. Admixtures shall conform to Section 215 of the Specifications. Neat cement grouts used in bonding post-tensioned tendons shall conform to Class B in PTI M55-1.12(13) Table 3.1 PILE JOINTS.

The bonding agent for the pile joints shall conform to Specifications Section 403.03 (b) 5.

E. Prestressing Reinforcement

Prestressing use for either pre-tensioning or post-tensioning piles shall conform to one of the following based on the pile exposure:
1. If top of pile is 3'-0" or more below the mudline after 100 year scour event or the prevailing ground elevation after scour is above MHHW + 5'-0", carbon steel strands for prestressing shall be in accordance with the Special Provision for Prestressing Steel in Post-Tensioned Structures for Design-Build and PPTA Contracts.

2. If the top of pile is between 3'-0" below the mudline after the 100 year scour event or the top of pile is below MHHW + 5'-0" then prestressing strands shall conform to one of the following
   a. Stainless steel strands meeting the Special Provision Copied Note for Stainless Steel Strand.
   b. Carbon fiber reinforced polymer (CFRP) strands meeting the Special Provision for Carbon Fiber Reinforced Prestressed Concrete Piles for Design-Build and PPTA Contracts.

F. Spiral Reinforcement
   Spiral reinforcement shall meet the requirements detailed in the special provision related to the applicable strand type.

G. Anchorage
   Anchorage fittings for post-tensioned assemblies, if required, shall conform to the latest ACI 318, Building Code Requirements.

H. Protective Coating in Tidal Zone
   When stainless steel or CFRP prestressing strands and spirals are used for cylinder piles protective coatings shall not be required. In all other cases, protective coatings shall be applied to the piles in accordance with Section 404.03(i) of the Specifications.

I. Backfill
   Materials for backfill shall conform to the requirements of the Specifications Section 202.03 for fine aggregate Grade B.

IV. MANUFACTURE

A. Experience
   Prestressed concrete cylinder piles shall be manufactured by a fabricator with at least 5 years of experience in the manufacturing of large diameter cylinder piles.

B. Casting Full Length Piles
   1. Pre-tensioned cylinder piles shall be manufactured by the static-casting process.

C. Casting Sections of Piles to be Post-Tensioned
   1. Concrete used in Spun Cast piles shall be deemed to meet the requirement for SCC in the Special Provision for Carbon Fiber Reinforced Prestressed Concrete Piles for Design-Build and PPTA Contracts if it meets the paragraphs 2 and 3 below.

   2. Post-tensioned cylindrical piles shall be manufactured by the centrifugal casting process. Concrete piles manufactured by the centrifugal process shall be formed and compacted by centrifugal force in a machine of suitable type so designed that the pile molds may be rotated at sufficient speed to ensure even distribution and dense packing of the concrete without the creation of voids behind the reinforcing steel.

   3. Filling the mold and spinning shall be a continuous operation and the spinning shall take place before any of the concrete in the mold has taken an initial set. Excess water forced to the center shall be drained or expelled in a suitable manner. The concrete pile shall not be removed from the mold until the concrete has attained sufficient strength to prevent deformation.

D. Tolerances
1. Section 405.06 shall apply except as modified herein:
   a. Voids in cylinder piles shall be located within 1/8" of their detailed position for each 4 feet of inside diameter. Center of gravity of strand group location shall be located within +/- ¼" of its design location. Assimilated deviation from straightness of the pile shall not exceed 1/8" per 10 feet of length.
   b. The ends of the forms used to cast the piles shall be a true plane perpendicular to the axis of the sections with the following tolerances:
      - Maximum allowable deviation for abutting end surface: 1/8 inch
      - Maximum allowable deviation for head end surface (top of the pile): 1/2 inch
      - Maximum allowable deviation for the butt end surface (bottom of the pile): 1 inch

E. Spiral Reinforcing

Spiral reinforcing sections shall have a spiral reinforcement cage, arranged and dimensioned as shown on the Approved for Construction (AFC) Plans. This reinforcing cage shall be securely held in position during the casting or casting and spinning of the concrete.

F. Post-Tensioned Pile Longitudinal Holes

Longitudinal holes for the post-tensioning strands shall be formed during casting of the walls of the pile sections. The holes shall be 1-3/8 inch (nominal diameter) and positioned as shown on the AFC Plans. The spiral steel reinforcing shall be outside the tendon holes and shall have a minimum concrete cover as shown on the AFC Plans to the outside surface of the pile section.

G. Arrangement of Strand

The arrangement of the prestressing strand shall be in accordance with the details shown on the AFC Plans.

H. Weep Holes

One tapered weep hole shall be provided at a maximum spacing of 16'-0" or at least one per 16 feet section. The holes shall be included during the forming of the pile. The tapered diameter shall vary from 1 to 1.5 inches. Drilling of weep holes shall not be allowed.

I. Handling

The method of handling the pile sections shall be such that no permanent damage to the concrete will occur. Care must be taken in handling to insure a minimum of spalling on the section end surface. Any section which has a greater than 10 percent of the end surfaces spalled to a depth greater than 0.12 inches will be rejected. The Department and the Design-Builder’s Engineer of Record retain the right to reject any section that is unsatisfactory.

J. Post-Tensioned Pile Assembly

1. Pile sections shall not be assembled until the concrete has attained a strength of 4,000 pounds per square inch. The abutting joint surface shall be covered with a bonding agent, as specified in Section 403.03 (b) 5 of the Specifications.

2. After the bonding agent is applied, the pile sections shall be brought into contact and held together by compression while the bonding agent sets. Each post-tensioning strand shall be tensioned in accordance with the applicable Special Provision according to the prestressing strand material used. Measurement of strand tension shall be as specified in Sections 405 of the Specifications.

3. After completion of post-tensioning, the tendons shall be held by temporary anchors or mechanical end locks. Post-Tensioning shall be performed in accordance with the Special Provision for Post-Tensioning System for Design-Build and PPTA Contracts. The piles shall not be handled or moved in any manner detrimental to the pile during this period. Upon transfer of the load from jack to the temporary anchorage, the aggregate stress loss shall not
exceed an average of 10 percent in one strand or an average 5 percent of all strands in a pile.

4. The grout curing period must be sufficient to permit the removal of the temporary wire anchors without slippage of the wires in the grout.

5. Prior to the start of manufacture of any piles, the Design-Builder shall submit for approval by the Design-Builder’s Engineer of Record, complete shop drawings showing the proposed yard layout, type of equipment and sequence of manufacture to be used.

6. The transfer of the prestressing force from temporary end-locks to grouted cables shall not be done until the grout has reached a compressive strength of not less than 4000 pounds per square inch. The prestressing cables shall be considered to be without slippage with the removal of the end-locks when, upon cutting the wires between the end of the pile and the anchor, with a burning torch, the wires do not part under stress with a “cup and cone” fracture but are burned through with the torch.

K. Extensions and Splices.
   1. Splices of prestressed concrete cylinder piles will not be permitted.

L. Cut-Offs and Build-Ups.
   1. Piles shall not be driven when the head is underwater without written approval of the Department.

   2. Tops of foundation piles shall be embedded in the concrete footing at least the penetration shown on the AFC Plans. Piles shall be cut off at the designated elevation. The length of pile cut-off shall be sufficient to permit the removal of all damaged material.

   3. The distance from the side of any pile to the nearest edge of the footing shall not be less than the minimum shown on the AFC Plans.

   4. When the cut-off elevation is below the elevation of the bottom of the footing concrete or cap, the pile shall be built-up from the head of the pile to the planned cut-off elevation by means of reinforced concrete extensions as shown on the AFC Plans.

   5. Cut-offs shall be made at right angles to the axis of the pile. The cuts shall be made in clean, straight lines.

   6. Rejected and withdrawn piles and excess pile material resulting from cut-offs or other reasons, shall be removed from the project site by the Design-Builder.

M. Pile Markings
   The Design-Builder shall mark each pile, prior to driving, with painted horizontal lines at 1 foot intervals, and painted numbers indicating the number of feet from the pile tip at 5 feet intervals. Markings shall be painted around the entire circumference of the pile and the number of feet from the tip of the piles shall be painted so that they are visible from any vantage point regardless of the manner in which the pile may be oriented during field operations.

V. DESIGN AND DETAILING

A. General
   1. No square piles with voids shall be permitted.

   2. The wall thickness of cylinder piles shall be not less than 1/10 of the external pile diameter measured in inches, nor 5”.

   3. Effective Prestressing after losses shall not be less than 1ksi.

   4. Net tension stress along the axis during driving shall not be allowed.

B. Reinforcement
1. Build-ups shall be constructed using corrosion resistant reinforcing Class III where prestressing accomplished using either stainless strands or CFRP strands. Where conventional strand is used reinforcing in Build-up shall match the pile or pier cap reinforcing.

2. Under no circumstances shall stainless steel bars come into contact with carbon fiber reinforced polymer (CFRP) prestressing strands or reinforcement.

C. Capacity

1. For cylinder piles designed to resist loads other than axial compression, design shall provide sufficient moment, shear and tension connection capacity between buildup and pile and between build up and cap to meet the design demand(s).

VI. CONSTRUCTION EQUIPMENT

A. General

1. Piles in water shall be driven from a jack-up barge, platform, or floating derrick barge of sufficient size, capacity and stability to handle and install piles of the specified lengths, sizes, and dimensions shown on the AFC Plans. Jetting with the use of external jets to remove soil from outside the surface of the pile in order to facilitate pile penetration shall not be allowed. Pile shall driven using the pile-driving hammer, which meets the requirements given in this provision. In case the pile cannot driven through any hard strata with the use of a hammer meeting requirements given in Special Provisions, the soil from inside of the pile can be cleaned by use of internal jets or bailed out or air lifting or dredging methods or any other method approved by the Design-Builder Engineer of Record. Spudding from inside of the pile can also be used to aid in driving through the hard stratum. The driving equipment shall be of the type generally used in standard marine pile driving practice and operated in accordance with the manufacturer’s recommendations. The Design Builder shall verify the stability of the pile driving system, for example, consider the weight ratio of the hammer and pile to the barge carrying it when lifting and transferring the hammer weight to the pile.

2. The Design Builder’s pile driving equipment shall be capable of driving the piles to the required tip elevation and required ultimate resistance without damaging or overstressing the pile. All pile driving equipment shall be of an approved type and shall not be transported to the site without approval by the Design-Builder’s Engineer of Record.

3. Jetting with the use of external jets to remove soil from outside the surface of the pile in order to facilitate pile penetration shall not be allowed.

B. Selection of Equipment for Driving Piles

1. Thirty working days prior to delivery of the equipment to the worksite, a pile and driving equipment data form shall be submitted for approval to the Design-Builder’s Engineer of Record. At this time, for each pile supported substructure unit and hammer combination, a full initial pre-construction pile drivability wave equation analysis prepared, signed and sealed by a licensed Professional Engineer registered in the Commonwealth of Virginia shall be submitted showing that the proposed hammer will satisfactorily meet all pile installation requirements and all requirements given in special provisions. The initial pre-construction pile drivability wave equation analysis shall specifically consider all phase of pile installation, including allowance such as for spudding or removing inside soil plug as stated above.

2. Approval of the proposed driving system by the Engineer shall be based upon the pile drivability wave equation analysis predictions indicating that the proposed driving system can drive the piles to at least ten feet beyond the estimated pile tip elevation shown on the AFC Plans, and to develop at least the required nominal resistance shown on the AFC Plans at driving resistances no less than 3 blows per one inch nor greater than 10 blows per one inch, while at all times maintaining maximum compressive and tensile stresses in the piles within allowable driving stress limits. The analysis shall also indicate that the pile driving system will not damage the piles should practical refusal (as defined elsewhere herein) be encountered.
3. Approval by the Design-Builder’s Engineer of Record of the Design-Builder’s proposed pile driving system on the basis of the Design Builder’s pile drivability wave equation analysis predictions of pile driving system performance shall not relieve the Design-Builder of the responsibility to mobilize, operate, and maintain equipment that will actually perform satisfactorily in the field and meet all contract requirements for installation of the piles. Approval of the Design-Builder’s proposed pile driving system shall not relieve the Design-Builder of the responsibility for piles damaged because of misalignment of leads, failure of the cap-block or cushion material, failure of splices, malfunctioning of the pile hammer, or other improper construction methods.

4. A new pile driving system, modifications to an existing system, or new pile installation procedures shall be proposed by the Design-Builder if the pile installation stresses predicted by wave equation analysis or measured by the pile driving analyzer exceed the following maximum values:

- Compression stresses ............... 0.85 f’c – fpe
- Axial Tension stresses ...................... fpe
- Hoop Tension Stresses (during driving) .................. 3*(f’c)^0.5

Where f’c = compressive strength of concrete, fpe = effective prestress.

5. A pile installation plan shall be submitted by the Design-Builder, this plan shall include pile driving equipment, pile hammer size, type and energy, proposed driving criteria, methods of removing the inside plug, when necessary, and other details described herein.

C. Hammers

1. The pile driving hammer shall be of the size and type able to consistently deliver an effective dynamic energy sufficient to drive the piles to the estimated tip elevations and to the required nominal resistance shown on the AFC Plans.

2. For hydraulic hammers, the ram weight of the hammer shall be greater than 65 kips; the maximum stroke of the hammer shall not be greater than 5 feet; and rated energy of the pile driving hammer shall be greater than 260,000 ft-lbs. The thickness of timber cushion for the piles shall be at least 9 inches. For other hammers, such as air/steam hammers, the requirement for ram weight of the hammer and rated energy shall be increased in proportion of the efficiency of hydraulic hammer to that of the other type of hammer. However, the requirement of maximum hammer stroke of 5 feet shall remain the same. The hammer should have a variable stroke feature, so that if lower height of stroke is needed to limit the driving stresses, the hammer can be adjusted. All fuel and or stroke settings must be precisely and readily adjustable at all times during hammer operation. Diesel hammers will not be allowed to drive cylinder piles.

3. Hammers shall be provided with proper driving helmets suited for the piles. The hammers shall be maintained in good operational condition and shall be operated according to the manufacturer’s recommendations. The driving equipment shall conform to the approved driving system. Approval shall be in accordance with the Contract Documents. The manufacturer’s representative shall confirm the efficiency of the hammer in writing.

4. All necessary gages required to monitor performance of the hammer, as suggested by the manufacturer, shall be installed prior to any pile driving.

5. All piles must penetrate to the minimum tip penetrations shown on the AFC Plans and to any additional penetration necessary to develop the nominal resistance shown on the AFC Plans, unless modified by the Engineer of Record.

6. When necessary, reduce hammer energy and/or use a thicker pile cushions to prevent pile cracking during pile driving. Protection against cracking of the piles shall be the Design-Builder’s responsibility. Repair or replacement of damaged piles shall be at the Design-
Builder’s expense. When the point of the pile is being driven into firm ground, the full capacity of the hammer shall be used to develop the final driving resistance.

7. The cost of proof-load testing, repairing, or removing and replacing any defective pile shall be borne by the Design-Builder with no additional expense to the Department.

8. When an air/steam or hydraulic hammer is used, provide calibrated pressure gauges, complete with calibration certificates, positioned on the hammer side of all valves, located and graduated so as to be conveniently and safely monitored by the Design-Builder’s Engineer of Record at all times during pile driving.

D. Hammer Cap Block

Cap block material shall be made of a stable and predictable material such as aluminum, nylon, or other suitable material as approved by the Design-Builder’s Engineer of Record.

E. Helmet

The helmet shall be seated onto the pile and bear evenly and concentrically with minimum play upon the pile. The driving head (helmet) shall be sufficiently large and shallow so as not to bind the head of the pile if it twists slightly during driving. The pile head shall be free to rotate about the long axis of the pile, unrestrained by the helmet.

F. Pile Cushion

1. The helmet shall contain a ring shaped cushion pad consisting of laminated wood (plywood) placed in the pile driving helmet. The cushion shall conform to the cross sectional shape of the pile. The minimum thickness of the cushion shall be 9 inches. A new, unused pile cushion shall be placed in the helmet at the start of driving of each pile.

2. The pile cushion shall be inspected periodically during driving. The cushion shall be replaced as soon as it has reached 50 percent of its original thickness or it is evident that it has begun to smoke, burn, or otherwise deteriorate.

3. If necessary, the cushion thickness shall be increased to reduce tension or compressive stresses as determined by the pile driving analyzer.

4. Under no circumstances will the use of small wood blocks, wood chips, rope or other material be permitted for use as a pile cushion.

G. Removal of Soil Plug Inside the Pile

If, at any time, hammer blow count exceeds 120 blows per foot, stop driving and measure the depth of soil plug from top of the pile. Remove the soil plug in the pile to 3 feet from the toe and resume pile driving. Design Builder shall use one of the methods stated in the Pile Installation Plan to remove the soil plug from inside the pile. The last five (5) feet shall be driven with no disturbance to the plug.

The materials removed from inside the cylinder piles shall be contained within the turbidity curtain or removed to an upland location, designated by the Design-Builder’s Engineer of Record.

H. Spudding

1. As an alternative or in addition to removing the soil plug from inside the pile, spudding from inside the pile can be performed. The spud shall have a diameter less than the inside diameter of cylinder pile. The last five (5) feet shall be driven with no disturbance to the plug.

2. Spud shall consist of a closed ended steel pipe pile having a minimum wall thickness of 1 inch.

VII. CONSTRUCTION PROCEDURES

A. Preparations for Driving

1. Pile Installation Plan
a. At least 30 days prior to the proposed start of the pile installation, the Design-Builder shall submit to the Design-Builder’s Engineer of Record for approval, a written work plan for the installation of the piles. The work plan, which shall include the aforementioned data and the following, shall adhere to all applicable provisions of this Section.

b. The Proposed Method of Operation. A narrative step by step description of the complete pile installation process from beginning to end by numbered paragraph. The narrative shall include, but not be limited to transportation, storage, setting of the pile, jetting and driving and any other method or variation of advancing the pile and removal of the driving frame. The number and type of personnel, including the foreman and supervision, as well as job task shall be set forth.

c. Experience. The experience of the firm driving the piles and the key personnel, who will be in charge of the pile installation, shall be identified. Resumes of both the firm and the key personnel showing experience with large diameter prestressed concrete cylindrical piles on 5 projects or similar size and scope with in the last 10 years shall be submitted for approval to the QAM. At least one person in the approved qualifications submission shall be present on site during all pile operations. The name(s) of such person(s) shall be given by the Design Builder in the pile installation plan.

d. Proposed mode of transportation from the supplier of piles to the site, together with a list of incidental permits that may be required for the transportation, shall be provided. When applicable, computations regarding stability of the piles during transportation and installation shall be submitted in accordance with the Special Provision for Stability to the Department for review. The proposed schedule of delivery to the site shall also be provided. The pile installation plan shall also indicate the intended location for storage of the piles at the site.

e. The proposed methods and equipment to move, lift and install the piles: This description shall include barges, access roads, temporary trestles, crane locations and type, and all relevant details essential to demonstrate the feasibility of the proposed scheme and support the proposed schedule of installation. Placement of fill or embankment in the water will not be permitted. The Design-Builder shall take into consideration that the channel water currents could impact the stability of the construction equipment.

f. A schedule of installation of all the piles, indicating the time allocated for manufacturing, transporting and installing the piles. The schedule shall indicate the proposed order of installation of the piles and the estimated time required to install each pile.

g. Contingency Plan: A plan for any interruption to the advancement of the pile resulting from equipment breakdowns or failures, accidents, resistance, need to change or improve method of advancing the pile, encountering of rocks, boulders, debris, or other buried objects and other unanticipated events.

h. Discontinuance Plan: A plan for discontinuing the pile driving due to damage to the pile, or inability to reach acceptance criteria or should the criteria set forth in the Project Specific Technical Specifications (PSTS) for Instrumentation and Monitoring of Adjacent Structures and Facilities be exceeded.

(1) The pile manufacturer’s structural details for the piling, section and assembly descriptions, in the form of shop drawings and working drawings, shall be adhered to in every respect for the work to be performed under this Contract.

(2) Production piles shall be installed by the same methods and equipment as those used for installation of driving test piles.

B. Order List of Piles

Production piles shall be furnished in accordance with the provisions of Section 403.05.

C. Handling, Storage and Erection
1. The Design-Builder shall comply with Section 403.03(b)4 of the Specifications except that the lifting and support points for the piles shall be determined by the Design-Builder and submitted to the Design-Builder’s Engineer of Record for approval.

2. The pile driving hammer shall be in good condition and be capable of delivering the maximum blows per minute required by the manufacturer's specifications.

3. The Design-Builder shall reduce the ram velocity or stroke during early driving when light soil resistance is encountered. At the first sign of soft driving, the Design-Builder shall reduce the ram velocity or stroke to avoid critical tensile stresses. The pile point shall be well seated with moderate soil resistance at the point before full driving energy is used.

4. Prior to lifting and driving, the Design-Builder shall inspect the full length of the pile to ensure that the top of the pile is perpendicular to the longitudinal axis of the pile, that no damage to the concrete is present, and that no strands or reinforcing is protruding from the head, sides, or corners of pile head. No piles shall be used that show any cracks prior to installation.

5. Piles shall be driven to the depths and at the locations indicated on the AFC Plans, or as directed by the Design-Builder’s Engineer of Record. Piles shall be accurately spaced in true alignment, unless otherwise indicated on the AFC Plans. Fixed leads shall be used during driving. Fixed leads shall form a track in which the hammer is engaged for the full length of the travel. The pile driving leads shall be of such type and height that they hold the pile firmly in position and alignment, and in axial alignment with the hammer. The leads shall not be suspended from a line, swinging or hanging, except as specified herein. The requirement for fixed leads will only be waived when the physical conditions of the construction site make the use of such equipment impractical. In such cases the piles shall be rigidly braced and held in alignment by suitable guide frames. The intent of these special provisions is that the leads supporting the hammer control the path of the pile throughout the entire length of driving.

6. Approved temporary fixed pile positioning templates shall be constructed whenever necessary to maintain the piles in proper position and alignment during installation. Templates shall maintain the pile in proper position and alignment during driving or any jetting operations to remove soil plug from inside the pile or during spudding. The top of the template shall be located within 5 feet of cut-off elevation. Floating templates or templates attached to the pile driving operations barge will not be allowed. Where practical, the template shall be placed so that the pile can be driven to cut-off elevation before the template is removed. Wherever necessary the Design-Builder shall provide a rigid double-level template which will independently support the pile. When driving piles with a follower using floating equipment, a double template or other approved equipment shall be provided to maintain alignment of the hammer, follower and pile. A double template shall consist of a pile template within 5 feet of cut-off elevation and a second level positioned above or below that level as necessary to provide rigid, stable pile positioning and alignment. Where practical, the template shall be placed so that the pile positions of the second upper template shall be adjustable in size to serve as a guide for both the pile and any follower equipment. Templates shall not restrict the vertical movement of the pile, pile hammer, followers, or jetting equipment.

7. During driving and re-striking, the Design-Builder shall maintain and operate the driving equipment in accordance with the manufacturer's recommendations and maintain the hammer concentric with the driving train in axial alignment on the pile. The hammer shall not be used to limit deviation of the pile during driving by exerting lateral forces or striking at an angle. If damage to the pile head (as determined by the Design-Builder's Engineer of Record) occurs during driving and the hammer can no longer strike the pile uniformly and axially, then driving shall cease and the top of the pile shall be checked for proper fit and alignment within the helmet cap.

8. Each pile shall be driven continuously from the start of driving, until the required minimum penetration is attained within the designed bearing stratum. Intermittent driving will not be permitted unless otherwise authorized by the Design-Builder’s Engineer of Record.
9. High internal pressures may occur inside hollow cylindrical piles during driving as soils and/or water enter the pile interior. The piles shall be checked periodically during driving to ascertain if this condition is occurring and to relieve the pressure by lowering water and/or soil levels as required. Piles damaged by such pressures shall be replaced at the expense of the Design-Builder. At the end of driving, the soil plug inside the pile shall be measured from top of the pile and recorded in the pile driving log.

10. Heads of piles shall not be pulled into position after final driving.

11. Piles shall be protected against excessive bending and accidental impact.

12. Piles shall be installed in an approved sequence that shall be based upon driving piles from the center of the pier group outward, or from one side of the pier group toward the opposite side. The driving sequence shall avoid driving any pile between two previously driven adjacent piles.

D. Post-Driving Inspection

1. For all driving test piles and production piles when pile damage due to high internal pressures or any other cause is suspected, when directed by the Design-Builder’s Engineer of Record, the Design-Builder shall bail, drill, or airlift soil from inside the pile to the original mudline or lower, as directed by the Design-Builder’s Engineer of Record, and shall provide full visual and camera inspection of the inside of the pile for damage.

2. The Design-Builder shall provide all required equipment to allow the Design-Builder’s Engineer of Record to observe the inspection including; hoisting equipment, power, flashing, work platforms, push board, motorized skiff, lights, boatswain’s chair, lift, oxygen, etc. The Design-Builder is hereby reminded that he shall comply with all applicable OSHA, federal, and local safety and environmental requirements while performing this work.

3. During the inspection, all cracking shall be noted as to length, width and depth, and recorded. If any of the crack criteria listed below is exceeded, the Design-Builder shall modify the installation procedure such that an accepted driving procedure and equipment are established.

4. Allowable cracks shall be limited to longitudinal cracks not exceeding five per 16'-0" length of pile; the crack shall be tight, allowing virtually no penetration of a penknife point; and shall show no indication of seepage.

E. Concrete Placement of Precast Concrete Piles

1. After the piles are driven to the required depth, the top of each pile shall be filled with Class A5 concrete. The depth of the concrete from the pile top shall equal or exceed the 130 percent of development length of the strands. The Engineer of Record shall show plug length the Approved For Construction Plans. Backfill materials conforming to the requirements of this Special Provision shall be added to fill the pile interior below the plug level. Reinforcing detailed in any build up shall extend to within 3 inches of the bottom of the plug.

2. Concrete placed inside cylinder piles for the pile to cap connection or any other reason must be protected from excess heat generated from hydration. Type III cement shall not be used. Low heat of hydration concrete mix designs shall be used, including concrete mixes containing granulated blast furnace slag cement or fly ash, to minimize heat from hydration.

F. Location Tolerance

1. Pile head tolerance at the conclusion of driving shall be in accordance with Section 403.06(f).

2. Axial alignment, as shown on AFC Plans: +/- 1/8 inch any direction per linear foot.

G. Driving Precautions and Pile Obstructions

1. Any sudden decrease in driving resistance shall be investigated with regard to the possibility of breakage of the pile. If such sudden decrease in driving resistance cannot be correlated to boring data and if the pile cannot be removed without damage for inspection, the pile will be
rejected. Rejected piles shall be pulled and replaced at no additional expense to the Department.

2. If conditions during driving indicate that the pile is hitting an obstruction, the following shall apply:
   a. If the elevation of the top of the obstruction is less than five (5) feet below the elevation of the ground surface or river bottom existing at the location of the pile, the Design-Builder shall use whatever means are necessary to remove or circumvent the obstruction. If the obstruction is removed by methods other than coring, the resulting excavation up to the original elevation shall be filled with suitable granular material, or bank-run gravel as directed by the Design-Builder's Engineer of Record.
   b. If the elevation at the top of the obstruction is five (5) feet or more below the elevation of the ground surface or river bottom, the Design-Builder shall use a combination of water jet applied inside the pile and hammer to drive through the obstruction without any additional compensation.
   c. If the use of the combination water jet and hammer does not allow the pile to be driven through the obstruction, the Design-Builder shall drive adjacent piles to determine the approximate size of the obstruction.
   d. After the approximate size of the obstruction is obtained, the Design-Builder Engineer of Record will determine whether the obstruction is to be removed, or if the foundation needs to be redesigned leaving the obstruction in place.
   e. If it is determined by the Design-Builder's Engineer of Record that the obstruction is to be removed, the Design-Builder shall have the option of either coring through the obstruction to permit the driving of the piles, or of requesting permission to excavate and remove the obstruction. Extra work for coring through the obstruction or excavation and removal of the obstruction shall conform to Section 104.03.

H. Dynamic Pile Monitoring

1. For dynamic pile testing requirements, refer to the Specifications and the (AFC) Plans.

I. Defects and Breakage

Damage to piling due to faulty materials or construction methods may be cause for rejection. No defects, cracking, or breakage will be permitted within 12 feet above MHHW for piles in water at MHHW or 5 feet below MLLW for piles in water. No defects, cracking, or breakage will be permitted within 12 feet above ground for piles on land. Arrange piling segments such that any minor damage deemed acceptable as defined below will occur outside the region specified above associated with the MLW after repair and driving. Piling cracked in the process of fabrication, handling, storing, hauling, or driving is subject to the following provisions:

1. Piling shall be examined for cracks prior to detensioning, transverse cracks 1/16 in. or wider which extend to the level of reinforcing shall be reported to the Engineer of Record for evaluation before detensioning. When narrow transverse cracks extending to the level of reinforcing within any 10'-0" length add up to more than 1/16 in., the cracks shall be reported to the Engineer of Record for evaluation before detensioning. Effects of the summation of crack width over the entire length of the pile shall be evaluated and considered as contributing to the prestressing loss when determining the effective prestress in the pile. If the effective prestress, fpe, is reduced below 1.0ksi the pile shall be rejected.

2. Piling with 1 or more cracks transverse to the longitudinal reinforcement or strand, 1/16 in. or wider after detensioning, will be rejected if the crack occurs in a region of the pile that will be below ground or 5 feet below MLLW water level after driving. If the crack will be located at least 12 feet above MHHW (or ground elevation) when driving is complete, the piling may be used if it is cut back to the crack and rebuilt with a splice buildup.
3. Piling with 1 or more cracks transverse to the longitudinal reinforcement or strand that is less than 1/16 in. wide after detensioning may be used if the crack is repaired in accordance with 2016 VDOT Road and Bridge Specification Section 412.03(b) for Epoxy Injection. If cracks develop during driving in the portion that will be 5 feet below MLLW, stop driving and repair the cracks before continuing.

4. Piling with one or more cracks parallel or diagonal to the longitudinal reinforcing steel or strand and extending to the determined plane of reinforcement may be rejected. If cracks are found acceptable, repair them in accordance with 2016 VDOT Road and Bridge Specification Section 412.03(b) for Epoxy Injection.

Fine hairline cracks or surface checks that do not extend to the plane of the nearest reinforcing steel, as determined by the Design-Builder’s Engineer of Record, will not require repair and will not be cause for rejection.

J. Rejection of Piles

1. Any pile which has been subjected to tensile forces under conditions of low penetration resistance or abuse resulting in spalling or crushing of the concrete sufficient in the opinion of the Design-Builder’s Engineer of Record to damage the pile; or which has been damaged, which develops excessive cracking, for which dynamic monitoring indicates pile damage, or which is driven sufficiently far out of location to impair its value to the structure, shall be repaired or removed and replaced with a suitable pile at the Design-Builder’s own expense.

2. Detail sketches of the proposed repair plus a complete description of the proposed repair materials shall be included. All repair work shall be at the Design-Builder’s own expense, with no additional cost to the Department. If during or following or the repair, the pile is subjected to forces great enough to impair its value as described above, or the completed repair is found to be unsatisfactory by the Design-Builder’s Engineer of Record, the pile shall be removed and replaced at the Design-Builder’s own expense.

VIII. CONSTRUCTION PROCEDURES

A. General

1. Piles shall be driven to the tip elevations shown on the Plans plus any additional penetration necessary to achieve the required ultimate resistance, or as determined during driving test pile installation.

2. The Engineer shall be the sole judge as to when the tip of the piles has reached the necessary tip elevation and the required ultimate resistance.

B. Pile Hammering Resistance Criteria

3. Pile hammering resistance criteria consisting of the minimum required penetration resistance blows per inch will be determined by the Engineer based on the Contractor’s pile drivability wave equation analysis for the approved pile driving equipment for the driving test piles.

4. Pile hammering resistance criteria established on the basis of the Contractor’s pile drivability wave equation analysis will later be verified by the Engineer or revised as necessary on the basis of subsequent Pile Driving Analyzer (PDA) measurements during dynamic monitoring of driving test piles and load test piles, including “CAPWAP” analysis of the PDA measurements, along with static load test results.

5. Bearing piles shall be driven until a pile hammering resistance no less the resistance determined to produce the required ultimate resistance has been continuously maintained for three consecutive feet of driving or to practical or absolute refusal, whichever occurs first, in all cases with the hammer operating at no less than the designated hammer stroke and blow rate that the that pile hammering criteria are based upon.

6. Practical refusal is defined as two times the pile hammering resistance required to produce the required ultimate resistance when maintained for one foot of continuous driving with the
hammer operating at no less than the designated hammer stroke and blow rate that the that pile hammering criteria are based upon.

7. Absolute refusal is defined as four times the pile hammering resistance required to produce the required ultimate resistance when maintained for one inch of driving with the hammer operating at no less than the designated hammer stroke and blow rate that the pile hammering criteria are based upon.

C. Driving Test Piles

1. Installation and evaluation of driving test piles shall conform to Section 403.04.

2. Driving test piles shall be driven prior to driving of any production piles at any given pier location.

3. Driving Test Piles requiring Dynamic Pile Testing (DPT) shall be driven, restrike and results provided to the Engineer for approval before any Driving Test Piles not requiring DPT are driven.

IX. MEASUREMENT AND PAYMENT

All cost for furnishing of plant, labor equipment, appliances and materials and the performance of operations in connection with the installation of prestressed pre-tensioned concrete cylinder piles or prestressed post-tensioned concrete cylinder piles should be included in the lump sum contract price. Such work includes, but is not limited to, furnishing equipment and supporting structure for driving prestressed concrete cylinder piles, of either type, including all material, labor, equipment, and all else necessary to construct any temporary supporting structure necessary or pre-boring necessary for driving prestressed concrete cylinder piles.

This work is integral to the relevant work package that is part of the lump sum contract price. There is no separate payment for this work. If an item does not satisfy the criteria stated herein, and in the event the Department accepts this item, the Quality Assurance Manager (QAM) will document the basis of acceptance. The Design Builder and the Department will negotiate an appropriate adjustment in the contract price, warranty, or other specific requirements or adjustments that are appropriate.
SECTION 105 – CONTROL OF WORK of the Specifications is amended as follows:

Section 105.10(c)3 – Concrete Structures and Prestressed Concrete Members is amended to insert the following:

Working Drawings for concrete structures and prestressed concrete members which are reinforced with Carbon Fiber Reinforced Polymer (CFRP) tendons and other CFRP reinforcement shall provide the following, as required for the successful prosecution of the Work and which are not included in the Plans furnished by the Department: additional details related to tendon coupler locations, stressing sequence accounting for coupler locations and differing moduli of elasticity, and spacing and ties for reinforcing. All additional information shall be included in the sealed package submitted for approval.

12-09-16 (SPCN)

SECTION 223 – STEEL REINFORCEMENT of the Specifications is renamed TENSILE REINFORCEMENT OF CONCRETE and amended as follows:

Section 223.02(a)8 – Carbon Fiber Reinforced Polymer (CFRP) reinforcement is inserted as follows:

Carbon Fiber Reinforced Polymer (CFRP) reinforcement shall have an ultimate tensile strength of at least 338 ksi based on the nominal area and a minimum ultimate strain of 1.30% when tested in accordance with ASTM D7205.

Section 223.02(b) – Prestressing Tendons is replaced with the following:

Prestressing Tendons, as designated on the Plans, shall be one of the following:

1. Seven-wire, whether stress-relieved strands, stress-relieved wire, or low-relaxation strands, shall conform to ASTM A416, Grade 270; ASTM A421; and ASTM A416, Supplement I, respectively, with the following modifications:
   a. Strands or wires used in units of any one-bed layout shall be manufactured by the same plant.
   b. A manufacturer’s certification and load-elongation curve in accordance with ASTM A416 or ASTM A421 shall be obtained by the prestressed concrete fabricator for each lot of strand planned for use in fabrication. The strand or wire manufacturer shall submit the data in permanent record form to the Design-Builder Engineer of Record for approval prior to fabrication.

2. CFRP tendons shall be from the VDOT Materials Division’s Special Products Evaluation List (SPEL).
The CFRP tendons shall have a nominal diameter as indicated on the Plans or Standard Drawings. CFRP tendons shall be free of scoring. “Nicks” or “gouges” will not be acceptable. Materials shall be shipped in coil form and shall be stored in such a way that kinks do not develop when the coil is unwound. Any CFRP tendon found to be damaged on the surface, bent, subjected to temperatures above 122°F at any time, or stored out of doors shall be discarded. A special handling guidelines manual shall be provided for CFRP tendons by the manufacturer.

12-09-16 (SPCN)

SECTION 403 – BEARING PILES of the Specifications is amended as follows:

Section 403.03(b) – Precast Concrete Piles is amended by replacing the first paragraph with the following:

Precast Concrete Piles: Precast concrete piles with conventional or Carbon Fiber Reinforced Polymer (CFRP) reinforcement or tendons shall be furnished in accordance with these Specifications. Prestressed concrete piles shall be furnished in accordance with the requirements of Section 405. Piles shall be manufactured to conform to Section 404. The Class of Concrete shall be as specified on the Plans or the Specifications. If not specified, then Class A3 concrete shall be used for piles which are not prestressed.

Section 403.03(b)1 – Casting is replaced with the following:

Casting

a. All Piles: Forms shall conform to Section 404 and shall be accessible for vibrating, tamping, and consolidating concrete. Care shall be taken to place concrete to produce a satisfactory bond with the reinforcement and avoid segregation of components, honeycombs, or other defects.

Concrete shall be continuously placed in each pile form and consolidated by vibrating. Forms shall be overfilled, the surplus concrete screeded off, and the top surface finished to a uniform, even texture similar to that produced by forms.

b. Piles using CRFP Reinforcement:

The Contractor shall use self-consolidating concrete (SCC) conforming to Section 217.11 when using CRFP. During concrete placement, internal vibrators shall be encased with a protective polyurethane sheath. External vibrators will be acceptable. Extreme care shall be taken to avoid damage to CFRP tendons and reinforcement from internal vibrators. SCC will not require any vibration; however, limited vibration that will not cause segregation may be applied to ensure flow of material in congested areas, and to provide a smooth surface.

Materials, including anchorages, couplers, and other miscellaneous hardware, shall be carefully handled to prevent any damage or deformation along the reinforcement surface, and will be stored in their original containers until required for use. Materials, including anchorages, couplers, and other miscellaneous hardware, shall not be placed directly on the ground and shall be kept free from grease, dirt, and dust. Any damaged material shall be removed from the final product prior to stressing. Workers shall not walk on or step on CFRP prestressing tendons during the placement of the tendons.

CFRP reinforcement shall be suitably covered to eliminate any environmental factors such as temperatures above 122°F, ultraviolet rays, and chemical substances; and shall be protected
from sudden shocks or heavy hard objects and welding sparks. The CFRP reinforcement shall not be mishandled, handled in a rough manner, nor damaged (e.g. shall not be stepped on, walked on, or dragged over rough or dirty surfaces nor through rough or jagged holes in steel or wood).

CFRP reinforcement shall be properly cut to the lengths as specified on the Plans. Cutting of carbon reinforcement shall be performed by use of a high-speed rotary grinder approved by the Design-Builder Engineer of Record, which will not damage the material. Heat oriented cutting tools, such as gas welding torches, shall not be used. Heating CFRP in any manner is dangerous and shall not be used. CFRP reinforcement shall not be field bent. Draping (harping) of tendons shall only be allowed as provided for in the Plans.

All supports, such as chairs, and tie wires shall be non-metallic material and shall not be in contact with metal reinforcement such as stainless steel. The Contractor shall use an inert, non-metallic, insulating material to prevent direct contact. All CFRP reinforcement shall be sufficiently tied down prior to placing of concrete to eliminate “floating” of reinforcement.

The Contractor shall be responsible for installing the special anchoring system on the CFRP tendons for pretensioning according to the guidelines provided by the CFRP tendon manufacturing company. The jacking operation shall be the same as for conventional steel, except that steel transfer couplers shall be used to transfer prestressing force to the CFRP tendons. The end preparation material and steel transfer coupler shall be provided by, or approved for use with the CFRP tendon by, the CFRP tendon manufacturer.

At least 5 days prior to jacking, the Contractor shall provide the Department with PE approved shop drawings showing the CFRP tendon layout, to include coupler placement locations and offset requirements necessary to prevent collision of couplers during pretensioning due to elongation of the tendon. The Contractor shall perform sequenced tendon jacking operations as noted on the approved Working Drawings. The Design-Builder Engineer of Record shall approve each strand force and strand elongation prior to “lock off” and jack removal. Jacking operations shall proceed to the next strand as sequenced on the approved Working Drawings. Steel transfer coupler shall temporarily be supported for vertical loads and prevented from any rotation movement during prestressing as noted on the approved Working Drawings. Release of the prestressing force for anchoring shall be uniform and gradual and shall not expose any part of the pile cross section to sudden eccentric stresses. A sudden release of pretensioning force shall not be permitted except as part of the approved detensioning process. Release of force shall also be simultaneous at each end of the pile. The jacking force for CFRP tendons shall be 10% greater than desired or effective prestressing force.

Section 403.03(b)2 – Curing is replaced with the following:

Curing: Steam curing will be permitted if the concrete temperature is kept below 165°F. If CFRP is specified, the environment outside the pile where the coupler is located shall be kept below 122°F, as high temperatures will have detrimental effects on carbon reinforcement and slippage in the coupling or the anchoring.

As soon as piles have set sufficiently, side forms shall be removed and the piles moist-cured for at least 7 days. However, if CFRP is used or the concrete piles are to be used in brackish water, tidal water, or alkali soils, the piles shall be moist-cured for at least 30 days before use. Piles shall not be driven until the concrete has reached the minimum 28-day compressive strength specified in Section 217.

12-09-16 (SPCN)
SECTION 405 – PRESTRESSED CONCRETE of the Specifications is amended as follows:

Section 405.02(a) – Concrete is amended by inserting the following:

Calcium nitrite will not be required for corrosion protection in piles when Carbon Fiber Reinforced Polymer (CFRP) tendons are specified.

The Contractor shall use self-consolidating concrete (SCC) conforming to Section 217.11 when using CFRP. Vibration of SCC shall conform to Section 403.03(b)1.

Section 405.05(b) – Placing Strands and Wires and Applying and Transferring Pretension is amended to replace the sixth paragraph with the following:

The final stressing of strands shall be performed by applying tension to each strand individually or to all CFRP tendons as a group. The strands shall be tensioned to the total pre-tensioning force as indicated on the plans, with a maximum applied stress indicated below.

<table>
<thead>
<tr>
<th>Strand Type</th>
<th>Percent of guaranteed ultimate strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFRP Strand</td>
<td>65%</td>
</tr>
<tr>
<td>Stress-Relieved Strands</td>
<td>70%</td>
</tr>
<tr>
<td>Low-Relaxation Strands</td>
<td>75%</td>
</tr>
</tbody>
</table>

The nominal area of the strand and reinforcing shall be confirmed between the precast concrete producer and the strand supplier. Care shall be exercised when cutting the strand to prevent damage to the region adjacent to the cut end.

12-09-16 (SPCN)

SECTION 406 – REINFORCING STEEL of the Specifications is amended as follows:

Section 406.02(e) – Carbon Fiber Reinforced Polymer (CFRP) pile confinement reinforcement is inserted as follows:

Carbon Fiber Reinforced Polymer (CFRP) pile confinement reinforcement shall be made from a product listed on VDOT Materials Division’s Special Products Evaluation List (SPEL). Ties for pile confinement shall be corrosion free. CFRP confinement reinforcement shall have a reinforcing strength per foot which meets or exceeds the force indicated on the plans.

12-09-16 (SPCN)
SECTION 223-STEEL REINFORCEMENT of the Specifications is revised as follows:

223.02(b), paragraph 1 —Detail Requirements is replaced with the following:

(b) Prestressing Tendons: Seven-wire low-relaxation strands shall be stainless steel shall have a minimum ultimate strength of 250 ksi. The stainless steel strand shall be Type 2205 (UNS S32205), meet the compositional requirements of ASTM A1022 and meet ASTM A416 except that the minimum elongation at breaking strength shall be 1.2%.

Section 405.05(b) is amended to replace paragraph 7 (which begins with “The final stressing of strands”) with the following:

The final stressing of strands shall be performed by applying tension to each strand individually or to all strands as a group. The strand shall be tensioned to the total pre-tensioning force as indicated on the Approved for Construction (AFC) plans, with a maximum applied stress of 60% of the ultimate strength for low relaxation stainless steel strand. The nominal area of the strand shall be confirmed between the precast concrete producer and the stainless steel supplier. Strand shall be furnished in a weldless state. Care should be exercised when cutting the strand to ensure wire does not become raveled.

12-9-16 (SPCN)

SECTION 406-REINFORCING STEEL of the Specifications is revised as follows:

Section 406.02(a) is replaced with the following:

(a) Steel used for reinforcement shall conform to the requirements of Section 223, except that spiral bars shall be stainless steel (size number W 3.5) that meets the requirements of ASTM A1022 – Type 304 (UNS S30400), minimum Grade 60. Tie wires shall be Gage 16 stainless steel. Tie wires of other alloys or materials shall be submitted to the Design Builder’s Engineer for review.

12-9-16 (SPCN)