BEDFORD
13527

January 27, 2011

S P E C I A L P R O V I S I O N

SECTION 592 – PRECAST CONCRETE MODULAR WALL

Item 592.31 – Precast Concrete Modular Wall

Description

1.1 This work shall consist of designing, furnishing and constructing a precast concrete modular (PCM) retaining wall system in accordance with these specifications and in close conformance with the lines, grades, design and dimensions shown on the plans or established by the Engineer. The PCM wall consists of a concrete leveling pad, precast concrete modules, reinforced precast or cast-in-place concrete coping, granular backfill within the wall limits indicated in the plan sheets, and other items as defined in these specifications or on the plans.

1.1.1 As described in 2.2, the PCM modules shall be reinforced with steel bars that are galvanized, and the concrete mix shall include a corrosion inhibitor (calcium nitrate) admixture from the Qualified Products List.

1.1.2 The exposed PCM face shall have an Ashlar Stone form liner pattern that conforms to Ashlar Stone P/C 30664, Symons Dura-Tex as manufactured by Symons Corporation; or Ashlar Stone No. 330 Multi-Cast, as manufactured by Greenstreak; or approved equal. The form liner pattern shall extend to a minimum of 12 inches below the finished grade at the face of the wall.

1.1.3 Item 534.3, Water Repellant (Silane-Siloxane), shall be applied to the entire wall coping, and to the exposed PCM face to 12 inches below the finished grade at the face of the wall.

1.1.4 All wall systems shall have a precast or cast-in-place concrete coping at the top of wall.

1.2 (Not used)

1.3 Approved Wall Systems. The following proprietary PCM wall systems are approved for this project for stand alone retaining walls with no overlying structures:

A. Doublewal
Doublewal Corporation
7 West Main Street
Plainsville, CT 06062

(860) 793-0295

B. T-Wall
The Neel Company
6520 Deepford Street
Springfield, VA 22150
(703) 922-6778

1.4 Requirements for Supplier Prepared Design and Plans. The Design-Builder shall submit plans and calculations for the wall in conformance with Section 105.02, the design criteria in sections 1.5 through 1.7 of this specification and the requirements listed below.

1.4.1 The fully detailed plans shall be prepared in ink on permanent, archival quality, 22 inch by 34 inch (559 by 864 mm) double matte mylar (minimum 4 mil thickness) with Project Name, Number and Proprietary Firm Name. All dimensions and elevations shall use the English system of units and the project datum.

1.4.2 The plans and calculations shall be prepared, stamped and signed by a Licensed Professional Engineer in the State of New Hampshire and shall be submitted a minimum of 45 days prior to beginning any wall related construction or module fabrication.

1.4.3 The PCM wall design calculations shall include a complete and thorough set of hand calculations that are specific to this project to support any computer generated calculations. The calculations shall include all applicable references to the LRFD code. A detailed explanation of any symbols and computer programs used in the design shall be provided. The design calculations shall be provided for external stability (sliding, overturning, and maximum bearing pressure) of the final wall configuration, and internal stability (sliding, overturning and stem pullout) for each module layer for the applicable strength and extreme event limit states. Calculations shall be performed in English units, with the final calculation results shown in English units.

1.4.4 Plan and elevation sheets shall be provided and shall contain the following information:

A. An elevation view of the wall that indicates the elevation at the top of the wall at all horizontal and vertical break points and at least every 50 feet (15 m) along the wall, elevations at the top of the concrete leveling pads, the designation as to the type and size of all modules and the location of the original and final ground line.

B. A plan view of the wall that indicates the offset from the construction centerline to the face of the wall at all changes in horizontal alignment, the limit of the widest module and the centerline of any drainage structure or drainage pipe that is behind or passes under or through the wall.

C. Any general notes required for design and construction of the wall.

D. All horizontal and vertical curve data affecting wall construction.

E. A summary listing of quantities provided on the elevation sheet for all items including subsidiary items.

F. Cross section showing limits of construction and the limits and extent of select granular backfill.

1.4.5 Detail sheets shall be provided and shall contain the following information:

A. All details for foundations and concrete leveling pads, including the maximum bearing pressures (factored).

B. All details for the precast concrete module including all dimensions to construct the module and all reinforcement steel within the module structure.

C. All reinforcing bar bending details.

D. All details for construction of the wall around drainage facilities and utilities, including details for any cast-in-place concrete headwall designs, and for any required end closures.

1.4.6 The submittal shall include the manufacturer's installation manual for the PCM system.

1.5 General Design Criteria. The PCM wall design shall meet all applicable requirements from the 2007 AASHTO LRFD Bridge Design Specifications as amended through 2010 for the applicable strength and extreme event limit states, including Sections 10.5, 10.6 and 11.11. General design criteria which is applicable to both wall systems shall include the following:

A. Traffic loads and impact loads shall be based on LRFD Section 11.10.10.2 with a soil unit weight of 125 pounds per cubic foot (19.7 kilonewtons per cubic meter).

B. The Extreme Event limit state shall be included in the wall analysis.

C. The soil retained by the wall shall be assumed to have a soil friction angle of 30 degrees and a soil unit weight of 120 pounds per cubic foot (18.9 kilonewtons per cubic meter).

D. The nominal bearing resistance (qn) for the PCM wall shall conform to Section 11.11.4.3 of the LRFD code and shall be based on the site specific geotechnical evaluation. The associated resistance factor shall be as defined in Table 11.5.6-1 of the LRFD code for the strength limit states, and 1.0 for the Extreme Event limit states as defined in Section 11.5.7 of the LRFD code.

E. The sliding resistance of the PCM wall shall conform to Section 11.11.4.2 of the LRFD code.

F. Design calculations shall be provided that verify conformance of the module structural design with the requirements of Section 11.11.5 of the LRFD code, and which also verify that the module is designed to accept all lifting and installation stresses.

1.6 T-Wall Design Criteria. The soil within and vertically above the modules shall be assumed to have the following design values:

A. Shear strength of 32 degrees and unit weight of 120 pounds per cubic foot.

B. fs (soil on soil friction) equal to 0.67

C. Ko (at-rest earth pressure coefficient) equal to 0.47

D. fj (precast concrete on joint material friction) equal to manufacturer's recommendations

E. Stem pullout resistance factor less than or equal to 0.9

1.7 Doublewal Design Criteria. The design of the Doublewal system shall meet the requirements of the referenced AASHTO Specification. The soil within the modules shall be assumed to have design values of 30 degrees for shear strength and 110 pounds per cubic foot (17.3 kilonewtons per cubic meter) for unit weight.

Materials

2.1 The Design-Builder shall make arrangements to purchase the materials covered by this section of the specifications, including concrete modules, lifting devices, joint materials and all necessary incidentals from one of the approved wall system suppliers. The Design-Builder, or the supplier as his agent, shall furnish the Engineer a Certificate of Compliance meeting the requirements of Section 106.04, certifying that the applicable materials comply with this section of the specifications. Materials not conforming to this section of the specifications shall not be used without the written consent of the Engineer.

2.2 Concrete Modules. Concrete modules shall have a minimum concrete cover on reinforcing steel of 1-1/2 inches (38 mm). Cement shall be Type II and shall conform to the requirements of AASHTO M 85. Concrete shall have a minimum compressive strength of 5000 psi (35 Mpa) at 28 days, and shall meet all other requirements of Concrete Class A as specified in Section 520. A corrosion inhibitor (calcium nitrate) admixture from the Qualified Products List shall be used at the rate recommended by the manufacturer, and as approved. Modules shall be reinforced with steel bars that are galvanized in accordance with AASHTO M111 or ASTM A767/767M. Lifting

devices shall be set in place to the dimensions and tolerances shown on the plans prior to casting. All concrete components shall meet or exceed specifications listed in Section 520.

2.2.1 Testing and Inspection. Acceptability of the precast modules shall be determined on the basis of compliance with the properties specified for Class A concrete in Section 520, compliance with the requirements in Section 2.2 of this specification, and visual inspection. The Design-Builder shall furnish all necessary facilities and access for the Engineer to sample, test and inspect the modules in an expeditious and satisfactory manner. The Design-Builder shall furnish all necessary facilities and shall perform sampling and testing to measure the compressive strength of the concrete in an expeditious and satisfactory manner as outlined in Section 2.2.7.

2.2.2 Casting. The concrete in each module shall be placed without interruption and shall be consolidated by the use of an approved vibrator, supplemented by such hand tamping as may be necessary to force the concrete into the corners of the forms and to prevent the formation of stone pockets or cleavage planes. Clear form oil or release agent shall be used throughout the casting operation.

2.2.3 Curing. The modules shall be cured as specified in Section 520.3.10, and as approved. Any production lot which does not conform to the strength requirements shall be rejected.

2.2.4 Removal of Forms. The forms shall remain in place until they can be removed without damage to the module.

2.2.5 Concrete Finish. The front face of the panels shall have a form liner finish as described in 1.1.2. The rear face of the panels shall have an unformed finish and shall be free of open pockets of aggregate and surface distortions in excess of 1/4 inch (6 mm). The front face of the panels shall be coated with water repellent, as described in 1.1.3.

2.2.6 Tolerances. All modules shall be manufactured within the following tolerances with respect to the dimensions shown on the shop drawings:

A. Module Dimensions – All module dimensions shall be within 1/4 inch (6 mm).

B. Module Squareness – The module stems or sidewalls shall be perpendicular with respect to the module face in both the horizontal and vertical planes. The acceptable horizontal tolerance shall not exceed 1 inch (25 mm) measured at the end of the stem or sidewalls at its furthest location from the module face. The acceptable vertical tolerance shall not exceed 1/4 inch (6 mm) measured at the end of the stem or sidewalls at its furthest location from the module face.

C. Module Face Squareness – Squareness, as determined by the difference between the two diagonals, shall not exceed 1/2 inch (12 mm) for modules up to 10 feet (3 m) in width and 3/4 inch (19 mm) for modules wider than 10 feet (3 m).

D. Module Face Surface Finish – Surface defects on smooth-formed surfaces, measured on a length of 5 feet (1.5 m), shall not exceed 1/4 inch (6 mm). Surface defects on textured-finished surfaces, measured on a length of 5 feet (1.5 m), shall not exceed 5/16 inch (8 mm).

2.2.7 Compressive Strength. Acceptance of the concrete modules, with respect to compressive strength, shall be determined on the basis of production lots. A production lot is defined as a group of modules that shall be represented by a single set of compressive strength samples and shall consist of not more than 20 modules or a single day's production, whichever is less.

2.2.7.1 During the production of the modules, the manufacturer shall randomly sample the concrete in accordance with AASHTO T 141. A single set of compressive strength samples, consisting of a minimum of four cylinders, shall be made for every production lot.

2.2.7.2 For every compressive strength sample, a minimum of two cylinders shall be cured in the same manner as the modules and tested at 7 days or less. The average compressive strength of these cylinders, when tested in accordance with AASHTO T 22, will determine the initial strength of the concrete. In addition, a minimum of two cylinders shall be cured in accordance with AASHTO T 23 and tested at 28 days. The average compressive strength of these cylinders, when tested in accordance with AASHTO T 22, will determine the compressive strength of the production lot.

2.2.7.3 If the initial strength test result indicates a compressive strength greater than or equal to the required 28-day strength, then this test result will be utilized as the compressive strength test results for that production lot, and the requirement for testing at 28 days will be waived for that particular production lot.

2.2.7.4 Acceptance of a production lot will be made if the compressive strength test result is greater than or equal to the required 28-day strength. If the compressive strength test results is less than the required 28-day strength, the acceptance of the production lot will be based on its meeting the following acceptance criteria in its entirety:

A. Ninety percent of the compressive strength test results for the overall production shall exceed 1.0375 times the required 28-day strength.

B. The average of any six consecutive compressive strength test results, including the one in question, shall exceed 1.0625 times the required 28-day strength.

C. No individual compressive strength test result shall fall below 0.9 times the required 28-day strength.

2.2.7.5 In the event that a production lot fails to meet the specified compressive strength requirements, the production lot shall be rejected. Such rejection shall prevail unless the Design-Builder, at no cost to the Department, obtains and submits evidence of a type acceptable to the Engineer that the strength and quality of the concrete placed in the modules within a production lot is acceptable. If such evidence consists of tests made on cores taken from the modules within the production lot, the cores shall be obtained and tested in accordance with AASHTO T 24.

2.2.8 Rejection. Modules shall be subject to rejection because of failure to meet any of the requirements specified above. In addition, any or all of the following defects may be sufficient cause for rejection:

A. Defects that indicate imperfect molding.

B. Defects indicating honeycombed or open-texture concrete.

C. Defects in the physical characteristics of the concrete, such as broken or chipped concrete.

2.2.9 The Engineer shall determine whether spalled, honeycombed, chipped or otherwise defective concrete shall be repaired or be cause for rejection. Repair of concrete, if allowed, shall be done in a manner satisfactory to the Engineer. Repair to concrete surfaces which will be exposed to view after completion of construction must be approved by the Engineer.

2.2.10 Marking. The date of manufacture, the production lot number, and the piece-mark shall be clearly marked on the back side of each module.

2.2.11 Handling, Storage and Shipping. All modules shall be handled, stored and shipped in such a manner as to minimize the danger of shipping, cracks, fractures and excessive bending stresses.

2.3 Reinforcing Steel. Reinforcing steel within the PCM panels shall conform to Section 544 and shall be galvanized as described in 2.2.

2.4 Joint Materials. Joint materials shall be as specified by the wall supplier, subject to the following requirements:

2.4.1 Bearing Pads. Bearing pads shall be approved by the wall supplier.

2.4.2 Joint Cover. Horizontal and vertical joints between modules shall be covered by a geotextile. The geotextile may be either a non-woven needle punched polyester geotextile or a

woven monofilament polypropylene geotextile as approved by the wall supplier. Adhesive used to hold the geotextile filter fabric material to the rear of the front module face prior to backfill shall be approved by the wall supplier.

2.5 Concrete Leveling Pad. Concrete for cast in place leveling pad shall conform to the requirements of Concrete Class B as specified in Section 520.

2.6 Module Backfill. The material used to backfill within, above and behind the modules within the limits indicated in the plans or in this specification shall conform to Granular Backfill (Gravel).

2.7 Wall Coping. Concrete for cast-in-place wall coping shall conform to the requirements of Concrete Class AA as specified in Section 520. Concrete for precast wall coping shall conform to 2.2. The wall coping shall be coated with water repellent, as described in 1.1.3. Reinforcing steel in the wall copings shall conform to Section 544 and shall be epoxy coated.

Construction Requirements

3.1 Coordination Meeting. A coordination meeting shall be held prior to initiating the PCM wall construction and related work. The purpose of the meeting shall be to review all aspects of the PCM wall construction and to facilitate coordination between all parties involved. The coordination meeting shall not take place until the Design-Builder has submitted and received approval for the PCM wall design. Individuals attending the meeting shall include the Engineer, the Design-Builder, the PCM wall Technical Representative, the Project Engineers from Highway Design, Bridge Design and the Geotechnical Section, and all other personnel deemed appropriate by the previously mentioned personnel. The Project Engineers shall be notified at least 7 days in advance of the meeting.

3.2 Wall Supplier's Representative. The Design-Builder shall make the necessary arrangements with the wall supplier to have a technical representative on the project to supervise the initial construction of the wall. The technical representative shall also be required to be on-site at any time during wall construction as requested by the Engineer. When a technical representative has been requested, no wall construction shall be allowed until the technical representative has arrived at the project site.

3.3 Foundation Preparation. The foundation for the structure shall be graded level for a width as shown on the plans. Prior to wall construction, the foundation, if not in rock, shall be compacted as directed by the Engineer. Any foundation soils found to be unsuitable shall be removed and replaced as directed by the Engineer. At each module foundation level, the concrete leveling pad shall be provided as shown on the approved plans. The leveling pad shall have minimum nominal dimensions of 6 inches by 12 inches (150 mm thick by 300 mm wide). The leveling pad shall be cast to the design elevations as shown on the plans. Allowable elevation

tolerances are plus 1/8 inch (3 mm) and minus 1/4 inch (6 mm) from the design elevation. The leveling pad shall be cured in accordance with 520.3.10. The requirements of 520.3.11 shall be followed before placement of wall modules.

3.4 Wall Erection.

3.4.1 The modules shall be erected in accordance with the wall supplier's recommendations. Special care shall be taken in setting the bottom course of modules to true line and grade. Assembly of the various components shall be performed in such a manner that no undue strain or stress is placed on the structure. Shims shall not be permitted without prior approval of the Engineer.

3.4.2 The vertical joint opening on the front face of the wall shall not exceed 3/4 inch (19 mm). Vertical tolerances and horizontal alignment tolerances measured from the face line shown on the plans shall not exceed 3/4 inch (19 mm) when measured along an 8-foot (2.4 meter) straightedge. The overall tolerance of the wall from top to bottom shall not exceed 1/2 inch (12 mm) per 8 feet (2.4 meter) of wall height or 1 inch (25 mm) total, whichever is less, measured from the face line shown on the plans.

3.4.3 Joint materials and bearing pads shall be installed in accordance with the wall supplier's requirements and the details shown on the plans.

3.4.4 For T-Wall modules, vertical steps shall be designed and constructed so that horizontal joints between modules consist of continuous horizontal rows along the entire length of the wall.

3.4.5 For Doublewal modules, all modules above the first course shall interlock with the lower courses and vertical joints shall be staggered with each successive course.

3.5 Soil Backfill Placement. Soil backfill materials placed within, behind and above the modules shall be as detailed on the plans. Backfill placement shall closely follow erection of each course of wall modules. Backfill shall be placed in such a manner as to avoid any damage to the wall materials or misalignment of the modules. Any wall components that become damaged or disturbed shall be either removed and replaced at the Design-Builder's expense or corrected, as directed by the Engineer. Any backfill material placed within the soil mass which does not meet the requirements of this specification shall be corrected or removed and replaced at the Design-Builder's expense, as directed by the Engineer.

3.5.1 Testing Requirements. The maximum dry density and optimum moisture content shall be determined in accordance with AASHTO T 99, Method C or D (with oversize correction, as outlined in Note 7 of AASHTO T 99). The in-place density determination shall be made in accordance with 304.3.7.

3.5.1.1 The frequency of sampling of select granular backfill material necessary to assure gradation control throughout construction shall be as directed by the Engineer. If 30 percent or

more of the select granular backfill material is greater than 3/4 inch (19 mm) in size, AASHTO T 99 is not applicable. For such a material, the acceptance criteria for control of compaction shall be either a minimum of 70 percent of the relative density of the material as determined by ASTM D 4253 and D 4254, or a method specification, based on a test compaction section that defines the type of equipment, lift thickness, number of passes of the specified equipment, and placement moisture content.

3.5.2 T-Wall Lift Thickness and Density Requirements. Material placed within the T-Wall modules and behind the T-Wall structure shall be placed in maximum 12 inch (300 mm) thick lifts measured before compaction, and shall be compacted to 95 percent of the maximum dry density.

3.5.3 Doublewal Lift Thickness and Density Requirements. Material placed within the Doublewal module shall be placed in maximum 24 inch (600 mm) thick lifts measured before compaction and shall be compacted to 90 percent of the maximum dry density. Material placed behind the Doublewal structure shall meet the same requirements as in 3.5.2. At no time shall the difference in backfill elevation between the interior and exterior of the wall module exceed 6 feet (1.8 m).

3.5.4 Compaction within 3 feet (0.9 m) of the back face of the modules shall be achieved by at least three passes of a lightweight mechanical tamper, roller or vibratory system. The specified lift thickness shall be adjusted as warranted by the type of compaction equipment actually used, but no soil density tests need be taken within this area. Care shall be exercised in the compaction process to avoid misalignment of or damage to the wall modules. Heavy compaction equipment shall not be used to compact backfill within 3 feet (0.9 m) feet of the wall face.

3.5.5 At the end of each day's operation, the Design-Builder shall slope the last level of backfill to direct runoff of rainwater away from the wall face. In addition, the Design-Builder shall not allow surface runoff from adjacent areas to enter the wall construction site. The Design-Builder shall be responsible for the repair of any damage to the PCM wall that results from surface or subsurface flow of water into the PCM wall construction site in accordance with 3.6.

3.6 Wall Repair. Any portion of a fully or partially constructed PCM wall that is damaged, or that does not meet the required construction tolerances shall be repaired by the Design-Builder to the satisfaction of the Engineer at no cost to the Department.