

APPENDIX F

Reference Retaining Wall Specifications

SECTION 32 32 16

PRECAST MODULAR BLOCK RETAINING WALL

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section includes furnishing all materials and labor required for the design and construction of a precast concrete modular block (PMB) retaining wall, or equivalent with or without geosynthetic reinforcement. Precast modular block retaining wall blocks under this section shall be cast utilizing a wet-cast concrete mix and exhibit a final handling weight in excess of 1,000 pounds (450 kg) per unit.
- B. Scope of Work: The work shall consist of furnishing materials, labor, equipment and supervision for the construction of a precast modular block (PMB) retaining wall structure including pedestrian barricade in accordance with the requirements of this section and in acceptable conformity with the lines, grades, design and dimensions shown in the project site plans.
- C. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 31, Division 32 and Division 33 also apply to this Section.

1.2 PRICE AND PAYMENT PROCEDURES

- A. Allowances. No allowance shall be made in the price of the retaining wall for excavation beyond the limits required for retaining wall construction as shown on the project plans. The cost of excavation for the purposes of site access shall be the responsibility of the General Contractor. Removal of unsuitable soils and replacement with select fill shall be as directed and approved in writing by the Owner or Owner's representative and shall be paid under separate pay items.
- B. Measurement and Payment.
 - 1. The unit of measurement for furnishing the precast modular block retaining wall system shall be the vertical area of the wall face surface as measured from the top of the leveling pad to the top of the wall including coping. The final measured quantity shall include supply of all material components and the installation of the precast modular block system.
 - 2. The final accepted quantities of the precast modular block retaining wall system will be compensated per the vertical face area as described above. The quantities of the precast modular block retaining wall as shown on the plans and as approved by the Owner shall be the basis for determination of the final payment quantity. Payment shall be made per square meter of vertical wall face.
 - 3. The contractor shall include in the bid price a Global Stability Analysis and Engineering design and review paid under separate lump sum pay item.
 - 4. The cost of the pedestrian barricade shall be paid for under separate linear metre pay item
 - 5. The cost of excavation, geotextile and bedding and backfill material shall be paid under separate lump sum pay item.
 - 6. Subdrainage shall be paid for under separate linear metre subdrain pay item.

1.3 REFERENCES

- A. Where the specification and reference documents conflict, the Owner's designated representative will make the final determination of the applicable document.
- B. Definitions:
1. Precast Modular Block (PMB) Unit – machine-placed, “wet cast” concrete modular block retaining wall facing unit.
 2. Geotextile – a geosynthetic fabric manufactured for use as a separation and filtration medium between dissimilar soil materials.
 3. Geogrid – a geosynthetic material comprised of a regular network of tensile elements manufactured in a mesh-like configuration of consistent aperture openings. When connected to the PMB facing units and placed in horizontal layers in compacted fill, the geogrid prevents lateral deformation of the retaining wall face and provides effective tensile reinforcement to the contiguous reinforced fill material.
 4. Drainage Aggregate – clean, crushed stone placed within and immediately behind the precast modular block units to facilitate drainage and reduce compaction requirements immediately adjacent to and behind the precast modular block units.
 5. Unit Core Fill – clean, crushed stone placed within the hollow vertical core of a precast modular block unit. Typically, the same material used for drainage aggregate as defined above.
 6. Foundation Zone – soil zone immediately beneath the leveling pad and the reinforced zone.
 7. Retained Zone – soil zone immediately behind the drainage aggregate and wall infill for wall sections designed as modular gravity structures. Alternatively, in the case of wall sections designed with geosynthetic soil reinforcement, the retained zone is the soil zone immediately behind the reinforced zone.
 8. Reinforced Zone – structural fill zone within which successive horizontal layers of geogrid soil reinforcement have been placed to provide stability for the retaining wall face. The reinforced zone exists only for retaining wall sections that utilize geosynthetic soil reinforcement for stability.
 9. Reinforced Fill – structural fill placed within the reinforced zone.
 10. Leveling Pad – hard, flat surface upon which the bottom course of precast modular blocks are placed. The leveling pad may be constructed with crushed stone or cast-in-place concrete. A leveling pad is not a structural footing.
 11. Wall Infill – the fill material placed and compacted between the drainage aggregate and the excavated soil face in retaining wall sections designed as modular gravity structures.
- C. Reference Standards
1. Design
 - a. AASHTO LRFD Bridge Design Specifications, 7th Edition, 2014.
 - b. Minimum Design Loads for Buildings and Other Structures – ASCE/SEI 7-10.
 - c. International Building Code, 2012 Edition.
 - d. FHWA-NHI-10-024 Volume I and GEC 11 Design of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes.
 - e. FHWA-NHI-10-025 Volume II and GEC 11 Design of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes.
 2. Precast Modular Block Units
 - a. ASTM C94 – Standard Specification for Ready-Mixed Concrete.
 - b. ASTM C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - c. ASTM C143 – Standard Test Method for Slump of Hydraulic-Cement Concrete.

- d. ASTM C260 – Standard Specification for Air-Entraining Admixtures for Concrete.
 - e. ASTM C494 – Standard Specification for Chemical Admixtures for Concrete.
 - f. ASTM C666 – Standard Test Method for Concrete Resistance to Rapid Freezing and Thawing.
 - g. ASTM C920 – Standard Specification for Elastomeric Joint Sealants.
 - h. ASTM C1116 – Standard Specification for Fiber-Reinforced Concrete.
 - i. ASTM C1611 – Standard Test Method for Slump Flow of Self-Consolidating Concrete.
 - j. ASTM D6638 – Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks).
 - k. ASTM D6916 – Standard Test Method for Determining Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks).
3. Geosynthetics
- a. AASHTO M 288 – Geotextile Specification for Highway Applications.
 - b. ASTM D3786 – Standard Test Method for Bursting Strength of Textile Fabrics Diaphragm Bursting Strength Tester Method.
 - c. ASTM D4354 – Standard Practice for Sampling of Geosynthetics for Testing.
 - d. ASTM D4355 – Standard Test Method for Deterioration of Geotextiles
 - e. ASTM D4491 – Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
 - f. ASTM D4533 – Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 - g. ASTM D4595 – Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
 - h. ASTM D4632 – Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
 - i. ASTM D4751 – Standard Test Method for Determining Apparent Opening Size of a Geotextile.
 - j. ASTM D4759 – Standard Practice for Determining Specification Conformance of Geosynthetics.
 - k. ASTM D4833 – Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.
 - l. ASTM D4873 – Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples.
 - m. ASTM D5262 – Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics.
 - n. ASTM D5321 – Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
 - o. ASTM D5818 – Standard Practice for Exposure and Retrieval of Samples to Evaluate Installation Damage of Geosynthetics.
 - p. ASTM D6241 – Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
 - q. ASTM D6637 – Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method.
 - r. ASTM D6706 – Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil.
 - s. ASTM D6992 – Standard Test Method for Accelerated Tensile Creep and Creep-Rupture of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method.

4. Soils
 - a. AASHTO M 145 – AASHTO Soil Classification System.
 - b. AASHTO T 104 – Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
 - c. AASHTO T 267 – Standard Method of Test for Determination of Organic Content in Soils by Loss of Ignition.
 - d. ASTM C33 – Standard Specification for Concrete Aggregates.
 - e. ASTM D422 – Standard Test Method for Particle-Size Analysis of Soils.
 - f. ASTM D448 – Standard Classification for Sizes of Aggregates for Road and Bridge Construction.
 - g. ASTM D698 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. (12,400 ft-lbf/ft (2,700 kN-m/m)).
 - h. ASTM D1241 – Standard Specification for Materials for Soil-Aggregate Subbase, Base and Surface Courses.
 - i. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method.
 - j. ASTM D1557 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort. (56,000 ft-lbf/ft (2,700 kN-m/m)).
 - k. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 - l. ASTM D2488 – Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
 - m. ASTM D3080 – Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions.
 - n. ASTM D4254 – Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - o. ASTM D4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - p. ASTM D4767- Test Method for Consolidated-Undrained Triaxial Compression Test for Cohesive Soils.
 - q. ASTM D4972 – Standard Test Method for pH of Soils.
 - r. ASTM D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Aggregate by Nuclear Methods (Shallow Depth).
 - s. ASTM G51 – Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing.
 - t. ASTM G57 – Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method.
5. Drainage Pipe
 - a. ASTM D3034 – Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

ASTM F2648 – Standard Specification for 2 to 60 inch [50 to 1500 mm] Annular Corrugated Profile Wall Polyethylene (PE) Pipe and Fittings for Land Drainage Applications.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Preconstruction Meeting. As directed by the Owner, the General Contractor shall schedule a preconstruction meeting at the project site prior to commencement of retaining wall construction. Participation in the preconstruction meeting shall be required of the General Contractor, Retaining Wall Design Engineer, Retaining Wall Installation Contractor, Grading Contractor and Inspection

Engineer. The General Contractor shall provide notification to all parties at least 10 calendar days prior to the meeting.

1. Preconstruction Meeting Agenda:
 - a. The Retaining Wall Design Engineer shall explain all aspects of the retaining wall construction drawings.
 - b. The Retaining Wall Design Engineer shall explain the required bearing capacity of soil below the retaining wall structure and the shear strength of in-situ soils assumed in the retaining wall design to the Inspection Engineer.
 - c. The Retaining Wall Design Engineer shall explain the required shear strength of fill soil in the reinforced, retained and foundation zones of the retaining wall to the Inspection Engineer.
 - d. The Retaining Wall Design Engineer shall explain any measures required for coordination of the installation of utilities or other obstructions in the reinforced or retained fill zones of the retaining wall.
 - e. The Retaining Wall Installation Contractor shall explain all excavation needs, site access and material staging area requirements to the General Contractor and Grading Contractor.

1.5 SUBMITTALS

- A. Product Data. At least 14 days prior to construction, the General Contractor shall submit a minimum of six (6) copies of the retaining wall product submittal package to the Owner's Representative for review and approval. The submittal package shall include technical specifications and product data from the manufacturer for the following:
 1. Precast Modular Block System brochure
 2. Precast Modular Block concrete test results specified in paragraph 2.01, subparagraph B of this section as follows:
 - a. 28-day compressive strength
 - b. Air content
 - c. Slump or Slump Flow (as applicable)
 3. Drainage Pipe
 4. Geotextile
 5. Geosynthetic Soil Reinforcement (if required by the retaining wall design). The contractor shall provide certified manufacturer test reports for the geosynthetic soil reinforcement material in the manufactured roll width specified. The test report shall list the individual roll numbers for which the certified material properties are valid.
- B. Installer Qualification Data. At least 14 days prior to construction, the General Contractor shall submit the qualifications of the business entity responsible for installation of the retaining wall, the Retaining Wall Installation Contractor, per paragraph 1.07, subparagraph A of this section.
- C. Retaining Wall Design Calculations and Construction Shop Drawings. At least 14 days prior to construction, the General Contractor shall furnish six (6) sets of construction shop drawings and six (6) copies of the supporting structural calculations report to the Owner for review and approval. This submittal shall include the following:
 1. Signed, sealed and dated drawings and engineering calculations prepared in accordance with these specifications.
 2. Qualifications Statement of Experience of the Retaining Wall Design Engineer as specified in paragraph 1.07, subparagraph B of this section.

3. Certificate of Insurance of the Retaining Wall Design Engineer as specified in paragraph 1.06, subparagraph B of this section.

1.6 CONSTRUCTION SHOP DRAWING PREPARATION

- A. The Retaining Wall Design Engineer shall coordinate the retaining wall construction shop drawing preparation with the project Civil Engineer, project Geotechnical Engineer and Owner's Representatives. The General Contractor shall furnish the Retaining Wall Design Engineer the following project information required to prepare the construction shop drawings. This information shall include, but is not limited to, the following:
 1. Current versions of the site, grading, drainage, utility, erosion control, landscape, and irrigation plans;
 2. electronic CAD file of the civil site plans listed in (1);
 3. report of geotechnical investigation and all addenda and supplemental reports;
 4. recommendations of the project Geotechnical Engineer regarding effective stress shear strength and total stress shear strength (when applicable) parameters for in-situ soils in the vicinity of the proposed retaining wall(s) and for any fill soil that may potentially be used as backfill in retained and/or foundation zones of the retaining wall.
- B. The Retaining Wall Design Engineer shall provide the Owner with a certificate of professional liability insurance verifying the minimum coverage limits of \$1 million per claim and \$1 million aggregate.
- C. Design of the precast modular block retaining wall shall satisfy the requirements of this section. Where local design or building code requirements exceed these specifications, the local requirements shall also be satisfied.
- D. The Retaining Wall Design Engineer shall note any exceptions to the requirements of this section by listing them at the bottom right corner of the first page of the construction shop drawings.
- E. Approval or rejection of the exceptions taken by the Retaining Wall Engineer will be made in writing as directed by the Owner.
- F. The precast modular block design, except as noted herein, shall be based upon AASHTO Load and Resistance Factor Design (LRFD) methodology as referenced in paragraph 1.03, subparagraph C.1.
- G. In the event that a conflict is discovered between these specifications and a reasonable interpretation of the design specifications and methods referenced in paragraph F above, these specifications shall prevail. If a reasonable interpretation is not possible, the conflict shall be resolved per the requirements in paragraph 1.03, subparagraph A of this section.
- H. Soil Shear Parameters. The Retaining Wall Design Engineer shall prepare the construction shop drawings based upon soil shear strength parameters from the available project data and the recommendations of the project Geotechnical Engineer. If insufficient data exists to develop the retaining wall design, the Retaining Wall Design Engineer shall communicate the specific deficiency of the project information or data to the Owner in writing.

- I. Allowable bearing pressure requirements for each retaining wall shall be clearly shown on the construction drawings.
- J. Global Stability. Overall (global) stability shall be evaluated in accordance with the principals of limit equilibrium analysis as set forth in FHWA-NHI-10-024 Volume I and FHWA-NHI-10-025 Volume II GEC 11 Design of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes as referenced in paragraph 1.03, subparagraph C.1. The minimum factors of safety shall be as follows:

Normal Service (Static)	1.4
Seismic	1.1
Rapid Drawdown (if applicable)	1.2

- K. Seismic Stability. Seismic loading shall be evaluated in accordance with AASHTO Load and Resistance Factor Design (LRFD) methodology as referenced in paragraph 1.03, subparagraph C.1.

1.7 QUALITY ASSURANCE

- A. Retaining Wall Installation Contractor Qualifications. In order to demonstrate basic competence in the construction of precast modular block walls, the Retaining Wall Installation Contractor shall document compliance with the following:
 - 1. Experience.
 - a. Construction experience with a minimum of 30,000 square feet (2,800 square meters) of the proposed precast modular block retaining wall system.
 - b. Construction of at least ten (10) precast modular block (large block) retaining wall structures within the past three (3) years.
 - c. Construction of at least 50,000 square feet (4,650 square meters) of precast modular block (large block) retaining walls within the past three (3) years.
 - 2. Retaining Wall Installation Contractor experience documentation for each qualifying project shall include:
 - a. Project name and location
 - b. Date (month and year) of construction completion
 - c. Contact information of Owner or General Contractor
 - d. Type (trade name) of precast modular block system built
 - e. Maximum height of the wall constructed
 - f. Face area of the wall constructed
 - 3. In lieu of the requirements set forth in items 1 and 2 above, the Retaining Wall Installation Contractor must be a certified Precast Modular Block Retaining Wall Installation Contractor as demonstrated by satisfactory completion of a certified precast modular block retaining wall installation training program administered by the precast modular block manufacturer.
- B. Retaining Wall Design Engineer Qualifications and Statement of Experience. The Retaining Wall Design Engineer shall submit a written statement affirming that he or she has the following minimum qualifications and experience.
 - 1. The Retaining Wall Design Engineer shall be licensed to practice in the jurisdiction of the project location.
 - 2. The Retaining Wall Design Engineer shall be independently capable of performing all internal and external stability analyses, including those for seismic loading, compound stability, rapid draw-down and deep-seated, global modes of failure.

3. The Retaining Wall Design Engineer shall affirm in writing that he or she has personally supervised the design of the retaining walls for the project, that the design considers all the requirements listed in paragraph 1.06 and that he or she accepts responsibility as the design engineer of record for the retaining walls constructed on the project.
 4. The Retaining Wall Design Engineer shall affirm in writing that he or she has personally designed in excess of 100,000 face square feet (9,000 face square meters) of modular block earth retaining walls within the previous three (3) years.
 5. In lieu of these specific requirements, the engineer may submit alternate documentation demonstrating competency in Precast Modular Block retaining wall design.
- C. The Owner reserves the right to reject the design services of any engineer or engineering firm who, in the sole opinion of the Owner, does not possess the requisite experience or qualifications.

1.8 QUALITY CONTROL

- A. The Owner's Representative shall review all submittals for materials, design, Retaining Wall Design Engineer qualifications and the Retaining Wall Installation Contractor qualifications.
- B. The General Contractor shall retain the services of an Inspection Engineer who is experienced with the construction of precast modular block retaining wall structures to perform inspection and testing. The cost of inspection shall be the responsibility of the General Contractor. Inspection shall be continuous throughout the construction of the retaining walls.
- C. The Inspection Engineer shall perform the following duties:
 1. Inspect the construction of the precast modular block structure for conformance with construction shop drawings and the requirements of this specification.
 2. Verify that soil or aggregate fill placed and compacted in the reinforced, retained and foundation zones of the retaining wall conforms with paragraphs 2.04 and 2.05 of this section and exhibits the shear strength parameters specified by the Retaining Wall Design Engineer.
 3. Verify that the shear strength of the in-situ soil assumed by the Retaining Wall Design Engineer is appropriate.
 4. Inspect and document soil compaction in accordance with these specifications:
 - a. Required dry unit weight
 - b. Actual dry unit weight
 - c. Allowable moisture content
 - d. Actual moisture content
 - e. Pass/fail assessment
 - f. Test location – wall station number
 - g. Test elevation
 - h. Distance of test location behind the wall face
 5. Verify that all excavated slopes in the vicinity of the retaining wall are bench-cut as directed by the project Geotechnical Engineer.
 6. Notify the Retaining Wall Installation Contractor of any deficiencies in the retaining wall construction and provide the Retaining Wall Installation Contractor a reasonable opportunity to correct the deficiency.
 7. Notify the General Contractor, Owner and Retaining Wall Design Engineer of any construction deficiencies that have not been corrected timely.
 8. Document all inspection results.

9. Test compacted density and moisture content of the retained backfill with the following frequency:
 - a. At least once every 1,000 square feet (90 square meters) (in plan) per 9-inch (230 mm) vertical lift, and
 - b. At least once per every 18 inches (460 mm) of vertical wall construction.
- D. The General Contractor's engagement of the Inspection Engineer does not relieve the Retaining Wall Installation Contractor of responsibility to construct the proposed retaining wall in accordance with the approved construction shop drawings and these specifications.
- E. The Retaining Wall Installation Contractor shall inspect the on-site grades and excavations prior to construction and notify the Retaining Wall Design Engineer and General Contractor if on-site conditions differ from the elevations and grading conditions depicted in the retaining wall construction shop drawings.

1.9 DELIVERY, STORAGE AND HANDLING

- A. The Retaining Wall Installation Contractor shall inspect the materials upon delivery to ensure that the proper type, grade and color of materials have been delivered.
- B. The Retaining Wall Installation Contractor shall store and handle all materials in accordance with the manufacturer's recommendations as specified herein and in a manner that prevents deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breaking, chipping, UV exposure or other causes. Damaged materials shall not be incorporated into the work.
- C. Geosynthetics
 1. All geosynthetic materials shall be handled in accordance with ASTM D4873. The materials should be stored off the ground and protected from precipitation, sunlight, dirt and physical damage.
- D. Precast Modular Blocks
 1. Precast modular blocks shall be stored in an area with positive drainage away from the blocks. Be careful to protect the block from mud and excessive chipping and breakage. Precast modular blocks shall not be stacked more than three (3) units high in the storage area.
- E. Drainage Aggregate and Backfill Stockpiles
 1. Drainage aggregate or backfill material shall not be piled over unstable slopes or areas of the project site with buried utilities.
 2. Drainage aggregate and/or reinforced fill material shall not be staged where it may become mixed with or contaminated by poor draining fine-grained soils such as clay or silt.

PART 2 – MATERIALS

2.1 PRECAST MODULAR BLOCK RETAINING WALL UNITS

- A. All units for the project shall be obtained from the same manufacturer. The manufacturer shall be licensed and authorized to produce the retaining wall units by the precast modular block system patent holder/licensor and shall document compliance with the published quality control standards

of the proprietary precast modular block system licensor for the previous three (3) years or the total time the manufacturer has been licensed, whichever is less.

- B. Concrete used in the production of the precast modular block units shall be first-purpose, fresh concrete. It shall not consist of returned, reconstituted, surplus or waste concrete. It shall be an original production mix meeting the requirements of ASTM C94 and exhibit the following:
1. Minimum 28-day compressive strength of 4,000 psi (27.6 MPa).
 2. Shall be free of water soluble chlorides and chloride based accelerator admixtures.
 3. 6% +/- 1½% air-entrainment in conformance ASTM C94.
 4. Maximum slump of 5 inches +/- 1½ inches (125 mm +/- 40 mm) per ASTM C143 for conventional concrete mix designs.
 5. Slump Flow for Self-Consolidating Concrete (SCC) mix designs shall be between 18 inches and 32 inches (450 mm and 800 mm) as tested in accordance with ASTM C1611.
- C. Each concrete block shall be cast in a single continuous pour without cold joints. With the exception of half-block units, corner units and other special application units, the precast modular block units shall conform to the nominal dimensions listed in the table below and be produced to the dimensional tolerances shown.

Block Type	Dimension	Nominal Value	Tolerance
28" (710 mm) Block	Height	18" (457 mm)	+/- 3/16" (5 mm)
	Length	46-1/8" (1172 mm)	+/- 1/2" (13 mm)
	Width*	28" (710 mm)	+/- 1/2" (13 mm)
41" (1030 mm) Block	Height	18" (457 mm)	+/- 3/16" (5 mm)
	Length	46-1/8" (1172 mm)	+/- 1/2" (13 mm)
	Width*	40-1/2" (1030 mm)	+/- 1/2" (13 mm)
60" (1520 mm) Block	Height	18" (457 mm)	+/- 3/16" (5 mm)
	Length	46-1/8" (1172 mm)	+/- 1/2" (13 mm)
	Width*	60" (1520 mm)	+/- 1/2" (13 mm)

* Excluding Variable Face Texture

- D. Individual block units shall have a nominal height of 18 inches (457 mm).
- F. With the exception of half-block units, corner units and other special application units, the precast modular block units shall have two (2), circular dome shear knobs that are 10 inches (254 mm), 7.5 inches (190 mm), or 6.75 inches (171 mm) in diameter and 4 inches (102 mm) or 2 inches (51 mm) in height. The shear knobs shall fully index into a continuous semi-cylindrical shear channel in the bottom of the block course above. The Peak interlock shear between any two (2) vertically stacked precast modular block units, with 10 inch (254 mm) diameter shear knobs, measured in accordance with ASTM D6916 shall exceed 6,500 lb/ft (95 kN/m) at a minimum normal load of 500 lb/ft (7kN/m). as well as an ultimate peak interface shear capacity in excess of 11,000 lb/ft (160 kN/m). The peak interlock shear between any two (2) vertically stacked precast modular block units, with 7.5 inch (190 mm) or 6.75 inch (171 mm) diameter shear knobs, measured in accordance with ASTM D6916 shall exceed 1,850 lb/ft (27 kN/m) at a minimum normal load of 500 lb/ft (7kN/m) as well as an ultimate peak interface shear capacity in excess of 10,000 lb/ft (146 kN/m). Test specimen blocks tested under ASTM D6916 shall be actual, full-scale production blocks of known compressive strength. The interface shear capacity reported shall be corrected for a 4,000 psi (27.6 MPa) concrete compressive strength. Regardless of precast modular block configuration, interface shear testing shall be completed without the inclusion of unit core infill aggregate.

- F. The 28" (710 mm) and 41" (1030 mm) precast modular block units shall be cast with a 13" (330 mm) wide, continuous vertical core slot that will permit the insertion of a 12" (305 mm) inch wide strip of geogrid reinforcement to pass completely through the block. When installed in this manner, the geogrid reinforcement shall form a non-normal load dependent, positive connection between the block unit and the reinforcement strip. The use of steel for the purposes of creating the geogrid to block connection is not acceptable.
- G. Without field cutting or special modification, the precast modular block units shall be capable of achieving a minimum radius of 14 ft 6 in (4.42 m).
- H. The precast modular block units shall be manufactured with an integrally cast shear knobs that establishes a standard horizontal set-back for subsequent block courses. The precast modular block system shall be available in the four (4) standard horizontal set-back facing batter options listed below:

<u>Horizontal Set-Back/Blk. Course</u>	<u>Max. Facing Batter</u>
3/8" (10 mm)	1.2°
1-5/8" (41 mm)	5.2°
9-3/8" (238 mm)	27.5°
16-5/8" (422 mm)	42.7°

The precast modular block units shall be furnished with the required shear knobs that provide the facing batter required in the construction shop drawings.

- I. The precast modular block unit face texture shall be selected by the owner from the available range of textures available from the precast modular block manufacturer. Each textured block facing unit shall be a minimum of 5.76 square feet (0.54 square meters) with a unique texture pattern that repeats with a maximum frequency of once in any 15 square feet (1.4 square meters) of wall face.
- J. The block color shall be selected by the owner from the available range of colors available from the precast modular block manufacturer.
- K. All precast modular block units shall be sound and free of cracks or other defects that would interfere with the proper installation of the unit, impair the strength or performance of the constructed wall. PMB units to be used in exposed wall construction shall not exhibit chips or cracks in the exposed face or faces of the unit that are not otherwise permitted. Chips smaller than 1.5" (38 mm) in its largest dimension and cracks not wider than 0.012" (0.3 mm) and not longer than 25% of the nominal height of the PMB unit shall be permitted. PMB units with bug holes in the exposed architectural face smaller than 0.75" (19 mm) in its largest dimension shall be permitted. Bug holes, water marks, and color variation on non-architectural faces are acceptable. PMB units that exhibit cracks that are continuous through any solid element of the PMB unit shall not be incorporated in the work regardless of the width or length of the crack.
- L. Preapproved Manufacturers.
 - 1. Manufacturers of Redi-Rock Retaining Wall Systems as licensed by Redi-Rock International, LLC, 05481 US 31 South, Charlevoix, MI 49720 USA; telephone (866) 222-8400; website www.redi-rock.com.

- M. Substitutions. Technical information demonstrating conformance with the requirements of this specification for an alternative precast modular block retaining wall system must be submitted for preapproval at least 14 calendar days prior to the bid date. Acceptable alternative PMB retaining wall systems, otherwise found to be in conformance with this specification, shall be approved in writing by the owner 7 days prior to the bid date. The Owner's Representative reserves the right to provide no response to submissions made out of the time requirements of this section or to submissions of block retaining wall systems that are determined to be unacceptable to the owner.
- N. Value Engineering Alternatives. The owner may evaluate and accept systems that meet the requirements of this specification after the bid date that provide a minimum cost savings of 20% to the Owner. Construction expediency will not be considered as a contributing portion of the cost savings total.

2.2 GEOGRID REINFORCEMENT

- A. Geogrid reinforcement shall be a woven or knitted PVC coated geogrid manufactured from high-tenacity PET polyester fiber with an average molecular weight greater than 25,000 ($M_n > 25,000$) and a carboxyl end group less than 30 ($CEG < 30$). The geogrid shall be furnished in prefabricated roll widths of certified tensile strength by the manufacturer. The prefabricated roll width of the geogrid shall be 12" (300 mm) +/- 1/2" (13 mm). No cutting of geogrid reinforcement down to the 12" (300 mm) roll width from a larger commercial roll width will be allowed under any circumstances.
- B. The ultimate tensile strength (T_{ult}) of the geogrid reinforcement shall be measured in accordance with ASTM D6637.
- C. Geogrid – Soil Friction Properties
1. Friction factor, F^* , shall be equal to $2/3 \tan \phi$, where ϕ is the effective angle of internal friction of the reinforced fill soil.
 2. Linear Scale Correction Factor, α , shall equal 0.8.
- D. Long-Term Tensile Strength (T_{al}) of the geogrid reinforcement shall be calculated in accordance with Section 3.5.2 of FHWA-NHI-10-024 and as provided in this specification.
1. The creep reduction factor (RF_{CR}) shall be determined in accordance with Appendix D of FHWA-NHI-10-025 for a minimum 75 year design life.
 2. Minimum installation damage reduction factor (RF_{ID}) shall be 1.25. The value of RF_{ID} shall be based upon documented full-scale tests in a soil that is comparable to the material proposed for use as reinforced backfill in accordance with ASTM D5818.
 3. Minimum durability reduction factor (RF_D) shall be 1.3 for a soil pH range of 3 to 9.
- E. Connection between the PMB retaining wall unit and the geogrid reinforcement shall be determined from short-term testing per the requirements of FHWA NHI-10-025, Appendix B.4 for a minimum 75-year design life.
- F. The minimum value of T_{al} for geogrid used in design of a reinforced precast modular block retaining wall shall be 2,000 lb/ft (29 kN/m) or greater.
- G. The minimum length of geogrid reinforcement shall be the greater of the following:
1. 0.7 times the wall design height, H.

2. 6 feet (1.83 m).
 3. The length required by design to meet internal stability requirements, soil bearing pressure requirements and constructability requirements.
- H. Constructability Requirements. Geogrid design embedment length shall be measured from the back of the precast modular block facing unit and shall be consistent for the entire height of a given retaining wall section.
- I. Geogrid shall be positively connected to every precast modular block unit. Design coverage ratio, R_c , as calculated in accordance with AASHTO LRFD Bridge Design Specifications Figure 11.10.6.4.1-2 shall not exceed 0.50.
- J. Preapproved Geogrid Reinforcement Products.
1. Miragrid XT Geogrids as manufactured by TenCate Geosynthetics of Pendergrass, Georgia USA and distributed by Manufacturers of the Redi-Rock Retaining Wall System.
- K. Substitutions. No substitutions of geogrid reinforcement products shall be allowed.

2.3 GEOTEXTILE

- A. Nonwoven geotextile fabric shall be placed as indicated on the retaining wall construction shop drawings. Additionally, the nonwoven geotextile fabric shall be placed in the v-shaped joint between adjacent block units on the same course. The nonwoven geotextile fabric shall meet the requirements Class 3 construction survivability in accordance with AASHTO M 288.
- B. Preapproved Nonwoven Geotextile Products
1. Mirafi 140N
 2. Propex Geotex 451
 3. Skaps GT-142
 4. Thrace-Linq 140EX
 5. Carthage Mills FX-40HS
 6. Stratatex ST 142

2.4 DRAINAGE AGGREGATE AND WALL INFILL

- A. Drainage aggregate (and wall infill for retaining walls designed as modular gravity structures) shall be a durable crushed stone conforming to No. 57 size per ASTM C33 with the following particle-size distribution requirements per ASTM D422:

U.S. Standard <u>Sieve Size</u>	<u>% Passing</u>
1-½" (38 mm)	100
1" (25 mm)	95-100
½" (13 mm)	25-60
No. 4 (4.76 mm)	0-10
No. 8 (2.38 mm)	0-5

2.5 REINFORCED FILL

- A. Material used as reinforced backfill material in the reinforced zone (if applicable) shall be a granular fill material meeting the requirements of USCS soil type GW, GP, SW or SP per ASTM D2487 or alternatively by AASHTO Group Classification A-1-a or A-3 per AASHTO M 145. The backfill shall exhibit a minimum effective internal angle of friction, $\phi = 34$ degrees at a maximum 2% shear strain and meet the following particle-size distribution requirements per ASTM D422.

U.S. Standard Sieve Size	% Passing
3/4" (19 mm)	100
No. 4 (4.76 mm)	0-100
No. 40 (0.42 mm)	0-60
No. 100 (0.15 mm)	0-10
No. 200 (0.07 mm)	0-15

- B. The reinforced backfill material shall be free of sod, peat, roots or other organic or deleterious matter including, but not limited to, ice, snow or frozen soils. Materials passing the No. 40 (0.42 mm) sieve shall have a liquid limit less than 25 and plasticity index less than 6 per ASTM D4318. Organic content in the backfill material shall be less than 1% per AASHTO T-267 and the pH of the backfill material shall be between 5 and 8.
- C. Soundness. The reinforced backfill material shall exhibit a magnesium sulfate soundness loss of less than 30% after four (4) cycles, or sodium sulfate soundness loss of less than 15% after five (5) cycles as measured in accordance with AASHTO T-104.
- D. Reinforced backfill shall not be comprised of crushed or recycled concrete, recycled asphalt, bottom ash, shale or any other material that may degrade, creep or experience a loss in shear strength or a change in pH over time.

2.6 LEVELING PAD

- A. The precast modular block units shall be placed on a leveling pad constructed from crushed stone or unreinforced concrete. The leveling pad shall be constructed to the dimensions and limits shown on the retaining wall design drawings prepared by the Retaining Wall Design Engineer.
- B. Crushed stone used for construction of a granular leveling pad shall meet the requirements of the drainage aggregate and wall infill in section 2.04 or a preapproved alternate material.
- C. Concrete used for construction of an unreinforced concrete leveling pad shall satisfy the criteria for AASHTO Class B. The concrete should be cured a minimum of 12 hours prior to placement of the precast modular block wall retaining units and exhibit a minimum 28-day compressive strength of 2,500 psi (17.2 MPa).

2.7 DRAINAGE

- A. Drainage Pipe
1. Drainage collection pipe shall be a 4" (100 mm) diameter, 3-hole perforated, HDPE pipe with a minimum pipe stiffness of 22 psi (152 kPa) per ASTM D2412.
 2. The drainage pipe shall be manufactured in accordance with ASTM D1248 for HDPE pipe and fittings.
- B. Preapproved Drainage Pipe Products

1. ADS 3000 Triple Wall pipe as manufactured by Advanced Drainage Systems.

PART 3 – EXECUTION

3.1 GENERAL

- A. All work shall be performed in accordance with OSHA safety standards, state and local building codes and manufacturer's requirements.
- B. The General Contractor is responsible for the location and protection of all existing underground utilities. Any new utilities proposed for installation in the vicinity of the retaining wall, shall be installed concurrent with retaining wall construction. The General Contractor shall coordinate the work of subcontractors affected by this requirement.
- C. New utilities installed below the retaining wall shall be backfilled and compacted to a minimum of 98% maximum dry density per ASTM D698 standard proctor.
- D. The General Contractor is responsible to ensure that safe excavations and embankments are maintained throughout the course of the project.
- E. All work shall be inspected by the Inspection Engineer as directed by the Owner.

3.2 EXAMINATION

- A. Prior to construction, the General Contractor, Grading Contractor, Retaining Wall Installation Contractor and Inspection Engineer shall examine the areas in which the retaining wall will be constructed to evaluate compliance with the requirements for installation tolerances, worker safety and any site conditions affecting performance of the completed structure. Installation shall proceed only after unsatisfactory conditions have been corrected.

3.3 PREPARATION

- A. Fill Soil.
 1. The Inspection Engineer shall verify that reinforced backfill placed in the reinforced soil zone satisfies the criteria of this section.
 2. The Inspection Engineer shall verify that any fill soil installed in the foundation and retained soil zones of the retaining wall satisfies the specification of the Retaining Wall Design Engineer as shown on the construction drawings.
- B. Excavation.
 1. The Grading Contractor shall excavate to the lines and grades required for construction of the precast modular block retaining wall as shown on the construction drawings. The Grading Contractor shall minimize over-excavation. Excavation support, if required, shall be the responsibility of the Grading Contractor.
 2. Over-excavated soil shall be replaced with compacted fill in conformance with the specifications of the Retaining Wall Design Engineer and "Division 31, Section 31 20 00 – Earthmoving" of these project specifications.

3. Embankment excavations shall be bench cut as directed by the project Geotechnical Engineer and inspected by the Inspection Engineer for compliance.

C. Foundation Preparation.

1. Prior to construction of the precast modular block retaining wall, the leveling pad area and undercut zone (if applicable) shall be cleared and grubbed. All topsoil, brush, frozen soil and organic material shall be removed. Additional foundation soils found to be unsatisfactory beyond the specified undercut limits shall be undercut and replaced with approved fill as directed by the project Geotechnical Engineer. The Inspection Engineer shall ensure that the undercut limits are consistent with the requirements of the project Geotechnical Engineer and that all soil fill material is properly compacted according project specifications. The Inspection Engineer shall document the volume of undercut and replacement.
2. Following excavation for the leveling pad and undercut zone (if applicable), the Inspection Engineer shall evaluate the in-situ soil in the foundation and retained soil zones.
 - a. The Inspection Engineer shall verify that the shear strength of the in-situ soil assumed by the Retaining Wall Design Engineer is appropriate. The Inspection Engineer shall immediately stop work and notify the Owner if the in-situ shear strength is found to be inconsistent with the retaining wall design assumptions.
 - b. The Inspection Engineer shall verify that the foundation soil exhibits sufficient ultimate bearing capacity to satisfy the requirements indicated on the retaining wall construction shop drawings per paragraph 1.06 I of this section.

D. Leveling Pad.

1. The leveling pad shall be constructed to provide a level, hard surface on which to place the first course of precast modular block units. The leveling pad shall be placed in the dimensions shown on the retaining wall construction drawings and extend to the limits indicated.
2. Crushed Stone Leveling Pad. Crushed stone shall be placed in uniform maximum lifts of 6" (150 mm). The crushed stone shall be compacted by a minimum of 3 passes of a vibratory compactor capable of exerting 2,000 lb (8.9 kN) of centrifugal force and to the satisfaction of the Inspection Engineer.
3. Unreinforced Concrete Leveling Pad. The concrete shall be placed in the same dimensions as those required for the crushed stone leveling pad. The Retaining Wall Installation Contractor shall erect proper forms as required to ensure the accurate placement of the concrete leveling pad according to the retaining wall construction drawings.

3.4 PRECAST MODULAR BLOCK WALL SYSTEM INSTALLATION

- A. The precast modular block structure shall be constructed in accordance with the construction drawings, these specifications and the recommendations of the retaining wall system component manufacturers. Where conflicts exist between the manufacturer's recommendations and these specifications, these specifications shall prevail.
- B. Drainage components. Pipe, geotextile and drainage aggregate shall be installed as shown on the construction shop drawings.
- C. Precast Modular Block Installation
 1. The first course of block units shall be placed with the front face edges tightly abutted together on the prepared leveling pad at the locations and elevations shown on the construction drawings. The Retaining Wall Installation Contractor shall take special care to ensure that the

- bottom course of block units are in full contact with the leveling pad, are set level and true and are properly aligned according to the locations shown on the construction drawings.
2. Backfill shall be placed in front of the bottom course of blocks prior to placement of subsequent block courses. Nonwoven geotextile fabric shall be placed in the V-shaped joints between adjacent blocks. Drainage aggregate shall be placed in the V-shaped joints between adjacent blocks to a minimum distance of 12" (300 mm) behind the block unit.
 3. Drainage aggregate shall be placed in 9 inch maximum lifts and compacted by a minimum of three (3) passes of a vibratory plate compactor capable exerting a minimum of 2,000 lb (8.9 kN) of centrifugal force.
 4. Unit core fill shall be placed in the precast modular block unit vertical core slot. The core fill shall completely fill the slot to the level of the top of the block unit. The top of the block unit shall be broom-cleaned prior to placement of subsequent block courses. No additional courses of precast modular blocks may be stacked before the unit core fill is installed in the blocks on the course below.
 5. Base course blocks for gravity wall designs (without geosynthetic soil reinforcement) may be furnished without vertical core slots. If so, disregard item 4 above, for the base course blocks in this application.
 6. Nonwoven geotextile fabric shall be placed between the drainage aggregate and the retained soil (gravity wall design) or between the drainage aggregate and the reinforced fill (reinforced wall design) as required on the retaining wall construction drawings.
 7. Subsequent courses of block units shall be installed with a running bond (half block horizontal course-to-course offset). With the exception of 90 degree corner units, the shear channel of the upper block shall be fully engaged with the shear knobs of the block course below. The upper block course shall be pushed forward to fully engage the interface shear key between the blocks and to ensure consistent face batter and wall alignment. Geogrid, drainage aggregate, unit core fill, geotextile and properly compacted backfill shall be complete and in-place for each course of block units before the next course of blocks is stacked.
 8. The elevation of retained soil fill shall not be less than 1 block course (18" (457 mm)) below the elevation of the reinforced backfill throughout the construction of the retaining wall.
 9. If included as part of the precast modular block wall design, cap units shall be secured with an adhesive in accordance with the precast modular block manufacturer's recommendation.
- D. Geogrid Reinforcement Installation (if required)
1. Geogrid reinforcement shall be installed at the locations and elevations shown on the construction drawings on level fill compacted to the requirements of this specification.
 2. Continuous 12" (300 mm) wide strips of geogrid reinforcement shall be passed completely through the vertical core slot of the precast modular block unit and extended to the embedment length shown on the construction plans. The strips shall be staked or anchored as necessary to maintain a taut condition.
 3. Reinforcement length (L) of the geogrid reinforcement is measured from the back of the precast modular block unit. The cut length (L_c) is two times the reinforcement length plus additional length through the block facing unit. The cut length is calculated as follows:
$$L_c = 2*L + 3 \text{ ft } (2*L + 0.9 \text{ m}) \text{ (28" (710 mm) block unit)}$$
$$L_c = 2*L + 5 \text{ ft } (2*L + 1.5 \text{ m}) \text{ (41" (1030 mm) block unit)}$$
 4. The geogrid strip shall be continuous throughout its entire length and may not be spliced. The geogrid shall be furnished in nominal, prefabricated roll widths of 12" (300 mm)+/- 1/2" (13 mm). No field modification of the geogrid roll width shall be permitted.

5. Neither rubber tire nor track vehicles may operate directly on the geogrid. Construction vehicle traffic in the reinforced zone shall be limited to speeds of less than 5 mph (8 km/hr) once a minimum of 9 inches (230 mm) of compacted fill has been placed over the geogrid reinforcement. Sudden braking and turning of construction vehicles in the reinforced zone shall be avoided.
- E. Construction Tolerance. Allowable construction tolerance of the retaining wall shall be as follows:
1. Deviation from the design batter and horizontal alignment, when measured along a 10' (3 m) straight wall section, shall not exceed 3/4" (19 mm).
 2. Deviation from the overall design batter shall not exceed 1/2" (13 mm) per 10' (3 m) of wall height.
 3. The maximum allowable offset (horizontal bulge) of the face in any precast modular block joint shall be 1/2" (13 mm).
 4. The base of the precast modular block wall excavation shall be within 2" (50 mm) of the staked elevations, unless otherwise approved by the Inspection Engineer.
 5. Differential vertical settlement of the face shall not exceed 1' (300 mm) along any 200' (61 m) of wall length.
 6. The maximum allowable vertical displacement of the face in any precast modular block joint shall be 1/2" (13 mm).
 7. The wall face shall be placed within 2" (50 mm) of the horizontal location staked.

3.5 WALL INFILL AND REINFORCED BACKFILL PLACEMENT

- A. Backfill material placed immediately behind the drainage aggregate shall be compacted as follows:
1. 98% of maximum dry density at $\pm 2\%$ optimum moisture content per ASTM D698 standard proctor or 85% relative density per ASTM D4254.
- B. Compactive effort within 3' (0.9 m) of the back of the precast modular blocks should be accomplished with walk-behind compactors. Compaction in this zone shall be within 95% of maximum dry density as measured in accordance with ASTM D698 standard proctor or 80% relative density per ASTM D 4254. Heavy equipment should not be operated within 3' (0.9 m) of the back of the precast modular blocks.
- C. Backfill material shall be installed in lifts that do not exceed a compacted thickness of 9" (230 mm).
- D. At the end of each work day, the Retaining Wall Installation Contractor shall grade the surface of the last lift of the granular wall infill to a $3\% \pm 1\%$ slope away from the precast modular block wall face and compact it.
- E. The General Contractor shall direct the Grading Contractor to protect the precast modular block wall structure against surface water runoff at all times through the use of berms, diversion ditches, silt fence, temporary drains and/or any other necessary measures to prevent soil staining of the wall face, scour of the retaining wall foundation or erosion of the reinforced backfill or wall infill.

3.6 OBSTRUCTIONS IN THE INFILL AND REINFORCED FILL ZONE

- A. The Retaining Wall Installation Contractor shall make all required allowances for obstructions behind and through the wall face in accordance with the approved construction shop drawings.

- B. Should unplanned obstructions become apparent for which the approved construction shop drawings do not account, the affected portion of the wall shall not be constructed until the Retaining Wall Design Engineer can appropriately address the required procedures for construction of the wall section in question.

3.7 COMPLETION

- A. For walls supporting unpaved areas, a minimum of 12" (300 mm) of compacted, low-permeability fill shall be placed over the granular wall infill zone of the precast modular block retaining wall structure. The adjacent retained soil shall be graded to prevent ponding of water behind the completed retaining wall.
- B. For retaining walls with crest slopes of 5H:1V or steeper, silt fence shall be installed along the wall crest immediately following construction. The silt fence shall be located 3' to 4' (0.9 m to 1.2 m) behind the uppermost precast modular block unit. The crest slope above the wall shall be immediately seeded to establish vegetation. The General Contractor shall ensure that the seeded slope receives adequate irrigation and erosion protection to support germination and growth.
- C. The General Contractor shall confirm that the as-built precast modular block wall geometries conform to the requirements of this section. The General Contractor shall notify the Owner of any deviations.

END OF SECTION 32 32 16

SECTION 32 32 23 SEGMENTAL RETAINING WALLS

PART 1 – GENERAL

1.1 SUMMARY

- .1 Section Includes: Furnishing materials and labor required for the design and construction of a ReCon recon segmental retaining wall or equivalent.
- .2 Related Sections:
 - Section 312000 Earth Moving
 - Section 099313.13 Exterior Staining
 - Section 099723 Concrete and Masonry Coatings
 - Section 099623 Graffiti-Resistance Coatings
- .3 Scope of Work: The work shall consist of furnishing materials, labor, equipment and supervision for the construction of a segmental retaining wall structure including pedestrian barricade in accordance with the requirements of this section and in acceptable conformity with the lines, grades, design and dimensions shown in the project site plans.

1.2 PRICE AND PAYMENT PROCEDURES

- .1 Allowances. No allowance shall be made in the price of the retaining wall for excavation beyond the limits required for retaining wall construction as shown on the project plans. The cost of excavation for the purposes of site access shall be the responsibility of the General Contractor. Removal of unsuitable soils and replacement with select fill shall be as directed and approved in writing by the Owner or Owner's representative and shall be paid under separate pay items
- .2 Measurement and Payment.
 - a. The unit of measurement for furnishing the precast modular block retaining wall system shall be the vertical area of the wall face surface as measured from the top of the leveling pad to the top of the wall including coping. The final measured quantity shall include supply of all material components and the installation of the precast modular block system.
 - b. The final accepted quantities of the precast modular block retaining wall system will be compensated per the vertical face area as described above. The quantities of the precast modular block retaining wall as shown on the plans and as approved by the Owner shall be the basis for determination of the final payment quantity. Payment shall be made per square meter of vertical wall face.
 - c. The contractor shall include in the bid price a Global Stability Analysis and Engineering design and review paid under separate lump sum pay item.
 - d. The cost of the pedestrian barricade shall be paid for under separate linear metre pay item
 - e. The cost of excavation, geotextile and bedding and backfill material shall be paid under separate lump sum pay item.
 - f. Subdrainage shall be paid for under separate linear metre subdrain pay item

1.3 REFERENCE STANDARDS

- .1 Concrete Segmental Retaining Wall Units – American Society for Testing and Materials (ASTM):
 - a. ASTM C-1372 Specifications for Segmental Retaining Wall Units (Section 7)

- b. ASTM C-94 Standard Specification for Ready Mix Concrete (Table 1 and Section 7)
- c. ASTM C-172 Standard Specification for Sampling Freshly Mixed Concrete
- .2 Drain Pipe – American Society for Testing Materials (ASTM):
 - a. ASTM D-3034 Specifications for Polyvinyl Chloride Pipe (PVC)
 - b. ASTM D-1248 Specification for Corrugated Plastic Pipe
- .3 Geogrid Reinforcement – Geosynthetic Research Institute (GRI) and American Society for Testing and Materials (ASTM):
 - a. GG1 Geogrid Rib Tensile Strength
 - b. GG2 Individual Geogrid Junction Strength
 - c. GG4a Determination of the Long-Term Design Strength of Stiff Geogrids
 - d. GG4b Determination of the Long-term Design Strength of Flexible Geogrid
 - e. ASTM D-4595 Tensile Properties of Geotextiles - Wide Width Strip
 - f. ASTM D-5262 Unconfined Tension Creep Behavior of Geosynthetics
 - g. ASTM D-5970 Deterioration of Geotextiles from Outdoor Exposure
 - h. ASTM D-6706 Measuring Geosynthetic Pullout Resistance in Soil
- .4 Engineering Design – National Concrete Masonry Association (NCMA):
 - a. NCMA Design Manual for Segmental Retaining Walls, 3rd Edition
 - b. NCMA SRWU-1 Test Method for Determining Connection Strength of SRW
 - c. NCMA SRWU-2 Test Method for Determining Shear Strength of SRW
- .5 Soils – American Society for Testing and Materials (ASTM):
 - a. ASTM D-698 Laboratory Compaction Characteristics of Soil – Standard Effort
 - b. ASTM D-4318 Liquid Limit, Plastic Limit and Plasticity Index of Soils
 - c. ASTM D-422 Gradation of Soils
 - d. ASTM D-424 Atterberg Limits of Soils
 - e. ASTM D-G51 Soil pH
- .6 ReCon Construction Detail Drawings:
 - a. As per www.reconwalls.com/retaining-wall-engineers-specifiers/retaining-walls-2/typical-construction-detail-drawings.html
- .7 Do precast work in accordance with CSA A23.4-09

1.4 QUALITY OF MANUFACTURER

- .1 Manufacturer shall be certified by CSA, meeting requirements of CSA A23.4-09 for appropriate class of work.
- .2 Manufacturer shall be fully experienced in and equipped for this type of work and shall be able to document minimum five consecutive years of activity in the field and have successfully completed projects of similar size and complexity.
- .3 Manufacturer shall be a member of the National Precast Concrete Association (NPCA).
- .4 Approved manufacturer: **Hy-Grade Precast Concrete** (905.684.8568).

1.5 DEFINITIONS

- .3 ReCon Retaining Wall Unit: Concrete, segmental facing block provided by an authorized manufacturer under license to ReCon Retaining Wall Systems, Inc.
- .4 Geogrid: A geosynthetic material manufactured of high tensile materials specifically for the purpose of reinforcing and creating a structural soil mass.
- .5 Drainage Aggregate: Clean, crushed rock located within and immediately behind ReCon units to facilitate drainage and avoid compaction in close proximity to ReCon wall units.
- .6 Reinforced Backfill: Soil zone extending from the Drainage aggregate zone to the back of the embedded geogrid.
- .7 Foundation Soil: Soil zone immediately beneath the retaining wall facing units, the wall leveling pad and the reinforced soil zone.
- .8 Retained Soil: Soil immediately behind retaining wall facing and drainage aggregate or reinforced backfill if present.
- .9 Construction Drawings: Approved final plan for construction prepared and stamped by the wall design engineer licensed to practice in the jurisdiction of the project.

1.6 QUALITY ASSURANCE

- .1 Installer Qualifications: Contractor shall have successfully installed at least three projects similar to that of this project within the last two years. Contractor shall maintain at least one mechanic on site at all times that worked on one or more of these previous installations.
- .2 Contractor shall employ the services of an independent geotechnical or materials engineering firm to provide soil testing and quality assurance inspection for wall construction and soils work. Contractor shall provide any quality control testing or inspection not provided by the Owner.

1.7 SUBMITTALS

- .1 Contractor shall submit Manufacturer's product data and installation instructions for approval.
- .2 Unless provided within these project documents and/or the project drawings, contractor shall submit two sets of the Construction Drawings for all ReCon retaining walls on the project.
 - a. Contractor shall retain a structure engineer, registered in Ontario, to provide signed and sealed retaining wall shop drawings and to conduct field review of the wall installation.
 - b. The design shall be prepared by a Professional Engineer licensed to practice in the jurisdiction of this project.
 - c. The design shall be per NCMA Design Guidelines for Segmental Retaining Walls, or the AASHTO Standard Specifications for Highway Bridges, whichever is applicable as determined by the retaining wall design engineer.
 - d. Construction Drawings shall include:
 - The retaining wall layout and retaining wall heights.
 - Proper placement, lengths and types of geogrid reinforcement where necessary.
 - Typical wall sections.
 - Types, locations and properties of all drainage materials, appurtenances and special installation requirements not covered in this specification.
 - Retaining wall elevation views.
 - Any soils reports or testing conducted in addition to that included within the project drawings and specifications.
 - Design assumptions.
- .3 If geogrid reinforcement is required in the final engineered construction drawings, submit manufacturer's product literature, product testing reports and a twelve inch or larger sample of each type to be used in wall construction.
 - a. Testing Reports shall include:
 - Connection strength data for each combination of ReCon segmental unit and geogrid used as determined by NCMA SRWU-1.
 - Long-term design strength as determined by GG4-91.
 - Geogrid soil pullout as determined by ASTM D-6706.
- .4 Submit gradation reports for aggregates used for the wall leveling pad, unit / drainage fill and for select reinforced fill if required in the final engineered wall design.
- .5 All submittals must be provided and reviewed prior to the start of retaining wall construction.

1.8 DELIVERY, HANDLING AND STORAGE

- .1 Contractor shall inspect all products at delivery to determine that the proper materials have been delivered and are usable. Damaged material shall not be incorporated into the work.
- .2 ReCon retaining wall units shall be stored in a location and manner that protects against excessive weathering and damage.
- .3 Contractor shall prevent ReCon units from excessive soiling and coming in contact with substances which may stain or adhere to the finished visual surfaces of the unit.

PART 2 – PRODUCTS

2.1 MATERIALS

- .1 Cement, aggregates, water, admixtures: to CSA A23.4-09.
- .2 Formwork materials: All forms shall be steel, accurately constructed, well braced and stiffened to avoid deformations under pressure of wet concrete and vibrators. The quality of forms shall be such that all dimensional tolerances and exposed concrete quality can be consistently maintained.
- .3 Use same brands and source of cement and aggregate for entire project to ensure uniformity of colouration and other mix characteristics.
- .4 Anchors: hot dip galvanized steel, concealed, designed to satisfy specific design and performance criteria.
- .5 Geogrid Reinforcement: Geosynthetic reinforcement shall be high tensile geogrid or geotextile manufactured specifically for soil reinforcement applications.
 - a. Construction Drawings shall indicate the type, strength, location and lengths of reinforcement used.
 - b. The geosynthetic manufacturer shall provide all relevant testing to the wall design engineer for incorporation in the wall design and shall be included in the submittal for the Construction Drawings.
 - c. No substitutions of geosynthetic shall be allowed that was not evaluated in the Construction Drawings.
- .6 Base Leveling Pad: The wall base leveling pad material shall consist of a compacted crushed stone base or non-reinforced concrete as indicated in the Construction Drawings.
- .7 Drainage Aggregate: Drainage aggregate shall consist of clean 1” minus crushed stone or gravel meeting the requirements of the Construction Drawings.
- .8 Backfill Material: All backfill material, borrow or imported, shall meet all requirements of the Construction Drawings.
- .9 Drainage Pipe: If required in Construction Drawings, drainage pipe shall be perforated or slotted PVC pipe manufactured in accordance with ASTM D-3034 or corrugated HDPE pipe manufactured in accordance with ASTM D-1248. Drainage pipe may also be covered with a geotextile filter fabric.
- .10 Unit Adhesive: Adhesive shall be a premium, construction grade suitable for concrete and exterior applications.

2.2 CONCRETE MIXES

- .1 Use concrete mix designed to produce minimum 28 MPa compressive strength at 28 Days.

2.3 FABRICATION

- .1 Mark each precast unit to correspond to identification mark on shop drawings for location.
- .2 Mark each precast unit with date cast.
- .3 Markings shall be on part of unit which will not be exposed.

2.4 FINISHES

- .1 ReCon unit face texture to be: **North Shore Granite or a suitable match to dugout finish. Contractor to submit wall finish to contract administrator for acceptance.**
- .2 Colour to be natural concrete grey or stained colour, choice of end user.

PART 3 – EXECUTION

3.1 EXAMINATION

- .1 Verify locations of utilities and existing structures prior to excavation.
- .2 Examine the Project site and evaluate conditions where the ReCon retaining wall will be constructed. Notify the proper supervising authority in writing of any conditions that may interfere with the proper construction of the ReCon wall or delay completion.
- .3 Promptly notify the wall design engineer of site conditions which may affect wall performance, soil conditions observed other than those assumed, or other conditions that may require a reevaluation of the wall design.

3.2 EXCAVATION

- .1 Contractor shall excavate to the lines and grades shown on the construction drawings. The contractor shall be careful not to disturb the base beyond the lines indicated.
- .2 Foundation soils shall be excavated as required for footing base / leveling pad dimensions shown on the construction drawings, or as directed by the wall engineer.
- .3 Over-excavated areas shall be filled with suitable base or backfill material and compacted to 95% standard proctor.

3.3 FOUNDATION SOILS PREPARATION

- .1 Foundation soils shall be evaluated by a Geotechnical Engineer or Owners Representative to ensure that the bearing soils meet or exceed the design conditions or assumptions.
- .2 Compact foundation soil zone to 95% standard proctor prior to installing base / leveling pad.

3.4 BASE / LEVELING PAD

- .1 Base shall be located as indicated on the Construction Drawings and shall have a minimum thickness of 6 inches. Base materials are to be as specified by the wall engineer (generally crushed stone, $\frac{3}{4}$ " minus, or similar).
- .2 Width of the base pad must extend a minimum of 6 inches in front and 6 inches in back of the ReCon Base Block footprint.
- .3 Base material shall be compacted so as to provide a smooth, hard surface on which to place the first course of units.
- .4 Compact base material to 95% of standard proctor.
- .5 Base shall be prepared to ensure full contact of the wall unit with base material. Spacing or gaps between units shall not exceed $\frac{1}{2}$ ".
- .6 Contractor may elect to substitute a portion of the specified granular base materials with a lean, unreinforced concrete topping.
- .7 When a reinforced footing is required by the Construction Drawings, it shall be located below the frost line.

3.5 UNIT INSTALLATION

- .1 First course of units shall be Base Block units and shall be placed in full contact with the base material.
- .2 Check units for level from side-to-side, front to back, and check to maintain unit batter front-to-back.
- .3 Place unit faces in contact side to side and avoid any gaps greater than $\frac{1}{2}$ ".
- .4 Fill and compact fill to grade in front of embedded units prior to compaction behind the wall units.
- .5 Fill voids between ReCon units with $\frac{3}{4}$ " clean crushed rock to a distance of one foot behind the unit depth unless otherwise instructed in the Construction Drawings.
- .6 Sweep and clean the top of each course before setting additional courses.
- .7 Lay each successive course making sure that the bottom recess is in full contact with the unit locators of the course below. Pull unit forward as far as possible. Backfill and compact soil behind the units.
- .8 Check and maintain level and wall batter by use of shims when necessary.
- .9 Follow ReCon recommended procedures to maintain acceptable running bond when

- constructing curved walls and / or corners. Build in accordance with Construction Drawings or ReCon Construction Detail Drawings.
- .10 Handle units with proper lifting devices that have been certified for the loads associated with the weights of the units. Avoid applying forces to the lifting loops in excess of the normal force associated with the weight of the unit (i.e., avoid applying “shear forces” or “dynamic loads” from bouncing or swinging of a unit). If the unit is to be transported over a significant distance in the field, it is recommended that a CABLE be used, NOT A CHAIN. The cable has some “stretch” in it that will absorb some of the dynamic loads.

3.6 GEOGRID INSTALLATION

- .1 Install geosynthetic reinforcement in accordance with manufacturer’s recommendations and the Construction Drawings.
- .2 Locate geosynthetic reinforcement at elevations and to the lengths shown on the Construction Drawings.
- .3 Prior to installation of geosynthetic reinforcement, level and compact backfill material to the level of the reinforcement layer.
- .4 Reinforcement design strength direction must be oriented perpendicular to wall face.
- .5 Position reinforcement on ReCon units over the tongue and groove and to within 2” of the front exposed face. The next course of units shall be placed such that the geogrid is deformed over the tongue and groove. The next course of units must be slid forward such that the back edge of the groove on this unit is up against the back edge of the tongue on the lower unit with the geogrid pinched between the tongue and groove. Hold in place by installing the next course of units.
- .6 Remove all wrinkles or folds in reinforcement by pulling taut prior to backfill placement. Secure using soil staples, stakes or hand tension until reinforcement is covered with sufficient fill to maintain tensioned position.
- .7 Reinforcement shall be continuous throughout the embedment length. Splicing along reinforcement strength direction is not allowed.
- .8 Position reinforcement sections side-by-side to provide 100% coverage along wall face.
- .9 Where curved wall sections cause overlap areas in reinforcement, maintain at least 3” of soil between layers where overlap occurs.

3.7 REINFORCED BACKFILL PLACEMENT

- .1 Wall fill material shall be placed in lifts no greater than 8” in depth and shall be less if necessary to achieve necessary compaction.
- .2 Compact backfill material to 95% of standard proctor.
- .3 Only hand-operated compaction equipment shall be used within 3 feet of the back of the ReCon units.
- .4 Wherever possible, backfill should be placed beginning at the face of the wall. Backfill shall be placed, spread, and compacted in a manner that minimizes the development of wrinkles, folds or movement of geogrid.
- .5 Tracked construction equipment shall not be operated directly on the geogrid. A minimum backfill thickness of 6 inches is required prior to operation of tracked vehicles over the geogrid. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and damaging the geogrid.
- .6 Rubber tired equipment may pass over the geogrid reinforcement at slow speeds, (less than 10 MPH). Avoid sudden braking and sharp turning.
- .7 At the conclusion of each days work, slope backfill at both the crest and bottom of wall away from wall face to prevent surface drainage from scouring or ponding.
- .8 During wall construction, the General Contractor shall be responsible for coordination of other project site operations so as to avoid adjacent construction site drainage from affecting wall construction area.
- .9 Upon completion of wall construction work, the General Contractor shall:
a. Ensure finished grading directs normal drainage away from the finished wall.
b. Ensure other trades do not operate heavy equipment or excavate near the wall and reinforced soil zone.

3.8 SITE TOLERANCES

- .1 Straight walls
 - a. Vertical Alignment: +/- 1.5" over any 12 ft. distance and no more than +/- 3" over the entire length of wall.
- .2 Horizontal Alignment Control:
 - a. Corners and radius location: +/- 1 foot to theoretical location indicated on the Grading Plan.
 - b. Radii: +/- 2 ft. from theoretical lines indicated on the Grading Plan.
- .3 Wall Batter at Completion of Work: +/- 2 degrees from the design batter and no batter less than 2 degrees.

3.9 FIELD QUALITY CONTROL

- .1 Contractor shall be responsible for proper installation and quality control of all ReCon wall components and appurtenant materials.
- .2 Owner shall, at their expense, retain a qualified professional to monitor and perform quality assurance checks of the installer's work.
- .3 Quality Assurance should include foundation soil inspection, frequent backfill compaction testing, verification of geotechnical design parameters and compliance with Construction Drawings and Project Specifications.

3.10 CLEANING

- .1 After completion of wall installation, remove construction debris and restore any adjacent finished areas affected by wall construction to their pre-construction state.
- .2 Wash wall face to remove soiling and stains. Do not use acid or detergents that may "burn" or discolor face.

END OF SECTION 32 32 23