

SECTION 323223

SEGMENTAL RETAINING WALL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. This section is only a portion of the Contract Documents. All of the Contract Documents, including Conditions of the Contract and Division 1 General Requirements, apply to this section.

1.2 DESCRIPTION OF WORK

- A. The work of this section shall include Contractor-Designed Segmental Retaining Wall. Work shall consist of designing and constructing a Segmental Retaining Wall (SRW) system including furnishing of all materials, labor, equipment, testing and inspection, in accordance with these specifications and in conformity with the lines, grades, design, and dimensions shown on the construction drawings. No other wall system will be considered.
- B. Work includes includes excavation and foundation soil preparation, furnishing and installing the leveling pad, drainage fill, drain pipe, geogrid, retained soil/fill, and geotextile filter to the lines and grades shown on the construction drawings. Walls for this project include geogrid reinforced segmental retaining wall systems at locations indicated on the drawings.

1.3 RELATED WORK

- A. Carefully examine all the Contract Documents for requirements that affect the work of this Section. Other specification sections that directly relate to the work of this Section include, but are not limited to the following:
  - 1. Section 311000 – Site Clearing and Preparation
  - 2. Section 312005 – Earth Moving
  - 3. Section 321216 – Asphalt Paving
  - 4. Section 321313 – Exterior Concrete
  - 5. Section 323100 - Fencing
  - 6. Section 333000 - Sanitary and Storm Sewer Systems

1.4 REFERENCE DOCUMENTS

- A. National Concrete Masonry Association (NCMA)
  - 1. NCMA Design Manual for Segmental Retaining Walls, [3rd Edition}
- B. American Society for Testing and Materials (ASTM)
  - 1. Segmental Retaining Wall Units
    - a. ASTM C140/C140M Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
    - b. ASTM C1262 Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units
    - c. ASTM C1372 Standard Specification for Dry-Cast Segmental Retaining Wall Units
    - d. ASTM C881/C881M Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

- e. ASTM D6916 Standard Test Method for Determining the Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks)
2. Geosynthetic Reinforcement
- a. ASTM D4603 Standard Test Method for Determining Inherent Viscosity of Poly(Ethylene Terephthalate) (PET) by Glass Capillary Viscometer
  - b. ASTM D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
  - c. ASTM D5262 Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics
  - d. ASTM D5321/D5321M Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
  - e. ASTM D5818 Standard Practice for Exposure and Retrieval of Samples to Evaluate Installation Damage of Geosynthetics
  - f. ASTM D6637 Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method
  - g. ASTM D6638 Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)
  - h. ASTM D6706 Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil
  - i. 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
  - j. ASTM D7409 Standard Test Method for Carboxyl End Group Content of Polyethylene Terephthalate (PET) Yarns
3. Soils
- a. ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
  - b. ASTM D448 Standard Classification for Sizes of Aggregate for Road and Bridge Construction
  - c. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft<sup>3</sup> (600 kN-m/m<sup>3</sup>))
  - d. ASTM D1241 Standard Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses
  - e. ASTM D1556/1556M Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
  - f. ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56 000 ft-lbf/ft<sup>3</sup> (2 700 kN-m/m<sup>3</sup>))
  - g. ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
  - h. ASTM D3080/3080M Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions
  - i. ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
  - j. ASTM D4767 Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils
  - k. ASTM D4972 Standard Test Method for pH of Soils
  - l. ASTM D6913 Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
  - m. ASTM D6938 Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
4. Drainage Pipe
- a. ASTM F667/F667M Standard Specification for 3 through 24 in. Corrugated Polyethylene Pipe and Fittings

- b. ASTM F758 Standard Specification for Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage
- 5. Geotextile Filter Fabric
  - a. ASTM D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
  - b. ASTM D4632/D4632M Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
  - c. ASTM D4491/D4491M Standard Test Methods for Water Permeability of Geotextiles by Permittivity
  - d. ASTM D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile
  - e. ASTM D5261 Standard Test Method for Measuring Mass per Unit Area of Geotextiles
- C. The General Contractor shall verify by field inspection that all items within this section conform to the specified requirements and approved submittals prior to installation.

#### 1.5 SUBMITTALS/CERTIFICATION

- A. Submit manufacturer's certification, at least [30] days before start of SRW construction, attesting that the retaining wall system components meet the requirements of Part 2 of this specification.
- B. Submit technical data sheets and installation instructions for each manufactured product specified
- C. Submit one (1) set of shop drawings and design calculations for the retaining wall system prepared, signed and sealed by a Professional Engineer licensed in the state of wall installation. Design shall meet all requirements established in NCMA Design Manual for Segmental Retaining Walls, 3rd Edition.
  - 1. A complete set of design calculations and shop drawings which shall include, but not be limited to, the following items for the Segmental Retaining Walls:
    - a. Legible, complete and organized design computations indicating soil parameters, design criteria, pressure diagrams, allowable stresses, stability computations and other details necessary to clearly demonstrate the rational basis for design
    - b. Drawings showing all material specifications and details for the structural elements and sequences of assembly including backfilling materials and procedures
    - c. The Site retaining walls shall be shown in plan, elevation, and section
    - d. The elevation and location of any structure or utilities affecting or affected by any retaining wall shall be shown in plan and section
    - e. Detailed construction procedures and sequencing for the installation of the retaining wall system shall be provided
    - f. Details of drainage provided behind wall and connection of drainage to on-site storm drains, as appropriate
    - g. Calculations documenting internal and global stability. Calculations should include special conditions such as included utilities, guard rails and railings
    - h. Drawings and computations shall bear the stamp and signature of a Professional Engineer who is licensed in the Commonwealth of Massachusetts and who is experienced in the design of retaining walls of the type proposed
    - i. Latest edition of manufacturer's standards and specifications for proposed materials, method of installation and list of material proposed for use
    - j. Detail of fence post installation into top of wall
- D. Samples: The Contractor Contractor shall provide samples of at least one in-line block, one corner block and one cap stone representative of the full range of color variations.

1.6 QUALITY ASSURANCE

- A. The Contractor shall provide a list of [5] successful completed projects by the wall installer of similar scope and size with references, at least [30] days before the start of the SRW construction.
- B. The Contractor shall provide evidence that the design Engineer has a minimum of [5] year of documental experience in the design of segmental retaining wall structures. The design Engineer shall provide proof of current professional liability insurance.
- C. Despite review and comment by the Geotechnical Consultant, the Contractor shall remain solely responsible for the wall design and the adequacy and safety of materials and methods used in construction.
- D. The Contractor is responsible for ensuring that construction adjacent to the wall does not disturb the wall or place temporary construction loads on the wall that exceed design loads, including loads such as water pressure, temporary grades, or equipment loading. Heavy paving or grading equipment shall be kept a minimum of 3 feet behind the back of the wall face. Equipment with wheel loads in excess of 150 psf live load shall not be operated within 10 feet of the face of the retaining wall during construction adjacent to the wall. Care should be taken by the Contractor to ensure water runoff is directed away from the wall structure until final grading and surface drainage collection systems are completed

1.7 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products and provide adequate protection against damage. Handle in strict compliance with manufacturer instructions and recommendations and store off the ground. Protect from all possible damage including, but not limited to chipping, staining, cracking and other damage. Sequence deliveries to avoid delays, but minimize on-site storage.
- B. The Contractor shall inspect the materials upon delivery to assure that proper type, grade, color, and certification have been received
- C. The Contractor shall store and handle all materials in accordance with manufacturer's recommendations and in a manner to protect all materials from damage due to job site conditions. Damaged materials shall not be incorporated into the SRW
- D. During delivery and storage, the Contractor shall protect geogrids from direct sunlight, ultraviolet radiation, heat and any other condition of the environment that would damage the geogrids
- E. All geosynthetic material labeling, shipment and storage shall follow ASTM D 4873
- F. The Contractor shall prevent chipping and cracking of SRW units, and protect against any damage the connectors between the SRW units. Replace damaged SRW units as directed by the Owner's Representative and/or Engineer.

1.8 COORDINATION

- A. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work as necessary to assure the steady progress of the work of this Contract.
- B. Substrates: Proceed with work only when substrate construction and penetrating work is complete.

1.9 GUARANTEE

- A. In addition to the specific guarantee requirements of the GENERAL CONDITIONS and SUPPLEMENTARY GENERAL CONDITIONS, the Contractor shall provide the manufacturers' standard written warranty for each product within this specification. All of these guarantees shall be in addition to, and not in lieu of, other liabilities that the Contractor may have by law or other provisions of the Contract Documents.

## PART 2 - PRODUCTS

### 2.1 DEFINITIONS

- A. Segmental Retaining Wall (SRW) system: a system where the basic components are the foundation soil, the leveling pad, the concrete wall units, the geogrid reinforcement, the retained soil/fill, the drainage fill, and the drain pipe.
- B. SRW unit: a dry-stacked concrete retaining wall unit manufactured as described in the specification here within.
- C. Geogrid reinforcement: a geosynthetic material formed by a regular network of intersecting ribs with apertures of sufficient size to allow interlock with surrounding soil, stone, or other materials and designed specifically to reinforce soil mass.
- D. Cantilever Fence Post Anchoring System: A pre-engineered below grade system allowing for back of wall installation of fence posts along top of SRW units, eliminating the 36" offset requirement for rails and fences under IBC 1015.2.
- E. Drainage fill: a free-draining aggregate material placed in the cores, between and extending behind the SRW units
- F. Drain pipe: a perforated pipe used to collect and convey water to an outlet, removing incidental water from the drainage fill
- G. Geotextile filter: a geosynthetic material comprised of textiles used adjacent to soil, allowing water to pass through it while retaining the soil on the upstream side
- H. Reinforced fill: fill soil placed directly behind the drainage fill. It contains horizontal geogrid reinforcement as outlined on the plans
- I. Retained soil/fill: an undisturbed native soil or fill soil placed directly behind the reinforced fill in reinforced soil SRW systems or behind the drainage fill in non-reinforced soil SRW systems
- J. Leveling pad: a level surface consisting of aggregate material or unreinforced concrete placed to provide a working surface for placement of the SRW units
- K. Foundation soil: Soil mass supporting the leveling pad and the reinforced fill soil zone of a SRW system.

### 2.2 MATERIALS

Materials Submittals: The Contractor shall submit manufacturers' certifications stating that the SRW units meet the material requirements of this specification. Submit the manufacturer's product information and technical data for the block units, masonry adhesive, drainage materials and installation recommendations.

2. Samples: The Contractor shall provide samples of at least one in-line block, one corner block and one cap stone representative of the full range of color variations.
3. Submit to the Owner's Geotechnical Consultant for review and comment at least 21 days prior to delivery of retaining wall materials to the Site and prior to the start of Site retaining wall construction the following:
  - a. Experience
    - 1) Provide at least three (3) examples of segmental retaining walls successfully constructed by the Contractor. Examples shall be of similar type, height and length and be constructed in similar soil conditions. Provide Owner's name and telephone number for each example.
    - 2) Provide documentation that Contractor's Engineer has at least five (5) years' experience designing selected wall types under similar conditions in excess of 100,000 face square feet. Provide references for at least three (3) projects.
  - b. Permanent Retaining Wall System(s)
    - 1) A complete set of design calculations and shop drawings which shall include, but not be limited to, the following items for the Site Retaining Walls:
      - a) Legible, complete and organized design computations indicating soil parameters, design criteria, pressure diagrams, allowable stresses, stability computations and other details necessary to clearly demonstrate the rational basis for design.
      - b) Drawings showing all material specifications and details for the structural elements and sequences of assembly including backfilling materials and procedures.
      - c) The Site retaining walls shall be shown in plan, elevation, and section.
      - d) The elevation and location of any structure or utilities affecting or affected by any retaining wall shall be shown in plan and section.
      - e) Detailed construction procedures and sequencing for the installation of the retaining wall system shall be provided.
      - f) Details of drainage provided behind wall and connection of drainage to on-site storm drains, as appropriate.
      - g) Calculations documenting internal and global stability. Calculations should include special conditions such as included utilities, guard rails and railings.
      - h) Drawings and computations shall bear the stamp and signature of a Professional Engineer who is licensed in the Commonwealth of Massachusetts and who is experienced in the design of retaining walls of the type proposed.
      - i) Latest edition of manufacturer's standards and specifications for proposed materials, method of installation and list of material proposed for use.

- c. Despite review and comment by the Geotechnical Consultant, the Contractor shall remain solely responsible for the wall design and the adequacy and safety of materials and methods used in construction.

E. Delivery, Storage, and Handling

1. Contractor shall check materials upon delivery to ensure that the specified type and grade of materials have been received and proper color and texture of SRW units have been received.
2. Contractor shall store and handle materials in accordance with manufacturer's recommendations and in a manner to prevent deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breaking, chipping or other causes.
3. Contractor shall prevent mud, wet concrete, epoxies and other deleterious materials from coming in contact with materials.
4. Contractor shall protect materials from damage; no damaged material shall be incorporated into the segmental wall.

F. Quality Control

1. The Contractor is responsible for ensuring that construction adjacent to the wall does not disturb the wall or place temporary construction loads on the wall that exceed design loads, including loads such as water pressure, temporary grades, or equipment loading. Heavy paving or grading equipment shall be kept a minimum of 3 feet behind the back of the wall face. Equipment with wheel loads in excess of 150 psf live load shall not be operated within 10 feet of the face of the retaining wall during construction adjacent to the wall. Care should be taken by the Contractor to ensure water runoff is directed away from the wall structure until final grading and surface drainage collection systems are completed.

G. Materials

A. Segmental Retaining Wall (SRW) Units

1. The basis of design SRW units shall be a textured pattern as produced by Redi-Rock and represented by Casey Scavone, 617-620-1667, or approved equal. Portland cement concrete blocks specifically designed for reinforced retaining wall application.
  2. The concrete wall modules shall be 18 x 46 x 28 inches with a maximum tolerance of plus or minus 1/8 in. for each dimension. The retaining wall modules shall be solid units and have a minimum weight of 1520 lbs. per unit. The concrete wall modules shall have an integral shear key connection that shall be offset to permit a minimum wall batter of 5.2 degrees.
  3. Acceptable other manufacturers with products that conform to the details required for this project are:
    - i. Stone Strong Systems, Fractured Ledge finish 877-501-5652.
    - ii. Recon Retaining Walls, Weathered Edge finish 800-696-7432
  4. The concrete wall modules shall have a minimum 28-day compressive strength of 4000 psi as tested in accordance with ASTM C 140 with an air entrainment of 6% +/- 1.5%.
2. Color of SRW units shall be selected by the Landscape Architect from the approved manufacturer's standard colors. The basis of design Redi-Rock shall have 2-color color hardener applied to the form surface for entire wall block faces. Approved equals that are unable to incorporate color hardener in their manufacturing process shall incorporate approved color admixture

within the mix and use approved masonry stain in a random pattern after installation to be equal to Redi-Rock New England LedgeStone.

H. Leveling Pad and Free Draining Backfill

1. Refer to Section 312000 Earth Moving for leveling pad, drainage aggregate, reinforced soil backfill and Geotextile filter materials.
  - a. Leveling pad shall be a non-frost susceptible, well graded compacted crushed stone and shall include an underdrain where indicated on the drawings.
  - b. The drainage soil shall be a free draining angular granular material of uniform particle size smaller than 25 mm (1 in.) separated from the retained soil by a geotextile filter. The drainage soil shall be installed directly behind the SRW units.
  - c. Backfill material shall be approved by the geotechnical engineer. Site excavated soils may be used if approved unless otherwise specified in the drawings. Unsuitable soils with a PL>6, organic soils and frost susceptible soils shall not be used within a 1 to 1 influence area.
  - d. Non-woven geotextile cloth shall be placed between the Free Draining Backfill and retained soil.
  - e. Where additional fill is needed, Contractor shall submit sample and specifications to the Engineer for approval.

I. Drainage

1. Internal and external drainage shall be evaluated and designed by the Professional Engineer who is responsible for the final wall design as part of the shop drawing submittal requirements.
2. Wall drains shall connect to the subsurface system as indicated on the civil dwgs.

J. Construction of Wall System

1. The Contractor shall contact DIG-SAFE at 1-888-344-7233 prior to commencing any excavation work at the site. Contractor shall verify location of existing structures and utilities prior to excavation. Contractor shall ensure all surrounding structures are protected from the effects of wall excavation. Excavation support, if required, is the responsibility of the Contractor.
2. Contractor shall excavate to the lines and grades shown on the project grading plans taking care to preserve the undisturbed state of the subgrade.
  - a. Following the excavation, the foundation soil shall be examined by the Owner's Engineer to assure actual foundation soil strength meets or exceeds the assumed design bearing strength. Soils not meeting the required strength shall be removed and replaced with compacted dense graded crushed s
  - b. Foundation soil shall be proof-rolled and compacted to 95% standard Proctor density and inspected by the Owner's Geotechnical Engineer prior to placement of leveling pad materials.
  - c. Leveling pad shall be placed as shown on the final, P.E.-sealed retaining wall plans with a minimum thickness of 6 inches. The leveling pad shall extend laterally at least a distance of 6 inches from the toe and heel of the lowermost SRW unit.
  - d. Granular leveling pad material shall be compacted to provide a firm, level bearing surface on which to place the first course of units. Well-graded sand can be used to smooth the top 1/4 inch to 1/2 inch of the leveling pad. Compaction will be with mechanical plate compactors to achieve 95% of maximum standard Proctor density (ASTM D 698).
  - e. All SRW units shall be installed at the proper elevation and orientation as shown on the final, P.E.-sealed wall plans and details or as directed by the Wall Design Engineer. The SRW units shall be installed in accordance with the manufacturer's recommendations.



- f. First course of SRW units shall be placed on the leveling pad. The units shall be leveled side-to-side, front-to-rear and with adjacent units, and aligned to ensure intimate contact with the leveling pad. The first course is the most important to ensure accurate and acceptable results, and each unit in the first course shall be in full contact with base. No gaps shall be left between the front of adjacent units. Alignment may be done by means of a string line or offset from base line to the back of the units. All units shall be checked for level and alignment as they are placed.
  - g. Place and compact drainage fill behind and around the SRW units. Place compacted ordinary fill behind drainage fill. Clean excess debris from top of units. Prior to placement of next course, the level and alignment of the units shall be checked and corrected where needed.
  - h. Install next course of wall units on top of base row. Position blocks to be offset from seams of blocks below. Blocks shall be placed fully forward so knob and groove are engaged. Check each block for proper alignment and level. Backfill to 12 inch width behind block with Free Draining Backfill. Spread backfill in uniform lifts not exceeding 9 inches. Employ methods using lightweight compaction equipment that will not disrupt the stability or batter of the wall. Hand-operated plate compaction equipment shall be used around the block and within 3 feet of the wall to achieve consolidation. Compact backfill to 95% of standard proctor (ASTM D 698, AASHTO T-99) density within 2% of its optimum moisture content.
  - i. Install each subsequent course in like manner. Repeat procedure to the extent of wall height.
  - j. Allowable construction tolerance at the wall face is 2 degrees vertically and 1 inch in 10 feet horizontally.
3. At completion of wall construction, backfill shall be placed level with final top of wall elevation. If final grading, paving, landscaping and/or storm drainage installation adjacent to the wall is not placed immediately after wall completion, temporary grading and drainage shall be provided to ensure water runoff is not directed at the wall nor allowed to collect or pond behind the wall until final construction adjacent to the wall is completed

### PART 3 - EXECUTION

#### 3.1 EXCAVATION

- A. Contractor shall excavate to the lines and grades shown on the construction drawings.
- B. Contractor shall take precautions to minimize over-excavation and assure that safe excavations and embankments are maintained throughout the course of the project.
- C. Contractor shall verify location of existing structures and utilities prior to excavation and shall ensure all surrounding structures are protected from the effects of wall excavation.
- D. Excavation support, if required, shall be designed by the Contractor.
- E. All excavation shall be done in full accordance with the prevailing trench and excavation safety laws applicable to the project site.

#### 3.2 FOUNDATION

- A. Following the excavation, the foundation soil shall be examined by the Owner's Representative to assure the actual foundation soil strength meets or exceeds the assumed design bearing

strength. Soils not meeting the required strength shall be removed and replaced with soil meeting the design criteria, as directed by the Owner's Representative.

- B. Contractor shall obtain approval from the Owner's Representative for the foundation bearing surface prior to proceeding with construction.

### 3.3 FIELD QUALITY CONTROL AND ASSURANCE

#### A. Quality Assurance

1. The Owner may retain the services of an independent testing and inspection firm to provide soil testing and quality assurance inspection for wall construction. This does not relieve the Contractor from securing the necessary construction quality control testing and inspection.
2. Quality assurance shall include sufficient testing and observation to verify that wall construction substantially conforms to the design drawings and specifications.

#### B. Quality Control

1. The Contractor shall engage inspection and testing services to perform the minimum quality control testing described in the retaining wall design plans and specifications.
2. Quality control testing shall include soil and backfill testing to verify soil types and compaction and verification that the retaining wall is being constructed in accordance with the design plans and project specifications.

### 3.4 CLEANING, REPAIR AND PROTECTION

- A. Repair minor damage to eliminate all evidence of repair. Remove and replace work that cannot be satisfactorily repaired.
- B. Provide temporary protection to ensure that the work will be without dirt, stains, damage or deterioration at time of final acceptance. Clean up stains and spills as they occur. Remove protections and clean as necessary immediately before final acceptance.
- C. Upon completion of the work and before acceptance, the Contractor shall remove and dispose of in an approved manner all surplus materials, rubbish, etc. which the Contractor may have accumulated during the course of the work and shall leave the site in a clean and orderly condition. The Contractor shall not abandon any material at or near the site regardless of whether or not it has any value

END OF SECTION