
02632 – SEGMENTAL RETAINING WALL SYSTEM

(Last Revised 6/22/10)

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PART 1 - GENERAL**1.1 DESCRIPTION**

The work includes furnishing and constructing a segmental concrete retaining wall (SRW) system, including leveling pad, soil reinforcement, unit drainage fill, reinforced backfill, and incidental materials required for SRW construction to the lines and grades shown on the construction drawings and specified herein.

1.2 REFERENCE STANDARDS**A. American Society for Testing and Materials (ASTM)**

- 1) **ASTM C90** Standard Specification for Loadbearing Concrete Masonry Units
- 2) **ASTM C140** Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
- 3) **ASTM C1262** Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units
- 4) **ASTM D422** Standard Test Method for Particle-Size Analysis of Soils
- 5) **ASTM D698** Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
- 6) **ASTM D1248** Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
- 7) **ASTM C1372** Standard Specification for Dry-Cast Segmental Retaining Wall Units
- 8) **ASTM D1388** Standard Test Method for Stiffness of Fabrics
- 9) **ASTM D2166** Standard Test Method for Unconfined Compressive Strength of Cohesive Soil

- 10) **ASTM D3080** Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions
- 11) **ASTM D4318** Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- 12) **ASTM D4475** Standard Test Method for Apparent Horizontal Shear Strength of Pultruded Reinforced Plastic Rods By the Short-Beam Method
- 13) **ASTM D4595** Standard Test Methods for Tensile Properties of Geotextiles by the Wide-Width Strip Method
- 14) **ASTM D5262** Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics
- 15) **ASTM F810** Standard Specification for Smoothwall Polyethylene (PE) Pipe for Use in Drainage and Waste Disposal Absorption Fields
- 16) **ASTM G51** Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing
- 17) **ASTM G57** Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

B. Geosynthetic Research Institute (GRI)

- 1) **GRI-GG4** Determination of Long Term Design Strength of Geogrids
- 2) **GRI-GG5** Determination of Geogrid (soil) Pullout

C. National Concrete Masonry Association (NCMA)

- 1) **NCMA SRWU-1** Test Method for Determining Connection Strength of SRW
- 2) **NCMA SRWU-2** Test Method for Determining Shear Strength of SRW

D. American Association of State Highway and Transportation Officials (AASHTO)

- 1) **AASHTO M288** Geotextiles Used for Subsurface Drainage Purposes
- 2) **AASHTO M252** Corrugated Polyethylene Drainage Tubing
- 3) Standard Specifications for Highway Bridges, Latest Edition

- E. Contact “**NC One Call**” at 811 before you dig.



1.3 DESIGN REQUIREMENTS

- A. **Wall Design Engineer:** The wall design shall be performed by a Professional Engineer licensed in the State of North Carolina that prepares and seals the design submittals. For the Town of Clayton minimum standard SRW design requirements, see ***Segmental Retaining Wall Design*** in the Town of Clayton Design Manual.
- B. **Design Method:** Design of SRW's using geosynthetic reinforcement shall be in accordance with the NCMA Design Guidelines for Segmental Walls, AASHTO or NCMA utilizing AASHTO earth pressure and stability design criteria. Metallic reinforcement systems shall be designed in accordance with AASHTO Standard Specification for Highway Bridges, Section 5.8, using the Coherent Gravity Method. All designs shall conform to the minimum safety factors in this Specification. Design submittals not meeting this design criteria or technical/administrative criteria specified will be rejected in their entirety until complete compliance is achieved.

1.4 SUBMITTALS

Fourteen Days prior to the anticipated start date for the SRW, the SRW contractor shall provide to the Town of Clayton a minimum of a submittal package for review including the following:

- A. A set of detailed SRW design plans sealed by a registered professional engineer licensed in the state of North Carolina. The SRW plans shall include plan and elevation views of each wall, cross sections and all details, dimensions and quantities necessary to construct the SRW.
- B. Detailed design calculations including soil bearing pressure. Calculations shall include assumed design properties for the Geogrid reinforcement such as SRW/soil reinforcement connection and shear, reinforcement strength.
- C. Product literature indicating specifically which SRW units and soil reinforcement are proposed for use on the project including color, face style and texture.
- D. Documentation for the SRW units and soil reinforcement demonstrating compliance with the requirements of this specification including but not limited to SRW compressive strength and absorption;
- E. If requested by the Town Engineer, Manufacturer's certification that the SRW units and soil reinforcement meet the requirements of this specification.
- F. Contractor's certification that
- 1) The specific SRW system proposed for use on this project has been successfully installed on a minimum of 500,000 square feet of retaining walls with a minimum of 5 similar projects that have been in place for a minimum of 5 years.
 - 2) The contractor has a minimum of 15,000 square feet of experience with the proposed SRW system. Contact names and telephone numbers shall be listed for projects used to document the 15,000 square feet.

1.5 DELIVERY, STORAGE AND HANDLING

The contractor shall check all materials upon delivery to assure that the proper type, grade, color and material certification have been received. Contractor shall protect materials from damage due to jobsite conditions and in accordance with the manufacturer's recommendations. Damaged materials shall not be incorporated into the work.

PART 2 - PRODUCTS

2.1 DEFINITIONS

- A. **Base Leveling Pad:** Level compacted gravel or unreinforced concrete pad upon which the first course of segmental concrete facing units is placed.
- B. **Foundation Soil:** Compacted, imported or in-situ soil beneath entire wall.
- C. **PET:** Polyethylene Terephthalate (polyester): PET, a Geogrid Polymer, is the material from which the majority of Geogrids are manufactured.
- D. **Reinforced Backfill:** Compacted soil that is within the reinforced soil volume as shown on the plans.
- E. **Retained Soil:** Compacted, imported or in-situ soil behind reinforced zone of the retaining wall.
- F. **Segmental Concrete Units:** A modular concrete facing unit machine made from Portland cement, water and mineral aggregates.
- G. **Soil Reinforcement:** Geosynthetic or steel reinforcement formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock or earth and function as reinforcement. Soil reinforcement shall be specifically manufactured for soil reinforcement.
- H. **Unit Drainage Fill:** Drainage aggregate that is placed within and behind the segmental concrete units.

2.2 SEGMENTAL CONCRETE UNITS SHALL MEET THE FOLLOWING REQUIREMENTS

- A. Manufactured in accordance with ASTM C1372 with a minimum 28-day compressive strength of 3000 psi (4000 psi for steel reinforced systems) for any one individual unit and 3500 psi for the average of three units. The 24-hour water absorption rate shall not exceed 8%. SRW units finish and appearance shall be per ASTM C1372. Units may be either solid or hollow as per the manufacturer's standard design.

Freeze-thaw durability testing will be required as described in ASTM C1372 Sections 4.2, 4.2.1 and 7.3. Testing shall be in accordance with ASTM C1262.

Exposed faces shall be free of chips, cracks or other imperfections when viewed from a distance of 20 feet under diffused lighting. All units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength of permanence of the construction.

SRW units dimensions shall not differ by more than 1/16-inch.

Unless otherwise identified prior to ordering, color shall be concrete gray and the face finish shall be a sculptured rock face in a flat planar configuration unless shown otherwise on the Plans.

Acceptable Manufacturers are Keystone Retaining Wall Systems, Rockwood Retaining Walls, or Versa-Lok.

- B. **Shear Pin Units:** Provide shear pins or connection devices to provide a mechanical connection between vertically and horizontally adjacent units so as to provide at a 2 psi normal pressure a minimum inter-unit shear strength of 500 plf per NCMA SRWU-2 and a geosynthetic to SRW unit peak connection strength of 500 lbs/ft per NCMA SRWU-1. Shear devices shall protrude at least 1 inch into receiving openings of the SRW units. At least one shear connector is required per linear foot of wall for each course. The shear connector must fit within an aperture of the soil reinforcement and be capable of holding the reinforcement in the proper position during tensioning and backfilling. Connectors shall result in a design wall batter of 1° to 10° .

2.3 SOIL REINFORCEMENT

- A. **Geosynthetic Reinforcement:** The type, strength, and placement location of the reinforcing Geogrid reinforcement shall be determined by the Wall Design Engineer as shown on the drawings.

Geogrid reinforcement shall be of a type recommended by the block supplier to be compatible with the facing units, with a minimum long term design strength (in pounds per foot) as specified by the Wall Design Engineer and shown on the wall plans. The Geogrid shall be a regular grid structure having an aperture geometry and rib and junction cross-sections sufficient to permit significant mechanical interlock with the granular backfill material. The Geogrid shall have high continuity of tensile strength through all ribs and junctions of the grid structure. The Geogrid shall have high resistance to deformation under sustained long term design load while in service and shall also be resistant to ultraviolet degradation, to damage under normal construction practices, and to all forms of biological or chemical degradation normally encountered in the granular backfill material.

- B. Geosynthetic reinforcement shall be evaluated in accordance with NCMA Section 3.5 with the following additions and clarifications.
- 1) The minimum RF_{ID} shall be ≥ 1.05 .
 - 2) The minimum RF_D shall be ≥ 1.10 .
 - 3) The minimum FS_{UNC} shall be ≥ 1.5 .
 - 4) Geogrids not providing a minimum junction strength of 40 lbs per foot per GRI: GG2 and all geotextiles shall have a minimum mass of 8 oz/sy and meet the strength requirements of AASHTO M288, Class 1 Geotextile.
 - 5) Geogrids not providing a minimum stiffness (flexural rigidity) of 30,000 mg-cm per ASTM D1388 and all geotextiles shall be staked during placement per Section 3.1.B.
 - 6) PET geosynthetics shall be coated with a suitable coating immutably bonded to the PET bundles. The coating shall contain a minimum of 1-% carbon black measured per ASTM D4218 *Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique*. Geogrids not meeting this requirement and all geotextiles shall use a minimum $RF_D = 1.6$.

- 7) PET geosynthetics shall possess a Molecular Weight $\geq 25,000$ g/m per GRI: GG8 and a carboxyl end group number ≤ 30 per GRI: GG7. PET geosynthetics not meeting this criteria shall use a minimum $RF_D = 2.0$.
- 8) HDPE geogrids shall have a melt flow index value ≥ 0.88 . HDPE geogrids not meeting this criteria shall use a minimum $RF_D = 2.0$.
- 9) Manufacturing Quality Control - The geosynthetic manufacturer shall have a quality control program that includes QC testing no less frequently than each 400,000 sf of production. The testing, as a minimum, shall include Tensile Strength per ASTM D4595 *Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method*.

C. **Steel Reinforcement:** Steel reinforcement shall meet the requirements of and possess the minimum strength and durability at the end of the 75-year design life per the AASHTO Standard Specifications for Highway Bridges. Allowable tensile stress shall not exceed $0.55F_y$ at the end of the design service life.

2.4 UNIT DRAINAGE FILL

Fill of concrete units in place shall be porous backfill and shall consist of clean 1" minus crushed stone or crushed gravel meeting the following gradation per ASTM D422 *Standard Test Method for Particle-Size Analysis of Soils*. Geotextile shall not be substituted for unit drainage fill.

Sieve Size	Percent Passing
1 inch	100
$\frac{3}{4}$ inch	75-100
No. 4	0-10
No. 50	0-5

2.5 SUBDRAIN:

Subdrain shall be a minimum of 4 inches in diameter. Pipe shall equal or exceed Hancor perforated co-extruded smoothwall pipe meeting ASTM F810 PVC bell & spigot or Hancor perforated heavy-duty Hi-Q or Sure-Lok pipe meeting AASHTO M252, Type S or SP.

2.6 REINFORCED BACKFILL

The fill soil material in the entire reinforced earth zone shall be granular backfill meeting the following requirements:

- A. Backfill shall consist of soil with:
 - 1) Less than 35% passing the No. 200 sieve per ASTM D422 *Standard Test Method for Particle-Size Analysis of Soils* with a maximum size of $\frac{3}{4}$ inches (4-inch maximum for steel reinforced systems).
 - 2) A plasticity index less than 10 per ASTM D4318.
 - 3) An effective internal angle of friction $\geq 30^\circ$ per ASTM D2166 or D3080 at the compaction standard.
 - 4) Less than 0.5% organic material.
 - 5) Material can be site-excavated soils where the above requirements can be met. Unsuitable soils for backfill including ML, CL, MH, CH, OH or PT shall not be used in the backfill or in the reinforced soil mass.

- B. Use of an effective friction angle greater than 30° for design shall be verified by appropriate testing submitted to and approved by the Town Engineer prior to construction.
- C. Backfill reinforced with geosynthetic shall have a pH in the range of 3 to 9 per ASTM G51.
- D. Backfill reinforced with steel reinforcement shall have a pH in the range of 5 to 10 per ASTM G51, minimum resistivity of 3000 ohm-cm at 100% saturation per ASTM G57 *Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method* and free of sulfates > 200 ppm or chlorides > 100 ppm. If the resistivity is \geq 5000 ohm-cm, the chloride and sulphate requirements are waived. Subject to approval, the Town Engineer may allow slightly wider ranges of pH for higher resistivities.

2.7 BASE LEVELING PAD

Unless otherwise recommended by the supplier/manufacturer, base leveling pad shall be constructed of dense graded crushed stone or crushed gravel. A concrete leveling pad consisting of lean unreinforced concrete (Class B Concrete) may be used at the wall contractor's option.

PART 3 - CONSTRUCTION

3.1 **GENERAL:** Construction and construction tolerances shall be in accordance with NCMA Section 6 and 7 or AASHTO Section 7 with the following additions or clarifications.

- A. A minimum of 1 cubic foot of unit drainage fill shall be used for each square foot of wall face and shall be placed within the cores, between and behind the SRW units and shall extend back from the face of the wall a minimum of 2 feet. Geotextile is not an acceptable substitute for unit drainage fill unless the entire reinforced backfill zone meets the requirements of AASHTO Section 7.3.6.3 and connection strength requirements can be met without unit drainage fill.
- B. Reinforcement not meeting the minimum stiffness requirement of Section 2.3.A (5) or wider than 12 feet shall be staked at the corners and on 12 foot centers along the roll edges to prevent wrinkling or other distortion of the reinforcement during backfill placement.

3.2 **FOUNDATION SOIL PREPARATION**

Foundation soil shall be excavated as required for base course leveling pad dimensions and limits of reinforced earth zone as shown on the construction drawings. Contractor shall take precautions to minimize over-excavation. Excavation support, if required, shall be accommodated and improved as directed by the Wall Design Engineer.

Prior to placement of the stone or concrete leveling pad, foundation soil shall be examined by the Engineer to assure that the actual foundation soil strength meets or exceeds the assumed design bearing strength. Soils not meeting the required strengths shall be removed and replaced with soil or stone meeting the design criteria.

The earth foundation shall have a density equal to or greater than 90% of the Maximum Standard Proctor Dry Density. The earth foundation shall be stepped at the required intervals to keep the subgrade at a minimum of 12 inches below the proposed toe side finished grade and no less than that shown on the construction drawings.

3.3 **LEVELING PAD**

The contractor shall place the leveling pad as shown on the construction drawings but no less than 6 inches thick. The contractor shall construct the leveling pad to ensure complete contact of the retaining wall unit with the leveling pad. Gap will not be allowed between the retaining wall unit and the leveling pad.

3.4 UNIT INSTALLATION

Materials shall be installed at the proper elevation and orientation shown on the plans. The concrete segmental units and Geogrid reinforcement shall be installed in general accordance with the approved submittals. The plans should govern in any conflict between the 2 requirements.

3.5 SUBDRAIN

Subdrain shall be installed as shown on the construction drawings to maintain gravity flow of water outside of the reinforced earth zone. The subdrains shall outlet into a storm sewer access or along a slope at an elevation lower than the lowest point of the pipe within the SRW reinforced earth zone

3.6 BACKFILL PLACEMENT

The granular backfill shall be compacted in accordance with section 02200 Earthwork. The granular backfill shall be placed as shown on the construction drawings in maximum 8-inch lift and compacted to a minimum of 95% of the Standard Proctor Maximum Dry Density (ASTM D698). The moisture limits shall be between 3% under optimum moisture to not more than the optimum moisture content. Backfill shall be placed, spread, and compacted in such a manner that eliminates the development of wrinkles and/or movement of the Geogrid reinforcement.

Only hand-operated compaction equipment shall be allowed within 3 feet of the front of the wall face.

Track construction equipment shall not be operated directly on the Geogrid reinforcement. A minimum backfill thickness of 6 inches is required prior to operation of tracked vehicles over the Geogrid reinforcement. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and damaging the Geogrid reinforcement.

Rubber-tired equipment may pass over the Geogrid reinforcement, if in accordance with the manufacture's recommendation. Sudden braking and sharp turning should be avoided.

3.7 GEOGRID INSTALLATION

Overlap of the Geogrid in the design strength direction shall not be permitted. The design strength direction is that length of Geogrid reinforcement perpendicular to the wall face and shall be one continuous piece of material. Adjacent sections of Geogrid shall be butted in a manner to assure 100% coverage after placement.

Geogrid reinforcement should be installed under tension. Apply a nominal tension to the reinforcement and maintain it by staples, stakes, or hand tensioning. The tension applied may be released after the Geogrid reinforcement has been covered and held in place with soil fill.

3.8 FIELD QUALITY CONTROL AND ASSURANCE

A. **Field Quality Assurance:** The Town of Clayton shall engage inspection and testing services through an independent laboratory to provide quality assurance and testing services during

construction. As a minimum, quality assurance testing should include foundation soil inspection, inspection for the need for any additional drainage, soil and backfill testing, verification of design parameters, and observation of construction for general compliance with design drawings and specifications. This does not relieve the Contractor from securing the necessary construction quality control testing during construction.

B. Field Quality Control: The Contractor's quality control testing and construction inspection services shall only be performed by independent, qualified and experienced technicians and engineers. The Contractor's quality control testing, as a minimum, shall include:

- 1) Field density testing
 - a. Subgrade: One test for every 2500 square feet of subgrade.
 - b. Reinforced Backfill: One test for every 2500 square feet of lift with a minimum of one test for every other lift.
 - c. Retained and Foundation Soil: Per Section 02200.
- 2) Laboratory Moisture Density: Minimum one test per soil type.
- 3) Gradation Analysis:
 - a. Unit Fill: One test per 500 CY
 - b. Backfill: One test per 1000 CY

3.9 CLEANUP AND RESTORATION OF SITE

- A. During the progress of the work, the Contractor shall keep the premises and the vicinity of the work clear from unsightly and disorderly piles of debris. Suitable locations shall be specified for the various construction materials and for debris. The materials shall be kept in their storage locations, except as needed for the work and debris shall be promptly and regularly collected and deposited in the specified location.
- B. Upon completion of section of the wall and appurtenances, the Contractor shall fine grade the ground adjacent thereto, removing all surplus excavated material, leaving the area free from surface irregularities. He shall dispose of all surplus material, excess SRW units, fabric, dirt, and rubbish from the site; and shall keep the site free of mud and dust to the satisfaction of the Town Engineer.
- C. When working on the shoulders of paved roads, the Contractor shall keep the pavement clean of all loose earth, dust, mud, gravel, etc., and shall restore road surfaces, shoulders, and ditches as required by either the NCDOT or the right-of-way owner.
- D. After all work is completed, the contractor shall remove all tools and other equipment, leaving the site free, clean, landscaped, and in good condition.

END OF SECTION 02632

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