

## DIVISION 32 – EXTERIOR IMPROVEMENTS

### SECTION 32 32 23.14– Segmental Concrete Unit Masonry Retaining Wall Height Over 5-0” High

#### PART 1: GENERAL

##### 1.01 Scope of Standards

- A. This standard provides general guidance concerning the specific preferences of the Texas State University for a Segmental Retaining Wall up to 5-0” high.
- B. Texas State University recognizes that project conditions and requirements vary, thus precluding the absolute adherence to the items identified herein in all cases. However, unless there is adequate written justification, it is expected that these guidelines will govern the design and specifications for Texas State University projects.

##### 1.02 Description

- A. Work includes furnishing and installing segmental retaining wall (SRW) units to the lines and grades designated on the project’s final construction drawings or as directed by the Architect/Engineer. Also included are furnishing and installing appurtenant materials required for construction of the retaining wall as shown on the construction drawings.

##### 1.03 Reference Standards

- A. Segmental Retaining Wall Units
  - 1. **ASTM C 140** - Sampling and Testing Concrete Masonry Units.
- B. Geosynthetic Reinforcement
  - 1. **ASTM D 4595** - Tensile Properties of Geotextiles by the Wide-Width Strip Method.
  - 2. **ASTM D 5262** - Test Method for Evaluating the Unconfined Creep Behavior of Geosynthetics
  - 3. **GRI:GG1** - Single Rib Geogrid Tensile Strength
  - 4. **GRI:GG5** - Geogrid Pullout
- C. Soils
  - 1. **ASTM D 698** - Moisture Density Relationship for Soils, Standard Method
  - 2. **ASTM D 422** - Gradation of Soils
  - 3. **ASTM 4318** - Atterberg Limits of Soil
- D. Drainage Pipe
  - 1. **ASTM 3034** - Specification for Polyvinyl Chloride (PVC) Plastic Pipe
  - 2. **ASTM D1248** - Specification for Corrugated Plastic Pipe

- E. Engineering Design
  - 1. “NCMA Design Manual for Segmental Retaining Walls,” Second Edition
- F. Where specifications and reference documents conflict, the Architect/ Engineer shall make the final determination of applicable document.

#### **1.04 Submittals**

- A. Materials Submittals: The Contractor shall submit manufacturers' certifications two weeks prior to start of work stating that the SRW units and geosynthetic reinforcement meet the requirements of Section 2 of this specification.
- B. Design Submittal: The Contractor shall submit two sets of detailed design calculations and final retaining wall plans for approval at least two weeks prior to the beginning of wall construction. All calculations and drawings shall be prepared and sealed by a professional Civil Engineer (P.E.) – (Wall Design Engineer) experienced in SRW design and licensed in the state where the wall is to be built.

#### **1.05 Delivery, Storage and Handling**

- A. Contractor shall check materials upon delivery to assure that specified type and grade of materials have been received and proper color and texture of SRW units have been received.
- B. Contractor shall prevent excessive mud, wet concrete, epoxies and like materials that may affix themselves from coming in contact with materials.
- C. Contractor shall store and handle materials in accordance with manufacturer's recommendations.

### **PART 2: MATERIALS**

#### **2.01 Segmental Retaining Wall Units**

- A. SRW units shall be machine formed, Portland Cement concrete blocks specifically designed for retaining wall applications. SRW units currently approved for this project are:
  - 1. Versa-Lok Square Foot Retaining Wall Units.
- B. Color of SRW units shall be “Alamo Buff” for base; “LC Cream” for top cap.
- C. Finish of SRW units shall be split-face.
- D. SRW unit faces shall be of straight geometry.
- E. SRW unit height shall be 8 inches, unit width shall be 18 inches, and unit depth shall be 12 inches
- F. SRW units (not including aggregate fill in unit voids) shall provide a minimum weight of 85 psf wall face area.

- G. SRW units shall be interlocked with connection pins, designed with proper setback of 1-inch setback for each eight inch high course of units to provide near vertical cant of approximately 2 degrees.
- H. SRW 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 or permanence of the structure. Cracking or excessive chipping may be grounds for rejection. Units showing cracks longer than 1/2" shall not be used within the wall. Units showing chips visible at a distance of 30 feet from the wall shall not be used within the wall.
- I. SRW units shall be interlocked with connection pins, designed with proper setback to provide 8:1 vertical-to-horizontal batter (a 7-degree cant from vertical).
- J. SRW units shall be capable of being erected with the horizontal gap between adjacent units not exceeding 1/8 inch.
- K. SRW units shall be capable of providing overlap of units on each successive course so that walls meeting at corner are interlocked and continuous. SRW units that require corners to be mitered shall not be allowed.
- L. SRW units shall be capable of providing a split-face, textured surface for all vertical surfaces that will be exposed after completion of wall, including any exposed sides and backs of units.
- M. SRW 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 or permanence of the structure. Cracking or excessive chipping may be grounds for rejection. Units showing cracks longer than ½ inch shall not be used within the wall. Units showing chips visible at a distance of 30 feet from the wall shall not be used within the wall.
- N. Concrete used to manufacture SRW units shall have a minimum 28 days compressive strength of 3,000 psi and a maximum moisture absorption rate, by weight, of 8% as determined in accordance with ASTM C1372. Compressive strength test specimens shall conform to the saw-cut coupon provisions of ASTM C140.
- O. SRW units' molded dimensions shall not differ more than  $\pm 1/8$  inch from that specified, in accordance with ASTM C1372.

## **2.02 Segmental Retaining Wall Unit Connection Pins**

- A. SRW units shall be interlocked with VERSA-Tuff connection pins. The pins shall consist of glass-reinforced nylon made for the expressed use with the SRW units supplied.

## **2.03 Geosynthetic Reinforcement**

- A. Geosynthetic reinforcement shall consist of geogrids or geotextiles manufactured as a soil reinforcement element. The manufacturers/suppliers of the geosynthetic reinforcement shall have demonstrated construction of similar size and types of segmental retaining walls on previous projects. The geosynthetic type must be approved one week prior to bid opening. Geosynthetic types currently approved for this project are: **VERSA-Grid Geogrids**

- B. The type, strength and placement location of the reinforcing geosynthetic shall be as determined by the Wall Design Engineer, as shown on the final, P.E.-sealed retaining wall plans.

#### 2.04 Leveling Pad

- A. Material for leveling pad shall consist of compacted sand, gravel, or combination thereof (USCS soil types GP, GW, SP, & SW) and shall be a minimum of 6 inches in depth. Lean concrete with a strength of 200-300 psi and 3 inches thick maximum may also be used as a leveling pad material. The leveling pad should extend laterally at least a distance of 6 inches from the toe and heel of the lowermost SRW unit.

#### 2.05 Drainage Aggregate

- A. Drainage aggregate shall be angular, clean stone or granular fill meeting the following gradation as determined in accordance with ASTM D422.

| <u>Sieve Size</u> | <u>Percent Passing</u> |
|-------------------|------------------------|
| 1 inch            | 100                    |
| 3/4 inch          | 75-100                 |
| No. 4             | 0-60                   |
| No. 40            | 0-50                   |
| No. 200           | 0-5                    |

#### 2.06 Drainage Pipe

- A. The drainage collection pipe shall be a perforated or slotted PVC, or corrugated HDPE pipe. The drainage pipe may be wrapped with a geotextile to function as a filter.
- B. Drainage pipe shall be manufactured in accordance with ASTM D 3034 and/or ASTM D 1248.

#### 2.07 Reinforced (Infill) Soil

- A. The reinforced soil material shall be free of debris. Unless otherwise noted on the final, P.E.-sealed, retaining wall plans prepared by the Wall Design Engineer, the reinforced material shall consist of the inorganic USCS soil types GP, GW, SW, SP, SM, meeting the following gradation, as determined in accordance with ASTM D422:

| <u>Sieve Size</u> | <u>Percent Passing</u> |
|-------------------|------------------------|
| 4 inch            | 100                    |
| No. 4             | 20-100                 |
| No. 40            | 0-60                   |
| No. 200           | 0-35                   |

- B. The maximum particle size of poorly-graded gravels (GP) (no fines) should not exceed 3/4 inch unless expressly approved by the Wall Design Engineer and the long-term design strength (LTDS)

of the geosynthetic is reduced to account for additional installation damage from particles larger than this maximum.

- C. The plasticity of the fine fraction shall be less than 20.

**PART 3: DESIGN PARAMETERS**

**3.01 Soil**

- A. The following soil parameters, as determined by the Owner's Geotechnical Engineer shall be used for the preparation of the final design:

|                  | Unit Weight ( $\gamma$ ) (pcf) | Internal Friction Angle ( $\phi$ )<br>(degrees) | Cohesion (c) |
|------------------|--------------------------------|---|--------------|
| Reinforced Fill: | _____                          | _____   | _____        |
| Retained Soil:   | _____                          | _____   | _____        |
| Foundation Soil: | _____                          | _____   | _____        |

- B. (If internal friction angles are not available for the above section, the specifier can provide the USCS soil type classification for the reinforced, retained, and foundation soils and/or attach the geotechnical investigation report for this project.)
- C. Should the actual soil conditions observed during construction differ from those assumed for the design, design shall be reviewed by the Wall Design Engineer at the Owner's Geotechnical Engineer's direction.

**3.02 Design**

- A. The design analysis for the final, P.E.-sealed retaining wall plans prepared by the Wall Design Engineer shall consider the external stability against sliding and overturning, internal stability and facial stability of the reinforced soil mass and shall be in accordance with acceptable engineering practice and these specifications. The internal and external stability analysis shall be performed in accordance with the "NCMA Design Manual for Segmental Retaining Walls," using the recommended minimum factors of safety in this manual.
- B. External stability analysis for bearing capacity, global stability, and total and differential settlement shall be the responsibility of the Owner and the Owner's Geotechnical Engineer. Geotechnical Engineer shall perform bearing capacity, settlement estimates, and global stability analysis based on the final wall design provided by the Wall Design Engineer and coordinate any required changes with Wall Design Engineer.
- C. While vertical spacing between geogrid layers may vary, it shall not exceed 2.0 feet maximum in the wall design.

- D. The geosynthetic placement in the wall design shall have 100% continuous coverage parallel to the wall face. Gapping between horizontally adjacent layers of geosynthetic (partial coverage) will not be allowed.

## **PART 4:CONSTRUCTION**

### **4.01 Inspection**

- A. The Owner or Owner's Representative is responsible for verifying that the Contractor meets all the requirements of the specification. This includes all submittals for materials and design, qualifications, and proper installation of wall system.
- B. Contractor's field construction supervisor shall have demonstrated experience and be qualified to direct all work at the site.

### **4.02 Excavation**

- A. Contractor shall excavate to the lines and grades shown on the project grading plans. Contractor shall take precautions to minimize over-excavation. Over-excavation shall be filled with compacted infill material, or as directed by the Engineer/Architect, at the Contractor's expense.
- B. 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.

### **4.03 Foundation Preparation**

- 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 infill soils, as directed by the Owner's Engineer.
- B. Foundation soil shall be proof-rolled and compacted to 95% standard Proctor density and inspected by the Owner's Engineer prior to placement of leveling pad materials.

### **4.04 Leveling Pad Construction**

- A. 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 should extend laterally at least a distance of 6 inches from the toe and heel of the lowermost SRW unit.
- B. 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).

### **4.05 SRW Unit Installation**

- A. 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 general accordance with the manufacturer's recommendations. The specifications and drawings shall govern in any conflict between the two requirements.
- B. 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. 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.
- C. The voids (cores) of the base course units shall be filled with crushed gravel. The cores of additional courses shall be filled with free-draining aggregate.
- D. All excess debris shall be cleaned from the top of units and the next course of units installed on top of the units below.
- E. Two VERSA-Tuff connection pins shall be installed through pin holes of each upper course unit into receiving slots in lower course units. Pins shall be fully seated in the pin slot below. Units shall be pushed forward to remove any looseness in the unit-to-unit connection and then check alignment. Level and alignment of the units shall be checked and corrected (if required) before proceeding.
- F. Prior to placement of next course, the level and alignment of the units shall be checked and corrected where needed.
- G. Lay out of curves and corners shall be installed in accordance with the plan details or in general accordance with SRW manufacturer's installation guidelines. Walls meeting at corners shall be interlocked by overlapping successive courses.
- H. Procedures "C" through "F" shall be repeated until reaching top of wall, just below the height of the cap units. Geosynthetic reinforcement, drainage materials, and reinforced backfill shall be placed in sequence with unit installation as described in Section 4.06, 4.07, and 4.08.

#### **4.06 Geosynthetic Reinforcement Placement**

- A. All geosynthetic reinforcement shall be installed at the proper elevation and orientation as shown on the final P.E.-sealed retaining wall plan profiles and details, or as directed by the Wall Design Engineer.
- B. At the elevations shown on the final plans, (after the units, drainage material and backfill have been placed to this elevation) the geosynthetic reinforcement shall be laid horizontally on compacted infill and on top of the concrete SRW units, to within 1 inch of the front face of the unit below. Embedment of the geosynthetic in the SRW units shall be consistent with SRW manufacturer's recommendations. Correct orientation of the geosynthetic reinforcement shall be verified by the Contractor to be in accordance with the geosynthetic manufacturer's recommendations. The highest-strength direction of the geosynthetic must be perpendicular to the wall face.

- C. Geosynthetic reinforcement layers shall be one continuous piece for their entire embedment length. Splicing of the geosynthetic in the design-strength direction (perpendicular to the wall face) shall not be permitted. Along the length of the wall, horizontally adjacent sections of geosynthetic reinforcement shall be butted in a manner to assure 100% coverage parallel to the wall face.
- D. Tracked construction equipment shall not be operated directly on the geosynthetic reinforcement. A minimum of 6 inches of backfill is required prior to operation of tracked vehicles over the geosynthetic. Turning should be kept to a minimum. Rubber-tired equipment may pass over the geosynthetic reinforcement at slow speeds (less than 5 mph).
- E. The geosynthetic reinforcement shall be free of wrinkles prior to placement of soil fill. The nominal tension shall be applied to the reinforcement and secured in place with staples, stakes or by hand tensioning until reinforcement is covered by 6 inches of fill.

#### **4.07 Drainage Materials**

- A. Drainage aggregate shall be installed to the line, grades and sections shown on the final P.E.-sealed retaining wall plans. Drainage aggregate shall be placed to the minimum thickness shown on the construction plans between and behind units (a minimum of 1 cubic foot for each exposed square foot of wall face unless otherwise noted on the final wall plans).
- B. Drainage collection pipes shall be installed to maintain gravity flow of water outside the reinforced-soil zone. The drainage collection pipe shall daylight into a storm sewer or along a slope, at an elevation below the lowest point of the pipe within the aggregate drain.

#### **4.08 Backfill Placement**

- A. The reinforced backfill shall be placed as shown in the final wall plans in the maximum compacted lift thickness of 10 inches and shall be compacted to a minimum of 95% of standard Proctor density (ASTM D 698) at a moisture content within 2% of optimum. The backfill shall be placed and spread in such a manner as to eliminate wrinkles or movement of the geosynthetic reinforcement and the SRW units.
- B. Only hand-operated compaction equipment shall be allowed within 3 feet of the back of the wall units. Compaction within the 3 feet behind the wall units shall be achieved by at least three passes of a lightweight mechanical tamper, plate, or roller.
- C. At the end of each day's operation, the Contractor shall slope the last level of backfill away from the wall facing and reinforced backfill to direct water runoff away from the wall face.
- D. 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.

#### **4.09 SRW Caps**

- A. SRW caps shall be properly aligned and glued to underlying units with VERSA-LOK adhesive, a flexible, high-strength concrete adhesive. Rigid adhesive or mortar are not acceptable.
- B. Caps shall overhang the top course of units by 3/4 inch to 1 inch. Slight variation in overhang is allowed to correct alignment at the top of the wall.

#### **4.10 Construction Adjacent to Completed Wall**

- A. The Owner or Owner's Representative is responsible for ensuring that construction by others 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 General Contractor to ensure water runoff is directed away from the wall structure until final grading and surface drainage collection systems are completed.

END OF SECTION 32 32 23.14