

**SECTION 32 32 23
CONCRETE SEGMENTAL RETAINING WALL SYSTEM**

PART 1 – GENERAL

- 1.01 SUMMARY
- A. Section Includes
 - 1. Concrete segmental retaining wall units
 - 2. Geosynthetic reinforcement
 - 3. Leveling pad base
 - 4. Drainage aggregate
 - 5. Reinforced backfill
 - 6. Drainage pipe
 - 7. Prefabricated drainage composite
 - 8. Geotextile filter
 - 9. Impervious materials
 - 10. Construction adhesive
 - B. Related Sections

Note to Specifier: Include Section 01270 only if Article 3.12 is included

- A. Section 01270 – Unit Prices

Note to Specifier: Include Section 02300 below for finish grading, and/or add other paving or surfacing related Sections if required

- B. Section 02300 – Earthwork: For finish grading.

1.02 REFERENCES

- A. American Association of State Highway Transportation Officials (AASHTO)
 - 1. AASHTO M288 Geotextile Specification for Highway Applications
 - 2. AASHTO Standard Specifications for Highway Bridges
- B. American Society for Testing and Materials (ASTM)
 - 1. ASTM C140 Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
 - 2. ASTM C1262 Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units
 - 3. ASTM C1372 Standard Specification for Segmental Retaining Wall Units
 - 4. ASTM D448 Standard Classification for Sizes of Aggregate for Road and Bridge Construction
 - 5. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/f³)(600 kN-m/m³)
 - 6. ASTM D1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method
 - 7. ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/f³)(2700 kN-m/m³)
 - 8. ASTM D2487 Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)
 - 9. ASTM D2922 Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
 - 10. ASTM D3034 Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
 - 11. ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
 - 12. ASTM D4491 Standard Test Method for Water Permeability of Geotextiles by the Permittivity Method

13. ASTM D4595 Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
 14. ASTM D4873 Standard Guide for Identification, Storage and Handling of Geosynthetics
 15. ASTM D5084 Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
 16. ASTM D5262 Standard Test Method for Evaluating the Unconfined Tension Creep Behavior of Geosynthetics
 17. ASTM D5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
 18. ASTM D5818 Standard Practice for Obtaining Samples of Geosynthetics from a Test Section for Assessment of Installation Damage
 19. ASTM D6637 Standard Test Method for Determining Tensile Properties of Geogrids by the Single- or Multi-Rib Tensile Method
 20. ASTM D6638 Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units
 21. ASTM D6916 Standard Test Method for Determining the Shear Strength Between Segmental Concrete Units
 22. ASTM D6706 Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil
 23. ASTM F405 Standard Specification for Corrugated Polyethylene (PE) Tubings and Fittings
 24. ASTM G51 Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing
- C. Federal Highway Administration
1. Elias, V., Christopher, B., and Berg, R., "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines," Federal Highway Administration Report No. FHWA-NHI-00-043, March 2001.
 2. Elias, V., Christopher, B., and Berg, R., "Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes," Federal Highway Administration Report No. FHWA-NHI-00-044, March 2001.
- D. National Concrete Masonry Association (NCMA)
1. NCMA *Design Manual for Segmental Retaining Walls*, Second Edition, Second Printing (1997) or *Design Manual for Segmental Retaining Walls*, Third Edition (2010).

1.03 DEFINITIONS

- A. Concrete Segmental Retaining Wall (SRW) Units: Dry-stacked masonry units used as the retaining wall fascia.
- B. Reinforced Backfill: Soil which is used as fill behind the SRW unit, and within the reinforced soil mass (if applicable).
- C. Drainage Aggregate: Material used (if applicable) within, between, and directly behind the concrete retaining wall units.
- D. Geotextile Filter: Material used for separation and filtration of dissimilar soil types.
- E. Foundation Soil: Soil mass supporting the leveling pad and reinforced soil zone of the retaining wall system.
- F. Geosynthetic Reinforcement: Polymeric material designed specifically to reinforce the soil mass.
- G. Prefabricated Drainage Composite: three-dimensional geosynthetic drainage medium encapsulated in a geotextile filter, used to transport water.
- H. Impervious Materials: Clay soil or low permeability geosynthetic used to prevent water percolation into the drainage zone and reinforced backfill behind the wall.
- I. Global Stability: The general mass movement of a soil reinforced segmental retaining wall structure and adjacent soil mass.
- J. Project Geotechnical Engineer: A registered engineer who provides site observations, recommendations for foundation support, and verifies soil shear strength parameters.

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01300:
1. Product Data: Material description and installation instructions for each manufactured product specified.
 2. Shop Drawings: Retaining wall system design, including wall elevation views, geosynthetic reinforcement layout, pertinent details, and drainage provisions. The shop drawings shall be signed by a registered professional engineer licensed in the state of wall installation.
 3. Design Calculations: Engineering design calculations prepared in accordance with the *NCMA Design Manual for Segmental Retaining Walls*, or the *AASHTO Standard Specifications for Highway Bridges*, Section 5.8 (whichever is applicable). Analysis of global stability must be addressed and incorporated into the shop drawings.
 4. Samples
 - a. Furnish one unit in the color and face pattern specified, if requested.
 - b. Furnish 12-inch square or larger piece of the geosynthetic reinforcement specified.
 5. Test Reports: Independent laboratory reports stating moisture absorption and compressive strength properties of the concrete retaining wall units meet the Project Specifications when tested in accordance with ASTM C140, Sections 6, 8 and 9.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Concrete Retaining Wall Units and Accessories: Deliver, store, and handle materials in accordance with manufacturer's recommendations, in such a manner as to prevent damage. Check the materials upon delivery to assure that proper material has been received. Store above ground on wood pallets or blocking. Remove damaged or otherwise unsuitable material, when so determined, from the site.
1. Exposed faces of concrete wall units shall be free of chips, cracks, stains, and other imperfections detracting from their appearance, when viewed from a distance of 10 feet.
 2. Prevent mud, wet cement, adhesives and similar materials that may harm appearance of units, from coming in contact with system components.
- B. Geosynthetics (including geosynthetic reinforcement, geotextile filter, prefabricated drainage composite) shall be delivered, stored, and handled in accordance with ASTM D4873.

1.06 EXTRA MATERIALS

- A. Furnish Owner with 3 replacement units identical to those installed on the Project.

PART 2 – PRODUCTS

2.01 MATERIALS

Note to Specifier: In Subparagraph below, select Diamond, Diamond Pro, Vertica or Vertica Pro

- A. Concrete Retaining Wall Units: Pavestone's "Anchor™ [Diamond, Diamond Pro, Vertica, Vertica Pro] Retaining Wall Units" as manufactured under license from Anchor Wall Systems.
1. Physical Requirements
 - a. Meet requirements of ASTM C1372, except the maximum water absorption shall be limited to 7 percent, and unit height dimensions shall not vary more than plus or minus 1/16 inch from that specified in the ASTM reference, not including textured face.
 - b. Unit Face Area: Not less than 0.67 square feet.

Note to Specifier: In Subparagraph below, select appropriate entity who will determine color

- c. Color: Selected by the [Architect] [Engineer] [Owner] from manufacturer's full range of standard colors.

Note to Specifier: In Subparagraph below, select straight or beveled face

- d. Face Pattern Geometry: [Straight Face] [Beveled Face].
 - e. Texture: Split-Rock Face.
 - f. Include an integral concrete shear connection flange/locator.

B. Geosynthetic Reinforcement: Polyester fiber geogrid or geotextile, or polypropylene woven geotextile, as shown on the Drawings.

C. Leveling Pad Base

1. Aggregate Base: Crushed stone or granular fill meeting the following gradation as determined in accordance with ASTM D448:

<u>Sieve Size</u>	<u>Percent Passing</u>
1 inch	100
No. 4	35 to 70
No. 40	10 to 35
No. 200	3 to 10

- a. Base Thickness: 6 inches (minimum compacted thickness).

2. Concrete Base: Nonreinforced lean concrete base.

- a. Compressive Strength: 3,000 psi (minimum).

- b. Base Thickness: At least 2 inches

D. Drainage Aggregate: Clean crushed stone or granular fill meeting the following gradation as determined in accordance with ASTM D448:

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

E. Backfill: Soil free of organics and debris and consisting of either GP, GW, SP, SW, or SM type, classified in accordance with ASTM D2487 and the USCS classification system.

1. Soils classified as SC, ML and CL are considered suitable soils for segmental retaining walls with a total height of less than 10 feet unless the Plasticity Index (PI) is 20 or more.
2. Maximum particle size for backfill is 4 inches.
3. Unsuitable soils are organic soils and those soils classified as CH, OH, MH, OL, or PT.

F. Impervious Material: Clayey soil or other similar material which will prevent percolation into the drainage zone behind the wall.

G. Drainage Pipe: Perforated or slotted PVC or corrugated HDPE pipe manufactured in accordance with D3034 and/or ASTM F405. The pipe may be covered with a geotextile filter fabric to function as a filter.

H. Construction Adhesive: Exterior grade adhesive as recommended by the retaining wall unit manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

Note to Specifier: In Paragraph below, select appropriate entity

- A. Examine the areas and conditions under which the retaining wall system is to be erected, and notify the [Architect] [Engineer] [Owner] [Contractor] in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
- B. 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.
- C. Verify the location of existing structures and utilities prior to excavation.

3.02 PREPARATION

- A. Ensure surrounding structures are protected from the effects of wall excavation.
- B. Excavation support, if required, is the responsibility of the Contractor, including the stability of the excavation and its influence on adjacent properties and structures.

3.03 EXCAVATION

Note to Specifier: In Paragraph below, select appropriate entity

- A. Excavate to the lines and grades shown on the Drawings. Over-excavation not approved by the [Architect] [Engineer] [Owner (or Owner's representative)] will not be paid for by the Owner. Replacement of these soils with compacted fill and/or wall system components will be required at the Contractor's expense. Use care in excavating to prevent disturbance of the base beyond the lines shown.

3.04 FOUNDATION PREPARATION

- A. Excavate foundation soil as required for footing or base dimension shown on the Drawings, or as directed by the Project geotechnical engineer.
- B. The Project geotechnical engineer will examine foundation soil to ensure that the actual foundation soil strength meets or exceeds that indicated on the Drawings. Remove soil not meeting the required strength. Oversize resulting space sufficiently from the front of the block to the back of the reinforcement, and backfill with suitable compacted backfill soils.
- C. The Project geotechnical engineer will determine if the foundation soils will require special treatment or correction to control total and differential settlement.
- D. Fill over-excavated areas with suitable compacted backfill, as recommended by the Project geotechnical engineer.

3.05 BASE COURSE PREPARATION

- A. Place base materials to the depths and widths shown on the Drawings, upon undisturbed soils, or foundation soils prepared in accordance with Article 3.04.
 - 1. Extend the leveling pad laterally at least 6 inches in front and behind the lowermost concrete retaining wall unit.
 - 2. Provide aggregate base compacted to 6 inches thick (minimum).
 - 3. The Contractor may at their option, provide a concrete leveling pad as specified in Subparagraph 2.01.C.2, in lieu of the aggregate base.
 - 4. Where a reinforced footing is required by local code official, place footing below frost depth.
- B. Compact aggregate base material to provide a level, hard surface on which to place the first course of units.
- C. Prepare base materials to ensure complete contact with retaining wall units. Gaps are not allowed.

3.06 ERECTION

- A. General: Erect units in accordance with manufacturer's instructions and recommendations, and as specified herein.
- B. Place first course of concrete wall units on the prepared base material. Check units for level and alignment. Maintain the same elevation at the top of each unit within each section of the base course.
- C. Ensure that foundation units are in full contact with natural or compacted soil base.
- D. Place concrete wall units side-by-side for full length of wall alignment. Alignment may be done by using a string line measured from the back of the block. Gaps are not allowed between the foundation concrete wall units.
- E. Place 12 inches (minimum) of drainage aggregate between, and directly behind, the concrete wall units. Fill voids in retaining wall units with drainage aggregate. Provide a drainage zone behind the wall units to within 9 inches of the final grade. Cap the backfill and drainage aggregate zone with 9 inches of impervious material.
- F. Install drainage pipe at the lowest elevation possible, to maintain gravity flow of water to outside of the reinforced zone. Slope the main collection drainage pipe, located just behind the concrete retaining wall units, 2 percent (minimum) to provide gravity flow to the daylighted areas. Daylight the main collection drainage pipe through the face of the wall, and/or to an appropriate location away from the wall system at each low point or at 50-foot (maximum) intervals along the wall. Alternately, the drainage pipe can be connected to a storm sewer system at 50-foot (maximum) intervals.
- G. Remove excess fill from top of units and install next course. Ensure drainage aggregate and backfill are compacted before installation of next course.
- H. Check each course for level and alignment. Adjust units as necessary to maintain level and

alignment prior to proceeding with each additional course.

- I. Install each succeeding course. Backfill as each course is completed. Pull the units forward until the locating surface of the unit contacts the locating surface of the units in the preceding course. Interlock wall segments that meet at corners by overlapping successive courses. Attach concrete retaining wall units at exterior corners with adhesive specified.
- J. Install geosynthetic reinforcement in accordance with geosynthetic manufacturer's recommendations and the shop drawings.
 1. Orient geosynthetic reinforcement with the highest-strength axis perpendicular to the wall face.
 2. Prior to geosynthetic reinforcement placement, place the backfill and compact to the elevation of the top of the wall units at the elevation of the geosynthetic reinforcement.
 3. Place geosynthetic reinforcement at the elevations and to the lengths shown on the Drawings.
 4. Lay geosynthetic reinforcement horizontally on top of the concrete retaining wall units and the compacted backfill soils. Place the geosynthetic reinforcement within one inch of the face of the concrete retaining wall units. Place the next course of concrete retaining wall units on top of the geosynthetic reinforcement.
 5. The geosynthetic reinforcement shall be in tension and free from wrinkles prior to placement of the backfill soils. Pull geosynthetic reinforcement hand-taut and secure in place with staples, stakes, or by hand-tensioning until the geosynthetic reinforcement is covered by 6 inches of loose fill.
 6. The geosynthetic reinforcements shall be continuous throughout their embedment lengths. Splices in the geosynthetic reinforcement strength direction are not allowed.
 7. Do not operate tracked construction equipment directly on the geosynthetic reinforcement. At least 6 inches of compacted backfill soil is required prior to operation of tracked vehicles over the geosynthetic reinforcement. Keep turning of tracked construction equipment to a minimum.
 8. Rubber-tired equipment may pass over the geosynthetic reinforcement at speeds of less than 5 miles per hour. Turning of rubber-tired equipment is not allowed on the geosynthetic reinforcement.

3.07 BACKFILL PLACEMENT

- A. Place reinforced backfill, spread and compact in a manner that will minimize slack in the reinforcement.
- B. Place fill within the reinforced zone and compact in lifts not exceeding 6 to 8 inches (loose thickness) where hand-operated compaction equipment is used, and not exceeding 12 inches (loose thickness) where heavy, self-propelled compaction equipment is used.
 1. Only lightweight hand-operated compaction equipment is allowed within 4 feet of the back of the retaining wall units. If the specified compaction cannot be achieved within 4 feet of the back of the retaining wall units, replace the reinforced soil in this zone with drainage aggregate material.
- C. Compaction testing shall be done in accordance with ASTM D1556 or ASTM D2922.

Note to Specifier: In Paragraph below, select revised modified Proctor densities if necessary, in lieu of standard Proctor densities specified

- D. Minimum Compaction Requirements for Fill Placed in the Reinforced Zone
 1. The minimum compaction requirement shall be determined by the project geotechnical engineer testing the compaction. At no time shall the soil compaction requirements be less than 95 percent of the soil's standard Proctor maximum dry density (ASTM D698) [modified Proctor maximum dry density (ASTM D1557)] for the entire wall height
 2. Utility Trench Backfill: Compact utility trench backfill in or below the reinforced soil zone to 98 percent of the soil's standard Proctor maximum dry density (ASTM D698) [modified Proctor maximum dry density (ASTM D1557)], or as recommended by the Project geotechnical engineer. If the height from the utility to finish grade is higher than 30 feet, increase compaction to 100 percent of the standard Proctor density [modified Proctor density].
 - a. Utilities must be properly designed (by others) to withstand all forces from the retaining wall units, reinforced soil mass, and surcharge loads, if any.

3. Moisture Content: Within 2 percentage points of the optimum moisture content for all wall heights.
 4. These specifications may be changed based on recommendations by the Project geotechnical engineer.
 - a. If changes are required, the Contract Sum will be adjusted by written Change Order.
- E. At the end of each day's operation, slope the last level of compacted backfill away from the interior (concealed) face of the wall to direct surface water runoff away from the wall face.
1. The General Contractor is responsible for ensuring that the finished site drainage is directed away from the retaining wall system.
 2. In addition, the General Contractor is responsible for ensuring that surface water runoff from adjacent construction areas is not allowed to enter the retaining wall area of the construction site.
- F. Refer to Article 3.10 for compaction testing.
- 3.08 CAP UNIT INSTALLATION
- A. Apply adhesive to the top surface of the unit below and place the cap unit into desired position.
 - B. Cut cap units as necessary to obtain the proper fit.
 - C. Backfill and compact to top of cap unit.
- 3.09 SITE CONSTRUCTION TOLERANCES
- A. Site Construction Tolerances
1. Vertical Alignment: Plus or minus 1-1/2 inches over any 10-foot distance, with a maximum differential of 3 inches over the length of the wall.
 2. Horizontal Location Control from Grading Plan
 - a. Straight Lines: Plus or minus 1-1/2 inches over any 10-foot distance.
 - b. Corner and Radius Locations: Plus or minus 12 inches.
 - c. Curves and Serpentine Radii: Plus or minus 2 feet.
 3. Immediate Post Construction Wall Batter: Within 2 degrees of the design batter of the concrete retaining wall units.
 4. Bulging: Plus or minus 1-1/4 inches over any 10-foot distance.
- 3.10 FIELD QUALITY CONTROL
- A. Installer is responsible for quality control of installation of system components.
 - B. The Owner or General Contractor, at their expense, will retain a qualified professional to perform quality assurance checks of the installer's work.
 - C. Correct work which does not meet these specifications or the requirements shown on the Drawings at the installer's expense.
 - D. Perform compaction testing of the reinforced backfill placed and compacted in the reinforced backfill zone.
 1. Testing Frequency
 - a. One test for every 2 feet (vertical) of fill placed and compacted, for every 50 lineal feet of retaining wall.
 - b. Vary compaction test locations to cover the entire area of the reinforced soil zone, including the area compacted by the hand-operated compaction equipment.
- 3.11 ADJUSTING AND CLEANING
- A. Replace damaged units with new units as the work progresses.
 - B. Remove debris caused by wall construction and leave adjacent paved areas broom clean.

Note to Specifier: Include Article 3.12 ONLY for municipal work when required

- 3.12 MEASUREMENT AND PAYMENT
- A. Measurement of segmental retaining wall shall be on an installed square foot basis computed on the total face area of wall installed. Wall face area includes the bottom of the base course to the top of the wall, and the entire length of the wall.
 - B. Payment for the wall will be made on a square foot basis at the agreed-upon Contract Unit Price.
 1. Payment should be considered full compensation for labor, materials, equipment and

testing required to install the wall in accordance with these specifications and the Drawings.

2. Quantities may vary from that shown on the Drawings depending on existing topography. Change to the total quantity of wall face area will be paid or withheld at the agreed-upon Contract Unit Price.

END OF SECTION