SECTION 32 32 23
CONCRETE SEGMENTAL RETAINING WALL SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

A. Work consists of furnishing and construction of a RETANI™ Retaining Wall System in accordance with these specifications and in general conformity with the lines, grades, design, and dimensions shown on the plans.

B. Earthwork includes:
   1. Preparing Foundation Soil and Retained Soil to the lines and grades shown on the construction drawings;
   2. Furnishing and installing Leveling Pad, Reinforced Fill (where required) and Low Permeability Soil (where required) to the lines and grades shown on the construction drawings; and,

C. Installation work includes:
   1. Furnishing and installing RETANI™ R812 ROCKFACE LARGE Concrete Facing Units and Unit Fill to achieve the lines and grades shown on the construction drawings.
   2. Furnishing and installing Geosynthetic Reinforcement and Separation Geotextile of the type, size, location and lengths designated on the construction drawings (if required).
   3. Furnishing and installing Subsurface Drainage System, including necessary fittings, of the type, size, and location designated on the construction drawings.

1.02 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

1.03 REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO)
   1. AASHTO Standard Specifications for Highway Bridges
   2. AASHTO M 288 Geotextile Specifications for Highway Applications
   3. AASHTO M 252 Corrugated Polyethylene Drainage Pipe
   4. AASHTO National Transportation Product Evaluation Program (NTPEP)

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. Samtani, Naresh C., Christopher, B., and Berg, R., “Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes”, Volumes 1 and 2, Federal Highway Administration Report Nos. FHWA-NHI-10-024 and FHWA-NHI-10-025, November 2009.
2. Elias, V., Fishman, K., 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-09-087, November 2009.

D. National Concrete Masonry Association (NCMA)
1. NCMA Design Manual for Segmental Retaining Walls, Third Edition, 2010

1.04 DEFINITIONS

A. Segmental Retaining Wall (SRW) Units: Dry-stacked concrete masonry units used as the retaining wall fascia.

B. Reinforced Fill: Soil which is used as fill behind the SRW unit and within the reinforced soil mass (if applicable).

C. Unit Fill and Drainage Aggregate: Material used (if applicable) within, between, and directly

behind the concrete retaining wall units.

D. Geotextile Separation Fabric: 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. Retained Soil: The soil mass located behind the reinforced soil zone, either undisturbed native soils or compacted fill.

G. Leveling Pad: A level surface consisting of crushed stone, sand and gravel or unreinforced concrete placed to provide a working surface for placement of the SRW unit.

H. Geosynthetic Reinforcement: Polymeric material designed specifically to reinforce the soil mass.

I. Pre-fabricated Drainage Composite: three-dimensional geosynthetic drainage medium encapsulated in a geotextile filter, used to transport water.

J. Subsurface Drainage System: horizontal pipe encapsulated within drainage aggregate at or near the base of the reinforced soil to facilitate removal of water from the wall system.

K. Low Permeability Soil: Clay soil or low permeability geosynthetic used to prevent water percolation into the drainage zone and reinforced backfill behind the wall.

L. Global Stability: The general mass movement of a soil reinforced segmental retaining wall structure and adjacent soil mass.

M. Project Geotechnical Engineer: A registered engineer who provides site observations, recommendations for foundation support/global stability, and verifies soil shear strength parameters.

1.05 SUBMITTALS / CERTIFICATION

A. Product Data
   1. Product Data: Material description and installation instructions for each manufactured product specified
   2. Name and address of the production facility where the proposed facing units will be manufactured. All units shall be manufactured at the same facility.
   3. Notarized letter from the facing unit manufacturer stating that the units supplied for this project are manufactured in complete compliance with this specification. The letter shall state that the units shown in the attached test reports are representative samples of the plants normal mix design and regular production runs.
   4. Notarized letter from the reinforcement manufacturer stating that the geosynthetic reinforcement has been manufactured in complete compliance with the reinforcement manufacturer's current NTPEP report.

B. Samples:
   1. Contractor shall submit to the owner for approval, and retain for the balance of the project, a minimum of one SRW unit that represents the range of texture and color permitted.

C. Test Reports:
   1. Independent Laboratory reports indicating compressive strength, moisture absorption and freeze-thaw durability of the concrete retaining wall units from the proposed production facility.
   2. Independent test reports verifying the long-term design strength properties (creep,

installation damage, and durability) and soil interaction properties of the geosynthetic reinforcement.
3. Independent test reports verifying the connection capacity between the geosynthetic reinforcement and the concrete retaining wall units.

D. Retaining Wall Contractor Qualifications:
1. Notarized statement showing that the retaining wall contractor has installed a minimum of 2,500 square feet of segmental retaining walls.
2. The Retaining Wall Installer shall furnish three (3) project references of similar size and scope to this project including the wall(s) height and square footage. References shall include the contact information of Owner or General Contractor.

E. Retaining Wall Design:
1. Shop Drawings: One digitally signed set of the retaining wall system design, including wall elevation views, geosynthetic reinforcement layout, pertinent details, and drainage provisions. A registered professional engineer licensed in the state of wall installation shall sign and certify that the shop drawings are designed in accordance with the project civil plans and specifications.
2. Design Calculations: One digitally signed set of engineering design calculations prepared in accordance with the NCMA Design Manual for Segmental Retaining Walls, 3rd Edition or the AASHTO Standard Specifications for Highway Bridges (whichever is applicable). Analysis shall include Internal, External and Bearing Capacity Calculations and include the short term and long term loading conditions on the wall. A Global Stability analysis should be coordinated with the project geotechnical engineer and incorporated into the wall design.

1.06 DELIVERY, STORAGE AND HANDLING

A. SRW 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 SRW units above ground on wood pallets or blocking. Remove damaged or otherwise unsuitable material, when so determined, from the site.

B. Exposed faces of SRW units shall be relatively free of chips, cracks, stains, and other imperfections detracting from their appearance, when viewed from a distance of 20 feet under diffused lighting.

C. Prevent mud, wet cement, adhesives and similar materials that may harm appearance of SRW units, from coming in contact with system components.

D. Geosynthetics (including geosynthetic reinforcement, geotextile filter, pre-fabricated drainage composite) shall be delivered, stored, and handled in accordance with ASTM D4873.

1.07 EXTRA MATERIALS

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

PART 2 - PRODUCTS

2.01 MATERIALS

A. SRW Units: RETANI™ R812 Retaining Wall Units
1. Physical Requirements
a. Meet requirements of ASTM C1372, except the 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 1.0 square feet.
c. Color: Selected by the [Architect] [Engineer] [Owner] from manufacturer's full range of standard colors.
d. Block Face: RETANI™ ROCKFACE LARGE, a single-piece, generally convex (rustic) hard split
e. Batter: Include an integral concrete shear connection flange/locator to provide a 1 inch setback for each wall course.

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

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

Sieve Size	Percent Passing
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: Non-reinforced lean concrete base.
a. Compressive Strength: 3,000 psi (maximum).
b. Base Thickness: At least 2 inches.

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

Sieve Size	Percent Passing
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. Reinforced Fill: 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 and meeting the following gradation as determined in accordance with ASTM D448:

Sieve Size	Percent Passing
1 inch	100
No. 4	20 to 100
No. 40	0 to 60
No. 200	0 to 35

1. Plasticity Index (PI) < 6 per ASTM D4318.
2. Maximum particle size for backfill is 1 inch unless field tests have been performed to evaluate potential strength reduction to the geosynthetic reinforcement due to damage during construction per ASTM D5818.
3. Unsuitable soils are organic soils and those soils classified as SC, CL, ML, CH, OH, MH, OL, or PT.

F. Low Permeability Soil: 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. All connectors and fittings shall match the piping material.

H. Geotextile Separation Fabric: Geotextile Separation fabric shall be minimum 4.0 oz/sy, polypropylene, needle-punched nonwoven fabric.

I. 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. Prior to commencing work, the retaining wall contractor shall examine the areas and conditions under which the retaining wall system is to be erected, and notify the [Architect] [Engineer] [Owner] [General 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. At the direction of the project geotechnical engineer, remove soil not meeting the required strength. Oversize resulting excavation 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 LEVELING PAD 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 SRW unit.
   2. Provide aggregate base compacted to 6 inches thick (minimum) or as shown on the drawings.
   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 SRW units.

C. Prepare base materials to ensure complete contact with SRW units. Gaps are not allowed.

3.06 ERECTION

A. General: Erect SRW 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 the leveling pad.

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 drainage aggregate between and directly behind the SRW. Fill any voids in SRW units with drainage aggregate. Provide a drainage zone behind the SRW units a minimum of 12 inches wide to within 8 inches of the final grade. Cap the backfill and drainage aggregate zone with separation fabric and then 8 inches of low permeability soil.

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 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 SRW 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 SRW 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 SRW units forward until the locating surface of the SRW unit contacts the locating surface of the SRW units in the preceding course. Interlock wall segments that meet at corners by overlapping successive courses. Attach SRW 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 SRW units and the compacted backfill soils. Place the geosynthetic reinforcement within one inch of the face of the SRW units. Place the next course of SRW 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 10 miles per hour. Turning of rubber-tired equipment is not allowed on the geosynthetic reinforcement.

3.07 BACKFILL PLACEMENT

A. Place reinforced fill, 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 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 3 feet of the back of the retaining wall units. If the specified compaction cannot be achieved within 3 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.

D. Minimum Compaction Requirements for Fill Placed in the Reinforced and Retained 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 SRW unit below and place the cap unit into desired position.

B. Cut cap SRW units as necessary to obtain the proper fit.

C. Backfill and compact to top of SRW 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 SRW units with new units as the work progresses.

B. Remove debris caused by wall construction and leave adjacent paved areas broom clean.

3.12 MEASUREMENT AND PAYMENT

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

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