

SECTION 32 32 23
CONCRETE SEGMENTAL RETAINING WALL SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Concrete segmental retaining wall units.
- B. Geosynthetic reinforcement
- C. Leveling pad base
- D. Drainage aggregate
- E. Reinforced Backfill
- F. Drainage pipe
- G. Pre-fabricated Drainage Composite
- H. Geotextile Filter
- I. Impervious Materials
- J. Construction Adhesive

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: 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 D6706 Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil
22. ASTM F405 Standard Specification for Corrugated Polyethylene (PE) Tubings and Fittings
23. 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)

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. Pre-fabricated 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

Due to the design-build nature of Segmental Retaining Wall Systems, contractors shall provide a system specific submittal package to the Civil Engineer at least thirty (30) days prior to construction for approval. Incomplete submittal packages will not be reviewed.

- A. Submit the following at least thirty (30) days prior to construction for approval
 - 1. Product Data
 - a. Material description and installation instructions for each manufactured product specified including Segmental Retaining Wall Units (SRW) and Geosynthetic Reinforcement.
 - b. Name and address of the production facility where the proposed SRW units will be manufactured. All units to be manufactured at the same facility.
 - c. Notarized letter from the SRW manufacturer stating that the units supplied for this project are manufactured in complete compliance with Section 2.01 of this specification. The letter shall state that the SRW units shown in the attached test reports are representative samples of the plants normal mix design and regular production runs.
 - 2. Samples:
 - a. Furnish one unit demonstrating the color, face pattern, and texture of the SRW unit if specified by the project Architect or Owner.
 - b. Furnish 12-inch square or larger piece of the geosynthetic reinforcement specified.
 - 3. Test Reports:
 - a. Independent laboratory reports indicating compressive strength, moisture absorption and freeze-thaw durability of the concrete retaining wall units from the proposed production facility. Only test performed within the past 12 months will be considered current and valid.
 - b. Independent test reports verifying the long-term design strength properties (creep, installation damage, and durability) and soil interaction properties of the geosynthetic reinforcement.
 - c. Independent test reports verifying the connection capacity between the geosynthetic reinforcement and the concrete retaining wall units.
 - 4. Wall Design Engineer Qualifications:
 - a. Current insurance policy verifying professional liability and errors and omissions insurance coverage for an aggregate and per claim limit of at least two million dollars (\$2,000,000).
 - b. Notarized letter certifying the proposed SRW Design Engineer is a licensed professional engineer in the state of wall installation and has a minimum of 4 years and 500,000 square feet of SRW system design experience.
 - 5. Retaining Wall Installer Qualifications:
 - a. Notarized statement showing that the retaining wall installer has installed a minimum of 100,000 square feet of segmental retaining walls.
 - b. The Retaining Wall Installer shall furnish five (5) 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.

- B. Submit the following at least thirty (30) days prior to start of construction for approval
 - 1. Retaining Wall Final Design Submittals
 - a. Shop Drawings: Four (4) sets 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.
 - b. Design Calculations: Four (4) sets of engineering design calculations prepared in accordance with the NCMA Design Manual For Segmental Retaining Walls, Second Edition, Second Printing, 1997. Analysis shall include Internal, External, Global Stability, and Bearing Capacity Calculations.

1.05 DESIGN REQUIREMENTS

- A. Designs for SRW's using extensible (geosynthetic) reinforcement shall be prepared according to design methodology presented in the NCMA "Design Manual for Segmental Retaining Walls, 1997, second edition, second printing" and conform to the minimum safety factors as specified in this specification section. Design submittals not meeting this design criteria or technical/administrative criteria as specified will be rejected in their entirety until complete compliance is achieved. Owner reserves all rights in determining compliance for plan approval and may reject any submittals.
- B. Design of the SRW shall be based on the following soil parameters as determined during the geotechnical investigation

	<u>Effective Friction Angle</u>	<u>Effective Cohesion</u>	<u>Unit Weight</u>
Reinforced Backfill	_____	<u>NA</u>	_____
Retained Backfill	_____	<u>NA</u>	_____
Foundation	_____	_____	_____

(Insert seismic comments if applicable)

The wall system shall be designed to withstand a peak horizontal ground acceleration of ___ g

The Design Engineer of Record shall be responsible for selecting and specifying reinforced fill material. The General Contractor is responsible for ensuring and documenting the reinforced fill meets the specified parameters for both strength and compaction. Compacted retained soil shall meet the minimum requirements specified.

- C. Design Criteria for Retaining Wall Systems:

Unless otherwise indicated below, SRW design shall be performed in strict accordance with the procedures presented in the NCMA Design Manual for Segmental Retaining Walls.

- 1. Internal Stability:
 - a. Minimum Factor of Safety on Tensile Overstress 1.0
 - b. Minimum Factor of Safety on Geogrid Pullout (peak load criterion) 1.5
 - c. Minimum Factor of Safety on Facing Shear

- | | | |
|------|---|-----|
| | (peak load criterion) | 1.5 |
| d. | Minimum Factor of Safety on Facing Shear
(serviceability criterion) 2% of height of SRW units | 1.0 |
| e. | Minimum Factor of Safety Connections
(peak load criterion) | 1.5 |
| f. | Minimum Factor of Safety for Uncertainties | 1.5 |
| 2. | External Stability: | |
| a. | Minimum Factor of Safety Against Base Sliding
(static condition) | 1.5 |
| b. | Minimum Factor of Safety Against Overturning | 2.0 |
| c. | Minimum Factor of Safety for Global Stability | 1.3 |
| d. | Minimum Factor of Safety for Bearing Capacity | 2.0 |
| 3. | Seismic factors of safety shall be 75% of the static values | |
| D. | Design shall address hydrostatic loading, seismic loading, rapid drawdown, surcharge, and backslopes where appropriate. Minimum Design Live Load of 150 psf shall be used for all walls supporting parking areas. Minimum Design Live Load of 250 psf shall be used for walls supporting entrance drives, service drives and other areas subject to traffic. | |
| E. | Minimum reinforcement length shall be 60 percent of the wall height. Reinforcement coverage at each layer shall be 100 percent (no gaps). | |
| F. | The maximum vertical distance between layers of soil reinforcement shall be limited to a maximum of 25" (inches) for systems that derive their connection capacity from friction and 31" (inches) for systems using a mechanical connection to derive their connection capacity (per NHI 043 and AASHTO). | |
| G. | Drainage Aggregate shall be placed within, between, and a minimum of 12" (inches) behind the segmental concrete facing units. | |
| 1.06 | 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, 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 units identical to those installed on the Project. | |

PART 2 PRODUCTS

2.01 MATERIALS

A. Segmental Retaining Wall units shall meet the following requirements:

- Physical Requirements:
 - a. Compression and Absorption: Concrete retaining wall units shall be tested in accordance with ASTM C140, Sections 6, 8 and 9. Concrete retaining wall units shall meet requirements of ASTM C1372, except the compressive strength requirements will be increased to a minimum of 3,500 psi and 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. Test shall be performed within the past 6 months to be considered current and valid.
 - b. Freeze-Thaw Durability: Shall be tested in accordance with ASTM C1262 when required. Test shall be performed within the past 12 months to be considered current and valid.

Note to Specifier: In Subparagraph below, select appropriate entity, color, and face pattern geometry

Per the [Architect][Owner]

- c. Color: [Natural Grey][Standard Color- List Name][Blended Color – List Name]
 - d. Face Pattern Geometry: [Straight] [Beveled][Stone Cut]
 - e. Texture: Split Rock Face that exposes the natural aggregates.
 - f. Batter: Include an integral batter control shear connector to provide a consistent setback for each wall course. Initial wall batter shall not exceed 7 degrees.
- B. Approved Systems
- Anchor Wall Systems
 - Competitor X
 - Competitor Y
- C. Geosynthetic Reinforcement shall be manufactured with high-tenacity polyester or HDPE in a grid or textile structure. The geosynthetic reinforcement must meet the long-term design strength, soil interaction, and connection capacity requirements as required by the design of the retaining wall.
1. Long-term Design Strength: As determined in accordance with Method A of the NCMA Design Manual for Segmental Retaining Walls, Second Edition, Second Printing, 1997.
 - a. Ultimate Tensile Strength: The ultimate tensile strength of the geosynthetic reinforcement shall be determined in accordance with ASTM D4595 or ASTM D6637.
 - b. Creep: Creep testing of the geosynthetic shall be performed in accordance with ASTM D5262. The creep reduction factor shall be determined in accordance with FHWA-NHI-00-043.
 - c. Installation Damage: The installation damage reduction factor shall be determined in accordance with ASTM D5818 and FHWA-NHI-00-043.
 - d. Durability: The durability reduction factor shall be determined in accordance with FHWA-NHI-00-044.
 2. Soil Interaction: The soil interaction properties include the coefficient of direct sliding and coefficient of interaction as determined through direct shear and pullout testing, respectively.

- a. Pullout: Shall be determined in accordance with ASTM D6706.
- b. Direct Sliding: Shall be tested in accordance with ASTM D5321.
3. Connection Capacity: As determined in accordance with ASTM D6638.

D. 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. Base Thickness: At least 2 inches
 - b. Minimum Compressive strength of 1,500 psi
- E. 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

- F. Reinforced Backfill: Suitable reinforced backfill soils shall be free of organics and debris and consisting of GP, GW, SP, SW, or SM type, classified in accordance with ASTM D2487 and the USCS classification system. Soils classified as SC, ML and CL are considered suitable soils for segmental retaining walls with a total height of less than 10 feet.
 1. The Plasticity Index (PI) of the reinforced backfill soils shall not be greater than 20 as measured in accordance with ASTM D4318.
 2. Unsuitable soils are organic soils and those soils classified as CH, OH, MH, OL, or PT.
 3. The pH of the reinforced backfill shall be between 3 and 10 and be tested in accordance with ASTM G51.
 4. Maximum particle size less than or equal to 4 inches.
- 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 to prevent fines migration into the pipe.
- H. Pre-fabricated Drainage Composite: The pre-fabricated drainage composite shall be Miradrain 5000, manufactured by Mirafi, or equal.
- I. Geotextile Filter: The geotextile filter shall be in accordance with AASHTO M288 guidelines.
- J. Impervious Material: Clay soil and/or low permeability geosynthetic shall have a coefficient of permeability of less than 10^{-6} cm/s as tested in accordance with ASTM D5084 or ASTM D4491, as applicable.
- K. Construction Adhesive: Exterior grade adhesive as recommended by the retaining wall unit manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. The Project Geotechnical Engineer shall examine the areas and conditions under which the retaining wall system is to be erected, and notify the Owner and 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 that 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

- A. Excavate to the lines and grades shown on the Drawings. The General Contractor shall replace any unsuitable soils discovered during excavation. 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. A thin, less than 1 inch, can be used to assist in leveling the base units

- C. Prepare base materials to ensure complete contact with retaining wall units.

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 or lean concrete leveling pad.
- D. Place concrete wall units side-by-side for full length of wall alignment. Alignment may be accomplished by using a string line measuring from the back of the block.
- E. Place 12 inches (minimum) of drainage aggregate directly behind the concrete wall units. Fill voids in and between retaining wall units with drainage aggregate. Provide a drainage zone behind the wall units to within 12 inches of the final grade. Cap the backfill and drainage aggregate zone with 12 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 to an appropriate location away from the wall system at each low point and at 50-foot (maximum) intervals along the wall.
- 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. Install alignment devices (pins, clips, bars etc.) if required.
- 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/device 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. Ensure that the geosynthetic reinforcement extends to 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 laid horizontally, pulled taught and be free from wrinkles prior to placement of the backfill soils. The geosynthetic reinforcement may be secured in place with staples, stakes, soil fill or by hand tensioning until the geosynthetic reinforcement is covered by 6 inches of loose fill.
 6. The geosynthetic reinforcements shall be continuous throughout its embedment length. 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, the wall installer shall 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 General Contractor or Owner, at their expense, shall retain a qualified independent testing agency to perform quality assurance checks, evaluation of foundation soils, and compaction testing of the installer's work.
- C. Installer shall correct work that does not meet these specifications or the requirements shown on the Drawings at the installer's expense.
- D. An independent testing agency, at the general contractors expense, shall be contracted to 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 from the bottom of the embedded base wall unit to the top of the wall, including cap unit, 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, and equipment 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