**Instructions are in red text and should be deleted when the specification is complete.**

**[Bracketed bold text indicates where project specific decisions are required, should be reviewed, and edited to meet the project requirements, and all brackets should be removed from finished document.] The specifier should review the bracketed options in Sections 2.01.A SRW Units, Section 3.01.A Examination, and Section 3.03.A Excavation.**

**This guide specification must be edited for project-specific requirements. It should be reviewed by a qualified civil or geotechnical engineer familiar with the site conditions.**

**This guide specification is for the furnishing and construction of a Diamond® Pro Air Retaining Wall System in accordance with these specifications and in general conformity with the lines, grades, design, and dimensions shown on the plans.**

**Only include 1.02.A – Unit prices only if Article 3.12 is included. Included Section 02300 below for finished grading, and/or other Earthwork related sections if required.**

**SECTION 32 32 23**

**CONCRETE SEGMENTAL RETAINING WALL SYSTEM**

**PART 1 - GENERAL**

* 1. **DESCRIPTION**
1. Work consists of furnishing and construction of a Diamond® Pro Air Retaining Wall System in accordance with these specifications and in general conformity with the lines, grades, design, and dimensions shown on the plans.
2. 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,
3. Installation work includes:
	* + 1. Furnishing and installing Diamond® Pro Air Concrete Facing and Cap Units, along with corner 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. **RELATED SECTIONS**
4. Section 01270 – Unit Prices
5. Section 02300 – Earthwork
	1. **REFERENCES**
6. 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 National Transportation Product Evaluation Program (NTPEP)
7. American Society for Testing and Materials (ASTM)
	1. ASTM C1372 Standard Specification for Segmental Retaining Wall Units
	2. ASTM D448 Standard Classification for Sizes of Aggregate for Road and Bridge Construction
	3. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/f3)(600 kN-m/m3)
	4. ASTM D1556 Standard Test Method for Density and Unit Weight of Soil In Place by the Sand Cone Method
	5. ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/f3)(2700 kN-m/m3)
	6. ASTM D2487 Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)
	7. ASTM D2922 Standard Test Methods for Density of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth)
	8. ASTM D3034 Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer pipe and Fittings
	9. ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

 ASTM D4873 Standard Guide for Identification, Storage and Handling of Geosynthetics

* 1. ASTM D5818 Standard Practice for Obtaining Samples of Geosynthetics from a Test Section for Assessment of Installation Damage
1. Concrete Masonry and Hardscapes Association (CMHA)
	1. NCMA Design Manual for Segmental Retaining Walls, Third Edition, 2010
	2. **SUBMITTALS / CERTIFICATION**
2. Product Data
	1. Product Data: Material description 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 in the same facility.
	3. 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. Letter from the reinforcement manufacturer stating that the geosynthetic reinforcement has been manufactured in complete compliance with the reinforcement manufacturer’s current NTPEP report.
3. Samples:
	1. The 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.
4. Test Reports:
	1. Independent Laboratory reports indicating compressive strength, moisture absorption and freeze-thaw durability, if required, 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.
5. Wall Design Engineer Qualifications:
	1. Current insurance policy verifying professional liability and errors and omissions insurance coverage for an aggregate and per claim limit of at least one million dollars ($1,000,000).
	2. Letter certifying the proposed retaining wall Design Engineer is a licensed professional engineer in the state of wall installation and has a minimum of 4 years and 200,000 square feet of retaining wall system design experience.
6. Retaining Wall Contractor Qualifications:
	1. Letter documenting the retaining wall contractor has installed a minimum of 100,000 square feet of segmental retaining walls.
	2. The Retaining Wall Installer shall furnish five (5) project references of comparable 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.
7. 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 shall be provided. 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.
	3. **DELIVERY, STORAGE AND HANDLING**
8. 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 ensure 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.
9. Exposed faces of SRW units shall be relatively free of chips, cracks, stains, and other imperfections detracting from their appearance, when viewed from 20 feet under diffused lighting.
10. Prevent mud, wet cement, adhesives, and similar materials that may harm the appearance of SRW units, from coming in contact with system components.
11. Geosynthetics (including geosynthetic reinforcement, geotextile filter, prefabricated drainage composite) shall be delivered, stored, and handled in accordance with ASTM D4873.

**PART 2 - PRODUCTS**

* 1. **MATERIALS**
1. SRW Units: Basis-of-Design Diamond® Pro Air Retaining Wall Units as manufactured under license from Anchor Wall Systems.
	1. Physical Requirements
		1. 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.
		2. Unit Face Area: Not less than 1.0 square foot.
		3. Color: Selected by the **[Architect] [Engineer] [Owner]**from manufacturer's full range of standard colors.
		4. Face Pattern Geometry: **[Straight] [Beveled] [Stone Cut] [Virtual Joint] [Quarry] [Smooth] [Split Multi Piece]**
		5. Texture: **[Split Rock Face] [Molded/Smooth Face]**
		6. Setback: Include an integral concrete shear connection flange/locator to provide a 1-inch setback for each wall course.
		7. Supplier: Anchor Wall Systems licensed producer
		8. Contact Person: Sales Representative and contact information.
		9. Substitutions: No substitutions permitted
2. Geosynthetic Reinforcement: Polyester fiber geogrid or geotextile, or polypropylene woven geotextile, as shown on the Drawings.
3. Leveling Pad 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

1. 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

1. 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

Plasticity Index (PI) < 6 per ASTM D4318.

The 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.

Unsuitable soils are organic soils and those soils classified as SC, CL, ML, CH, OH, MH, OL, or PT.

1. Low Permeability Soil: Clayey soil or other similar material which will prevent percolation into the drainage zone behind the wall.
2. 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.
3. Geotextile Separation Fabric: Geotextile Separation fabric shall be minimum 4.0 oz/sy, polypropylene, needle-punched nonwoven fabric meeting the requirements of AASHTO M 288.
4. Construction Adhesive: Exterior grade adhesive as recommended by the retaining wall unit manufacturer.

**PART 3 – EXECUTION**

1. **EXAMINATION**
2. 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.
3. 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.
4. Verify the location of existing structures and utilities prior to excavation.
5. **PREPARATION**
6. Ensure surrounding structures are protected from the effects of wall excavation.
7. Excavation support, if required, is the responsibility of the Retaining Wall Contractor, including the stability of the excavation and its influence on adjacent properties and structures.
8. **EXCAVATION**
9. Excavate 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.
10. **FOUNDATION PREPARATION**
11. Excavate foundation soil as required for footing or base dimension shown on the Drawings, or as directed by the Project geotechnical engineer.
12. 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.
13. The Project geotechnical engineer will determine if the foundation soils require special treatment or correction to control total and differential settlement.
14. Fill over-excavated areas with suitable compacted backfill, as recommended by the Project geotechnical engineer.
15. **LEVELING PAD PREPARATION**
16. 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. Where a reinforced footing is required by the local code official, place footing below frost depth.
17. Compact aggregate base material to provide a level, hard surface on which to place the first course of SRW units.
18. Prepare base materials to ensure complete contact with SRW units. Gaps are not allowed.
19. **ERECTION**
20. Erect SRW units in accordance with manufacturer's instructions and recommendations, and as specified herein.
21. Place the 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.
22. Ensure that foundation units are in full contact with the leveling pad.
23. 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.
24. 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.
25. 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.
26. Remove excess fill from top of SRW units and install next course. Ensure drainage aggregate and backfill are compacted before installation of next course.
27. Check each course for level and alignment. Adjust SRW units as necessary to maintain level and alignment prior to proceeding with each additional course.
28. 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.
29. 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.
30. **BACKFILL PLACEMENT**
31. Place reinforced fill, spread and compact in a manner that will minimize slack in the reinforcement.
32. 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.
33. Compaction testing shall be done in accordance with ASTM D1556 or ASTM D2922.
34. 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) or 92 percent 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 100 percent of the soil's standard Proctor maximum dry density (ASTM D698) or 98 percent of modified Proctor maximum dry density (ASTM D1557), or as recommended by the Project geotechnical engineer.
		1. 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: The backfill moisture content will be within 2 percentage points of the optimum moisture content for all wall heights.
	4. These compaction specifications may be changed based on recommendations by the Project geotechnical engineer.
		1. If changes are required, the Contract Sum will be adjusted by written Change Order.
35. 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.
36. Refer to Article 3.10 for compaction testing.
37. **CAP UNIT INSTALLATION**
38. Apply adhesive to the top surface of the SRW unit below and place the cap unit into desired position.
39. Cut cap SRW units as necessary to obtain the proper fit.
40. Backfill and compact to top of SRW unit or to the top of cap in accordance with the design drawings.
41. **SITE CONSTRUCTION TOLERANCES**
42. 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
		1. Straight Lines: Plus, or minus 1-1/2 inches over any 10-foot distance.
		2. Corner and Radius Locations: Plus, or minus 12 inches.
		3. 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.
43. **FIELD QUALITY CONTROL**
44. The installer is responsible for quality control of installation of system components.
45. The Owner or General Contractor, at their expense, will retain a qualified professional to perform quality assurance checks of the installer's work.
46. Correct work which does not meet these specifications, or the requirements shown on the Drawings at the installer's expense.
47. Perform compaction testing of the reinforced backfill placed and compacted in the reinforced backfill zone.
	1. Testing Frequency
		1. One test for every 2 feet (vertical) of fill placed and compacted, for every 50 lineal feet of retaining wall.
		2. Vary compaction test locations to cover the entire area of the reinforced soil zone, including the area compacted by the hand-operated compaction equipment.
48. **ADJUSTING AND CLEANING**
49. Replace damaged SRW units with new units as the work progresses.
50. Remove debris caused by wall construction and leave adjacent paved areas broom clean.
51. **MEASUREMENT AND PAYMENT**
52. 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.
53. 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