

SECTION 32 32 17
PRECAST MODULAR BLOCK GRAVITY RETAINING WALL

PART 1 GENERAL

1.01 SUMMARY

- A. This section includes furnishing all materials and labor required for the design and construction of a precast concrete modular block (PMB) gravity retaining wall, without geosynthetic reinforcement. Precast modular concrete retaining wall blocks under this section shall be cast utilizing a wet-cast concrete mix and exhibit a final handling weight in excess of 400 pounds per unit. Dry-cast concrete segmental retaining wall blocks are not covered by this specification.
- B. Scope of Work: The Work shall consist of furnishing materials, labor, equipment, and supervision for construction of a precast modular block (PMB) gravity retaining wall structure in accordance with the requirements of this section and in acceptable conformity with the lines, grades, design, and dimensions shown on the Drawings or as established by the Contracting Officer.

1.02 PRICE AND PAYMENT PROCEDURES

- A. Allowances: No allowance shall be made in the price of the retaining wall for excavation beyond the limits required for retaining wall construction as shown on the Drawings. Removal of unsuitable soils and replacement with select fill shall be as directed and approved in writing by the Contracting Officer and shall be paid under separate pay items.

1.03 REFERENCES

- A. Where the Specifications and reference documents conflict, the Contracting Officer will make the final determination of the applicable document.
- B. The following is a list of standards which may be referenced in this section:
 - 1. American Association of State Highway and Transportation Officials (AASHTO):
 - a. LRFD Bridge Design Specifications, 5th Edition, 2010.
 - b. M 145, Soil Classification System.
 - c. M 194, Standard Specification for Chemical Admixtures for Concrete.
 - d. M 288, Geotextile Specification for Highway Applications.
 - e. T 104, Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.

- f. T 267, Standard Method of Test for Determination of Organic Content in Soils by Loss of Ignition.
- 2. ASTM International (ASTM):
 - a. C33, Standard Specification for Concrete Aggregates.
 - b. C94, Standard Specification for Ready-Mixed Concrete.
 - c. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - d. C140, Standard Test Method of Sampling and Testing Concrete Masonry Units.
 - e. C143, Standard Test Method for Slump of Hydraulic-Cement Concrete.
 - f. C260, Standard Specification for Air-Entraining Admixtures for Concrete.
 - g. C920, Standard Specification for Elastomeric Joint Sealants.
 - h. C1116, Standard Specification for Fiber-Reinforced Concrete.
 - i. C1262, Standard Test Method for Evaluating Freeze-Thaw Durability of Dry-Cast Segmental Retaining Wall Units and Related Concrete Units.
 - j. C1372, Standard Specification for Dry-Cast Segmental Retaining Wall Units.
 - k. C1611, Standard Test Method for Slump Flow of Self-Consolidating Concrete.
 - l. D422, Standard Test Method for Particle-Size Analysis of Soils.
 - m. D448, Standard Classification for Sizes of Aggregates for Road and Bridge Construction.
 - n. D698, Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. (12,400 ft-lbf/ft (2,700 kN-m/m)).
 - o. D1241, Standard Specification for Materials for Soil-Aggregate Subbase, Base and Surface Courses.
 - p. D1556, Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method.
 - q. D1557, Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort. (56,000 ft-lbf/ft (2,700 kN-m/m)).
 - r. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 - s. D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
 - t. D3034, Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 - u. D3080, Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions.
 - v. D3786, Standard Test Method for Bursting Strength of Textile Fabrics Diaphragm Bursting Strength Tester Method.

- w. D4254, Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
- x. D4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- y. D4354, Standard Practice for Sampling of Geosynthetics for Testing.
- z. D4355, Standard Test Method for Deterioration of Geotextiles
- aa. D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
- bb. D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
- cc. D4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
- dd. D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
- ee. D4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile.
- ff. D4759, Standard Practice for Determining Specification Conformance of Geosynthetics.
- gg. D4767, Test Method for Consolidated-Undrained Triaxial Compression Test for Cohesive Soils.
- hh. D4833, Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.
- ii. D4873, Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples.
- jj. D4972, Standard Test Method for pH of Soils.
- kk. D5262, Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics.
- ll. D5321, Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
- mm. D5818, Standard Practice for Exposure and Retrieval of Samples to Evaluate Installation Damage of Geosynthetics.
- nn. D6241, Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
- oo. D6637, Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method.
- pp. D6638, Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks).
- qq. D6706, Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil.
- rr. D6916, Standard Test Method for Determining Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks).

- ss. D6938, Standard Test Method for In-Place Density and Water Content of Soil and Aggregate by Nuclear Methods (Shallow Depth).
- tt. D6992, Standard Test Method for Accelerated Tensile Creep and Creep-Rupture of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method.
- uu. F2648, Standard Specification for 2 to 60 inch [50 to 1500 mm] Annular Corrugated Profile Wall Polyethylene (PE) Pipe and Fittings for Land Drainage Applications.
- vv. G51, Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing.
- ww. G57, Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method.
- 3. Federal Highway Administration National Highway Institute (FHWA-NHI):
 - a. 10-024 Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume I.
 - b. 10-025 Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume II.
- 4. International Building Code, 2009 Edition.
- 5. Minimum Design Loads for Buildings and Other Structures – ASCE/SEI 7-10.

1.04 DEFINITIONS

- A. Drainage Aggregate: Clean, crushed stone placed within and immediately behind the precast modular block units to facilitate drainage and reduce compaction requirements immediately adjacent to and behind the precast modular block units.
- B. Foundation Zone: Soil zone immediately beneath the leveling pad and the reinforced zone.
- C. Geotextile: A geosynthetic fabric manufactured for use as a separation and filtration medium between dissimilar soil materials.
- D. Leveling Pad: Flat surface upon which the bottom course of precast modular blocks are placed. The leveling pad may be constructed with crushed stone. A leveling pad is not a structural footing.
- E. Precast Modular Block (PMB) Unit: “Wet cast” concrete modular block retaining wall facing unit.
- F. Retained Zone: Soil zone immediately behind the drainage aggregate in a non-reinforced “gravity” precast modular block wall.

- G. The Retaining Wall Design Engineer: Engineer shall be the certified, licensed engineer retained by the Contractor to develop the engineering shop drawings for the modular block gravity retaining wall.
- H. Onsite Engineer: Engineer who is experienced with the construction of precast modular block retaining wall structures to perform Onsite and testing retained by the Contractor.
- I. Retaining Wall Installation Contractor Qualifications: Qualified subcontractor meeting qualifications in Article Quality Assurance.
- J. Unit Core Fill: Clean, crushed stone placed within the hollow vertical core of a precast modular block unit. Typically, the same material used for drainage aggregate as defined above.
- K. Wall Infill: In gravity precast modular block wall installations, the fill material placed and compacted between the drainage aggregate and the excavated soil face.

1.05 ADMINISTRATIVE REQUIREMENTS

- A. Preconstruction Meeting: As directed by the Agency, the Contractor shall schedule a preconstruction meeting at the Project Site prior to commencement of retaining wall construction. Participation in and/or attendance at the preconstruction meeting shall be required of the Contractor, Retaining Wall Design Engineer, Retaining Wall Installation Contractor, Grading Contractor, and Contracting Officer. The Retaining Wall Design Engineer shall be furnished by the Contractor. The Contractor shall provide notification to all parties at least 10 calendar days prior to the meeting.

1.06 SUBMITTALS

- A. Product Data:
 - 1. At least 14 days prior to construction, the Contractor shall submit a minimum of four copies of the retaining wall product submittal package to the Contracting Officer for review and approval. The submittal package shall include technical specifications and product data from the manufacturer for the following:
 - a. Precast Modular Gravity Block System brochure.
 - b. Precast Modular Gravity Block concrete test results specified in Article Precast Modular Block Retaining Wall Units of this specification as follows:
 - 1) 28-day compressive strength.
 - 2) Air content.
 - 3) Slump or slump flow (as applicable).
 - c. Drainage pipe.

- d. Drainage composite (if applicable).
 - e. Geotextile.
- B. Installer Qualification Data: In the Bid Form, as identified for Subcontractors, the Contractor shall submit the qualifications of the business entity responsible for installation of the retaining wall, the Retaining Wall Installation Contractor, per Article Construction Drawing Preparation of these Specifications.
- C. Retaining Wall Design Calculations and Construction Drawings:
 - 1. The Contractor shall furnish the precast modular block gravity retaining wall construction drawings as part of this Contract, at least 21 days prior to construction, the Contractor shall furnish four sets of construction drawings and four copies of the supporting structural calculations report to the Contracting Officer for review and approval. This submittal shall include the following:
 - a. Signed, sealed, and dated drawings and engineering calculations prepared in accordance with these Specifications.
 - b. Qualifications Statement of Experience of the Retaining Wall Design Engineer as specified in Article Construction Drawing Preparation of these Specifications.
 - c. Certificate of Insurance of the Retaining Wall Design Engineer as specified in Paragraph Installer Qualification Data of this section.
- D. Block Face Samples: With the retaining wall product submittal package, the Contractor shall submit one sample panel of the precast modular block face with dimensions sufficient to accurately exhibit the face texture proposed. The sample shall be a full-scale representation of the facing texture and color specified. The block face sample shall not weigh more than 100 pounds.

1.07 CONSTRUCTION DRAWING PREPARATION

- A. The Retaining Wall Design Engineer shall coordinate the retaining wall construction drawing preparation with the Contracting Officer. The Retaining Wall Design Engineer shall be furnished the Project information required to perform the design of the retaining walls. This information shall include, but is not limited to, the following:
 - 1. Current versions of the site, grading, drainage, utility, erosion control, landscape, and irrigation plans.
 - 2. Electronic CAD file of the civil site plans listed in Item 1 above.
 - 3. Assumed soil type information and slope above the wall at very locations.

- B. The Retaining Wall Design Engineer shall provide the Contracting Officer a certificate of professional liability insurance verifying the minimum coverage limits of \$1 million per claim and \$1 million aggregate.
- C. Design of the precast modular block gravity retaining wall shall satisfy the requirements of this section. Where local design or building code requirements exceed these Specifications, the local requirements shall also be satisfied.
- D. The Retaining Wall Design Engineer shall note any exceptions to the requirements of this section by listing them at the bottom right corner of the first page of the Drawings.
- E. Approval or rejection of the exceptions taken by the Retaining Wall Engineer will be made in writing as directed by the Contracting Officer.
- F. The precast modular block design, except as noted herein, shall be based upon the requirements of this section and the following:
 - 1. Wall system shall be gravity system.
 - 2. AASHTO LRFD Bridge Design Specifications, Fifth Edition, 2010.
 - 3. FHWA-NHI-10-024 Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume I.
 - 4. FHWA-NHI-10-025 Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume II.
 - 5. International Building Code, 2009 Edition.
- G. In the event that a conflict is discovered between these Specifications and a reasonable interpretation of the design specifications and methods referenced in the paragraph above, these Specifications shall prevail. If a reasonable interpretation is not possible, the conflict shall be resolved per the requirements in Article References of this section.
- H. Soil Shear Parameters: The Retaining Wall Design Engineer shall prepare the retaining wall design based upon soil shear strength parameters from the available Project data. If insufficient data exists to develop the retaining wall design, the Retaining Wall Design Engineer shall communicate the specific deficiency of the Project information or data to the Contracting Officer in writing.
- I. Internal and External Stability: The internal and external stability analyses shall be prepared in accordance with AASHTO LRFD Bridge Design Specifications, Fifth Edition, 2010. Gravity walls shall be designed in accordance with Section 11.11. Load combinations and Load Factors shall be in accordance with Tables 3.4.1-1 and 3.4.1-2. Resistance Factors shall be in accordance with Tables 11.5.6 1 and 10.5.5.2.2-1.

- J. Allowable bearing capacity requirements for each retaining wall shall be clearly shown on the Drawings.
- K. Global Stability (Static): Overall (global) stability shall be evaluated in accordance with AASHTO LRFD Bridge Design Specifications, Fifth Edition, 2010, Section 11.6.2.3 for Load Combination Resistance Factor, $\phi = 0.65$ for Service I Load Combination.
- L. Seismic Stability: Seismic loading shall be evaluated in accordance with AASHTO LRFD Bridge Design Specifications, Fifth Edition, 2010, Sections 11.6.5 and 11.10.7. Seismic design acceleration shall be as directed by the Project data. In the absence of this recommendation, the seismic design acceleration shall be determined in accordance with AASHTO LRFD Bridge Design Specifications, Fifth Edition, 2010, Figures 3.10.2.1-1 through 3.10.2.1-21 or the requirements of the local building code as appropriate for the overall project construction category type.

1.08 QUALITY ASSURANCE

A. Retaining Wall Installation Contractor Qualifications:

- 1. In order to demonstrate basic competence in the construction of precast modular block walls, the Retaining Wall Installation Contractor shall document compliance with the following:
 - a. Experience: Construction of at least two precast modular block structures with heights that are comparable (within 4 feet) to the proposed structure.
 - b. Retaining wall installation contractor experience documentation for each qualifying project shall include:
 - 1) Project name and location.
 - 2) Date of construction.
 - 3) Contact information of Owner or General Contractor.
 - 4) Type (trade name) of precast modular block system built.
 - 5) Maximum height of the wall constructed.
 - 6) Face area of the wall constructed.

B. Retaining Wall Design Engineer Qualifications and Statement of Experience:

When the General Contractor furnishes the retaining wall design for the Contracting Officer's review and approval as part of a design-build contract, the Retaining Wall Design Engineer shall submit a written statement affirming that he or she has the following minimum qualifications and experience.

- 1. The Retaining Wall Design Engineer shall be licensed to practice in the state of Arizona.
- 2. The Retaining Wall Design Engineer shall be independently capable of performing all internal and external stability analyses, including those

for seismic loading, compound stability, rapid draw-down and deep-seated, global modes of failure.

3. The Retaining Wall Design Engineer shall affirm in writing that he or she has designed a minimum of 10,000 total square feet of retaining walls in each of the preceding 3 years. Acceptable experience can be attributed to the design of any combination of the following retaining wall system types; (i) precast modular block gravity retaining walls, (ii) segmental retaining walls, (iii) welded wire form faced retaining walls, (iv) mechanically stabilized earth panel retaining walls, or (v) reinforced soil slopes.
4. The Retaining Wall Design Engineer shall be prepared to provide, upon the Contracting Officer's request, documentation of the above experience that includes:
 - a. Project name and location.
 - b. Date of design.
 - c. Client contact information.
 - d. Type and trade name of the wall system designed.
 - e. Maximum design height of each retaining wall.
 - f. Face area of each retaining wall designed.

- C. The Contracting Officer reserves the right to reject the design services of any engineer or engineering firm who, in the sole opinion of the Contracting Officer, does not possess the requisite experience and qualifications.

1.09 QUALITY CONTROL

- A. The Contracting Officer shall review all submittals for materials, design, Retaining Wall Design Engineer qualifications and the Retaining Wall Installation Contractor qualifications.
- B. The Contractor shall retain, at its cost, an Onsite Engineer who is experienced with the construction of precast modular block retaining wall structures to perform Onsite and testing.
- C. The Onsite Engineer shall perform the following duties:
 1. Inspect the construction of the precast modular block structure for conformance with construction drawings and the requirements of this specification.
 2. Verify that soil or aggregate fill placed and compacted in the retained, reinforced and foundation zones of the retaining wall conforms with Article Geotextile and Article Leveling Pad of this specification and exhibits the shear strength parameters specified by the Retaining Wall Design Engineer.
 3. Verify that the shear strength of the in-situ soil assumed by the Retaining Wall Design Engineer is appropriate.

4. Inspect and document soil compaction in accordance with these Specifications:
 - a. Required dry unit weight.
 - b. Actual dry unit weight.
 - c. Allowable moisture content.
 - d. Actual moisture content.
 - e. Pass/fail assessment.
 - f. Test Location: Wall station number.
 - g. Test elevation.
 - h. Distance of test location behind the wall face.
 5. Verify that all excavated slopes in the vicinity of the retaining wall are bench-cut as directed by the Retaining Wall Design Engineer.
 6. Notify the Retaining Wall Installation Contractor of any deficiencies in the retaining wall construction and provide the Retaining Wall Installation Contractor a reasonable opportunity to correct the deficiency.
 7. Notify the Contractor, Contracting Officer, and Retaining Wall Design Engineer of any construction deficiencies that have not been corrected timely.
 8. Document all onsite results.
 9. Test compacted density and moisture content of the reinforced and retained backfill with the following frequency:
 - a. At least once every 1,000 square feet (in plan) per 9-inch vertical lift.
 - b. At least once per every 18 inches of vertical wall construction.
- D. Contracting Officer's engagement of the Onsite Engineer does not relieve the Retaining Wall Installation Contractor of responsibility to construct the proposed retaining wall in accordance with the Drawings and these Specifications.
- E. The Retaining Wall Installation Contractor shall inspect the onsite grades and excavations prior to construction and notify the Retaining Wall Design Engineer and Contractor if onsite conditions differ from the elevations and grading conditions depicted in the retaining wall drawings.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. The Retaining Wall Installation Contractor shall inspect the materials upon delivery to ensure that the proper type, grade, and color of materials have been delivered.
- B. The Retaining Wall Installation Contractor shall store and handle all materials in accordance with the manufacturer's recommendations as specified herein and in a manner that prevents deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breaking, chipping, UV

exposure or other causes. Damaged materials shall not be incorporated into the Work.

C. Geosynthetics:

1. All geosynthetic materials shall be handled in accordance with ASTM D4873. The materials should be stored off the ground and protected from precipitation, sunlight, dirt, and physical damage.
2. Geogrid reinforcement material shall be marked in such a manner as to make the style of the material readily identifiable to both the construction crew and the Contracting Officer after the manufacturer's packaging and product labels have been removed.

D. Precast Modular Blocks: Precast modular blocks shall be stored in an area with positive drainage away from the blocks. Be careful to protect the block from mud and excessive chipping and breakage. Precast modular blocks shall not be stacked more than two units high in the storage area.

E. Drainage Aggregate and Backfill Stockpiles:

1. Drainage aggregate or backfill material shall not be piled over unstable slopes or areas of the Project Site with buried utilities.
2. Drainage aggregate shall not be staged where it may become mixed with or contaminated by poor draining fine-grained soils such as clay or silt.

PART 2 PRODUCTS

2.01 PRECAST MODULAR BLOCK RETAINING WALL UNITS

A. Manufacturers:

1. Manufacturers of Redi-Rock PC (Positive Connection Retaining Wall Block Units.
2. Or equal.

B. Physical Characteristics:

1. Concrete used in the production of the precast modular block units shall not consist of returned, reconstituted, or waste concrete. It shall be an original production mix meeting the requirements of ASTM C94 and exhibit the following:
 - a. Minimum 28-day compressive strength of 4,000 psi.
 - b. Shall be free of water soluble chlorides.
 - c. Air-entrained in conformance ASTM C94.

- d. Maximum slump of 5 inches plus or minus 1-1/2 inches per ASTM C143 for conventional concrete mix designs.
 - e. Slump Flow for Self-Consolidating Concrete (SCC) mix designs shall be between 18 inches and 32 inches as tested in accordance with ASTM C1611.
2. Each concrete block shall be cast in a single continuous pour without cold joints. With the exception of half-block units, corner units and other special application units, the precast modular block units shall conform to nominal dimensions listed in the table below and be produced to the dimensional tolerances shown as measured in accordance with ASTM C140.

Block Type	Dimension	Nominal Value	Tolerance
28" Block	Height	18 inches	+/- 3/16 inch
	Length	46-1/8 inches	+/- 1/2 inch
	Width	28 inches	minus 1 inch
41" Block	Height	18 inches	+/- 3/16 inch
	Length	46-1/8 inches	+/- 1/2 inch
	Width	40-1/2 inches	+/- 1 inch
60" Block	Height	18 inches	+/- 3/16 inch
	Length	46-1/8 inches	+/- 1/2 inch
	Width	60 inches	+/- 1 inch

3. With the exception of half-block units, corner units and other special application units, the precast modular block units shall have two, circular dome shear knobs that are 10 inches maximum in diameter and 4 inches maximum in height. The shear knobs shall fully index into a continuous shear channel in the bottom of the block course above. Interlock shear between any two vertically stacked precast modular block units shall exceed 9,000 pounds per foot at a maximum horizontal displacement of 0.24 inch in accordance with ASTM D6916.
4. Without field cutting or special modification, the precast modular block units shall be capable of achieving a minimum radius of 14 feet 6 inches without exposing the untextured top face of the block.
5. The 28-inch block and 41-inch block precast modular block units shall be cast with a continuous vertical core slot that will allow a 12-inch wide strip of continuous geogrid reinforcement to pass completely through the block. When installed in this manner, the geogrid reinforcement shall form a non-normal load dependent, positive connection between the block unit and the reinforcement strip. The continuous vertical core slot shall have a nominal width of 13 inches.

The 60-inch precast modular block units may be furnished with or without the continuous vertical core slot.

6. The precast modular block units shall include the option of production with various shear knob locations that result in individual unit-to-unit setback (face batter) of 26.6 degrees, 5.1 degrees, 1.2 degrees or 0 degree as measured from vertical.
7. The precast modular block unit face texture shall be "Ledgestone" approximating the appearance of stacked, cut field stones. The face texture shall exhibit minimum relief of 3 inches to 5 inches. Each textured block facing unit shall be a minimum of 5.75 square feet with a unique texture pattern that repeats with a maximum frequency of once in any 50 square feet of wall face. The block unit face texture shall be manufactured with a custom color blend selected by the Contracting Officer from the manufacturer's full range of color options.
8. Block color shall be determined by Contracting Officer.

C. Functional Characteristics:

1. Connection strength between the precast modular block units and the geosynthetic reinforcement strip shall be evaluated in accordance with ASTM D6638.
2. All precast modular block units shall be sound and free of cracks or other defects that would interfere with the proper installation of the unit, impair the strength or performance of the constructed wall or create an unsatisfactory appearance as determined by the Contracting Officer. Acceptable cracks or chips observed during construction shall be within the guidelines outlined in ASTM C1372.

D. Performance Characteristics: All units for the Project shall be obtained from the same manufacturer. The manufacturer shall be licensed and authorized to produce the retaining wall units by the precast modular block system patent holder/licensor and shall have maintained this manufacturing license in good standing since its inception or for the previous 3 years prior to supplying material for this Project.

2.02 REINFORCED BACKFILL

A. Physical Characteristics:

1. Material used as reinforced backfill material in the reinforced zone (if applicable) shall be a granular soil meeting the requirements of USCS soil type GW, GP, SW or SP per ASTM D2487 or alternatively by AASHTO Group Classification A-1-a or A-3 per AASHTO M145. The backfill shall exhibit a minimum effective internal angle of friction, $\phi = 32$ degrees at a maximum 2 percent shear strain and meet the following particle-size distribution requirements per ASTM D422.

U.S. Standard Sieve Size	% Passing
2"	100
No. 4	20 - 100
No. 40	0 - 60
No. 200	0 - 10

2. Reinforced backfill shall not be comprised of crushed or recycled concrete, recycled asphalt, bottom ash, shale or any other material that may degrade, creep or experience a loss in shear strength or a change in pH over time.

B. Functional Characteristics:

1. The reinforced backfill material shall be free of sod, peat, roots or other organic or deleterious matter including, but not limited to, ice, snow, or frozen soils. Materials passing the No. 40 sieve shall have a liquid limit less than 30 and plasticity index less than 10 per ASTM D4318. Organic content in the backfill material shall be less than 1 percent per AASHTO T-267 and the pH of the backfill material shall be between 3 and 9.
2. Soundness. The reinforced backfill material shall exhibit a magnesium sulfate soundness loss of less than 30 percent after four cycles, or sodium sulfate of less than 15 percent after five cycles as measured in accordance with AASHTO T-104.

C. Performance Characteristics: None.

2.03 GEOTEXTILE

A. Manufacturers and Products:

1. Mirafi; 140N.
2. Or equal.

B. Physical Characteristics: Nonwoven geotextile fabric shall be placed between the drainage aggregate and the reinforced backfill when the wall is reinforced and between the drainage aggregate and the retained soil when the wall is designed as a gravity structure. Additionally, the nonwoven geotextile fabric shall be placed in the v-shaped joint between adjacent block units on the same course and at any other locations noted in the design drawings prepared by the Retaining Wall Design Engineer. The nonwoven geotextile fabric shall be a needle-punched, polypropylene material with a minimum nominal weight of 4 ounces per square yard.

C. Functional Characteristics:

1. The geotextile shall meet the minimum requirements of AASHTO M288-06 Class 3 for elongation greater than 50 percent and the following properties:

Mechanical Property	Test Method	Unit	Minimum Average Roll Value (MARV)	
			MD	CD
Grab Tensile	ASTM D4632	lbs.	115	115
Puncture Resistance	ASTM D4833	lbs.	45	45
Trapezoid Tear Strength	ASTM D4533	lbs.	45	45
Apparent Opening Size	ASTM D4751	U.S. Sieve	70	
Flow Rate	ASTM D4491	gal./min./ft ²	120	

D. Performance Characteristics: None.

2.04 TIE-BACKS

A. Physical Characteristics: None.

B. Functional Characteristics: None.

C. Performance Characteristics: As required and designed by the Retaining Wall Design Engineer.

2.05 DRAINAGE AGGREGATE

A. Physical Characteristics:

1. Drainage aggregate shall be a durable crushed stone conforming to No. 57 size per ASTM C33 with the following particle-size distribution requirements per ASTM D422:

U.S. Standard Sieve Size	% Passing
1-1/2"	100
1"	95 - 100
1/2"	25 - 60
No. 4	0 - 10
No. 8	0 - 5

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.06 LEVELING PAD

A. Physical Characteristics:

1. The precast modular block units shall be placed on a leveling pad constructed from crushed stone as defined below. The leveling pad shall be constructed to the dimensions and limits shown on the retaining wall design drawings prepared by the Retaining Wall Design Engineer.
2. Crushed stone used for construction of a granular leveling pad shall meet the requirements of well-graded gravel (GW) as defined by ASTM D2487 with the following particle size distribution requirements:

US Standard Sieve Size	3/4-Inch Minus Aggregate Base – Percent Passing
1-inch	100
3/4-inch	90 - 100
3/8-inch	
No. 4	40 - 65
No. 8	30 - 50
No. 30	
No. 200	3 - 9

- B. Functional Characteristics: None.
- C. Performance Characteristics: None.

2.07 DRAINAGE

A. Manufacturers and Products:

1. The approved drainage composite product for this application shall be J-Drain 302 as manufactured by JDR Enterprises, Inc. of Alpharetta, GA ((800) 843-7569, www.jdrain.com).
2. Or equal.

B. Physical Characteristics:

1. Perforated Pipe: Drainage collection pipe shall be a 4-inch perforated or slotted HDPE or PVC pipe. Perforations or slots shall be sized to prevent migration of drainage aggregate or unit core fill into the pipe.

C. Functional Characteristics:

1. Drainage Composite: Drainage composite will only be used if directed by the Contracting Officer; it is not considered a part of the base bid. Drainage composites may be used to construct a chimney drain between the reinforced and retained soil zones. The drainage composite shall be comprised of two layers of nonwoven, needle-punched geotextile laminated to a polyethylene or polypropylene geonet core. Drainage composite cores utilized for this application may not have “dimple” or “punchboard” type cores.
2. Perforated Pipe:
 - a. The drainage pipe shall be manufactured in accordance with ASTM D3034, SDR 35, for PVC pipe and fittings or AASHTO M 252 for HDPE pipe and ASTM F477 for fittings.
 - b. The type of drainage pipe and fittings selected by the Retaining Wall Installation Contractor in accordance with these Specifications and the retaining wall design drawings shall remain consistent within each retaining wall structure.

D. Performance Characteristics: None.

PART 3 EXECUTION

3.01 GENERAL

- A. All work shall be performed in accordance with OSHA safety standards, state and local building codes and manufacturer’s requirements.

- B. The Contractor is responsible for the location and protection of all existing underground utilities. Any new utilities proposed for installation in the vicinity of the retaining wall, shall be installed concurrent with retaining wall construction. The Contractor shall coordinate the work of subcontractors affected by this requirement.
- C. The Contractor is responsible to ensure that safe excavations and embankments are maintained throughout the course of the Project.
- D. All work shall be inspected by the Contracting Officer.

3.02 EXAMINATION

- A. Prior to construction, the Contractor, Grading Contractor, Retaining Wall Installation Contractor and Contracting Officer shall examine the areas in which the retaining wall will be constructed to evaluate compliance with the requirements for installation tolerances, worker safety and any site conditions affecting performance of the completed structure. Installation shall proceed only after unsatisfactory conditions have been corrected.

3.03 PREPARATION

A. Fill Soil:

1. The Contracting Officer shall verify that reinforced backfill placed in the reinforced soil zone satisfies the criteria of this section.
2. The Contracting Officer shall verify that any fill soil installed in the foundation and retained soil zones of the retaining wall satisfies the specification of the Retaining Wall Design Engineer as shown on the Drawings.

B. Excavation:

1. The Grading Contractor shall excavate to the lines and grades required for construction of the precast modular block retaining wall as shown on the Drawings. The Grading Contractor shall minimize over-excavation. Excavation support, if required, shall be the responsibility of the Grading Contractor.
2. Over-excavated soil shall be replaced with compacted fill in conformance with the Specifications of the Retaining Wall Design Engineer and Section 31 23 13; Subgrade Preparation, of these Specifications.

C. Foundation Preparation:

1. Prior to construction of the precast modular block gravity retaining wall, the leveling pad area, and the reinforced zone (if applicable) shall be

cleared and grubbed per Section 01 35 00; Environmental Protection and Special Controls. All topsoil, brush, frozen soil, and organic material shall be removed. Unsatisfactory foundation soils shall be undercut and replaced with approved fill as directed by the Contracting Officer. The Contracting Officer shall ensure that the undercut limits are consistent with the requirements of the Project data and that all soil fill material is properly compacted according to the Specifications. The Contracting Officer shall document the volume of undercut and replacement.

2. Following excavation for the leveling pad and reinforced zone (if applicable), the Contracting Officer shall evaluate the in-situ soil in the foundation and retained soil zones.
 - a. The Contracting Officer shall verify that the shear strength of the in-situ soil assumed by the Retaining Wall Design Engineer is appropriate. The Contracting Officer shall immediately stop work and notify the Agency if the in-situ shear strength is found to be inconsistent with the retaining wall design assumptions.
 - b. The Contracting Officer shall verify that the foundation soil exhibits sufficient allowable bearing capacity according the requirements indicated on the retaining wall construction drawings.

D. Leveling Pad:

1. The leveling pad shall be constructed to provide a level, hard surface on which to place the first course of precast modular block units. The leveling pad shall be placed in the dimensions shown on the retaining wall construction drawings and extend to the limits indicated.
2. Leveling Pad: 3/4-inch minus crushed stone shall be placed in uniform maximum lifts of 9 inches. The crushed stone shall be compacted by a minimum of three passes of a vibratory compactor capable of exerting 2,000 pounds of centrifugal force and to the satisfaction of the Onsite Engineer.

3.04 PRECAST MODULAR BLOCK GRAVITY WALL SYSTEM INSTALLATION

- A. The precast modular block structure shall be constructed in accordance with the Drawings, these Specifications and the recommendations of the retaining wall system component manufacturers. Where conflicts exist between the manufacturer's recommendations and these Specifications, these Specifications shall prevail.
- B. Drainage Components: Pipe, drainage composite, geotextile and drainage aggregate shall be installed as shown on the Drawings.

C. Precast Modular Block Installation:

1. The first course of block units shall be placed with the front face edges tightly abutted together on the prepared leveling pad at the locations and elevations shown on the Drawings. The Retaining Wall Installation Contractor shall take special care to ensure that the bottom course of block units are in full contact with the leveling pad, are set level and true and are properly aligned according to the locations shown on the Drawings.
2. Backfill shall be placed in front of the bottom course of blocks prior to placement of subsequent block courses. Nonwoven geotextile fabric shall be placed in the V-shaped joints between adjacent blocks. Drainage aggregate shall be placed in the V-shaped joints between adjacent blocks to a minimum distance of 12 inches behind the block unit.
3. Drainage aggregate shall be placed in 9-inch maximum lifts and compacted by a minimum of three passes of a vibratory plate compactor capable exerting a minimum of 2,000 pounds of centrifugal force.
4. Unit core fill shall be placed in the precast modular block unit vertical core slot. The core fill shall completely fill the slot to the level of the top of the block unit. The top of the block unit shall be broom-cleaned prior to placement of subsequent block courses. No additional courses of precast modular blocks may be stacked before the unit core fill is installed in the blocks on the course below.
5. Base course blocks for gravity wall designs (without geogrid reinforcement) may be furnished without vertical core slots. If so, disregard Step 4 above, for the base course blocks in this application.
6. Nonwoven geotextile fabric shall be placed between the drainage aggregate and the retained soil (gravity wall design) or between the drainage aggregate and the reinforced fill (reinforced wall design) as required on the retaining wall Drawings.
7. Subsequent courses of block units shall be installed with a running bond (half block horizontal course-to-course offset). With the exception of 90-degree corner units, the shear channel of the upper block shall be fully engaged with the shear knobs of the block course below. The upper block course shall be pushed forward to fully engage the interface shear key between the blocks and to ensure consistent face batter and wall alignment. Drainage aggregate, unit core fill, geotextile and properly compacted backfill shall be complete and in-place for each course of block units before the next course of blocks is stacked.
8. The elevation of retained fill shall not be less than one block course (18 inches) below the elevation of the reinforced backfill throughout the construction of the retaining wall. This requirement shall not apply to unreinforced, gravity wall designs.

9. If included as part of the precast modular block wall design, cap units shall be secured with an adhesive in accordance with the precast modular block manufacturer's recommendation.

D. Construction Tolerance:

1. Allowable construction tolerance of the retaining wall shall be as follows:
 - a. Deviation from the design batter and horizontal alignment, when measured along a 10-foot straight wall section, shall not exceed 1 inch.
 - b. Deviation from the overall design batter shall not exceed 1 degree with respect to vertical.
 - c. The maximum allowable offset (horizontal bulge) of the face in any precast modular block joint shall be 3/4-inch.
 - d. The base of the precast modular block wall excavation shall be within 1 inch of the staked elevations, unless otherwise approved by the Onsite Engineer.
 - e. Differential vertical settlement of the face shall not exceed 1 foot along any 100 feet of wall length.
 - f. The maximum allowable vertical displacement of the face in any precast modular block joint shall be 3/4-inch.
 - g. The wall face shall be placed within 2 inches of the horizontal location staked.

3.05 REINFORCED BACKFILL

- A. Reinforced backfill will only be used if required by the Contracting Officer and is not considered part of the Base Bid. Backfill material placed in the reinforced zone (reinforced wall design) or immediately behind the drainage aggregate (gravity wall design) shall be compacted as follows:
 1. 95 percent of maximum dry density at plus or minus 2 percent optimum moisture content per ASTM D698 (standard proctor) or 92 percent of maximum dry density at plus or minus 2 percent optimum moisture content per ASTM D1557 (modified proctor). NOTE: The editor must choose one of the above compaction test standards.
- B. Compactive effort within 4 feet of the wall face should be accomplished with walk-behind compactors. Compaction in this zone shall be within 93 percent of maximum dry density as measured in accordance with ASTM D698.
- C. Within 18 inches of a pavement section, soil shall be compacted to within 100 percent of the maximum dry density as measured in accordance with ASTM D698.

- D. Backfill material shall be installed in lifts that do not exceed a compacted thickness of 9 inches.
- E. At the end of each workday, the Retaining Wall Installation Contractor shall grade the surface of the last lift of reinforced backfill to a 3 percent plus or minus 1 percent slope away from the precast modular block wall face and compact it as a temporary measure to prevent surface water from overtopping the retaining wall crest that could potentially soil stain the wall face.
- F. The Contractor shall direct the Grading Contractor to protect the precast modular block wall structure against surface water runoff at all times through the use of berms, diversion ditches, silt fence, temporary drains and/or any other necessary measures to prevent soil staining of the wall face, scour of the retaining wall foundation or erosion of the reinforced backfill/wall backfill.

3.06 OBSTRUCTIONS IN THE REINFORCED ZONE

- A. The Retaining Wall Installation Contractor shall make all required allowances for obstructions in the reinforced zone in accordance with the Drawings.
- B. Should unplanned obstructions in the reinforced zone become apparent for which the Drawings do not account, the affected portion of the wall shall not be constructed until the Retaining Wall Design Engineer can provide a written description of the required procedures for construction of the wall section in question.

3.07 COMPLETION

- A. Soil shall be graded to prevent ponding of water behind the completed retaining wall.
- B. For retaining walls with crest slopes of 5H:1V or steeper, silt fence shall be installed along the wall crest immediately following construction. The silt fence shall be located 3 feet to 4 feet behind the uppermost precast modular block unit. The crest slope above the wall shall be immediately seeded to establish vegetation. The Contractor shall ensure that the seeded slope receives adequate irrigation and erosion protection to support germination and growth.
- C. The Contractor shall confirm that the as-built precast modular block wall geometries conform to the requirements of this section. The Contractor shall notify the Contracting Officer of any deviations.

END OF SECTION