SECTION 548
RETAINING WALL SYSTEMS

548-1 Description.

Construct permanent and temporary retaining wall systems in accordance with this Section and in conformance with the lines, grades, design, and dimensions shown in the Contract or established by the Engineer. ~~Unless otherwise noted in the Plans, provide a wall system listed on the Department's Approved Product List (APL) based on the Department's Wall Type shown in the Plans.~~ Sheet pile walls and cast-in-place walls are not included in this Section. ~~All other wall systems used to cut back existing slopes are paid for under the same pay item numbers shown in 548-12.~~ Construct all walls of a specific type (mechanically stabilized earth (MSE), counterfort, etc.), using the same wall system and supplier. If different types of wall systems must be used in such a manner that causes one wall to interact with or influence another wall, coordinate the detailing of these areas of interaction/influence with the assistance of the Contractor's Engineer of Record.

Obtain each reinforced concrete precast concrete retaining wall system from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Ensure that each wall system component is ~~permanently and legibly~~ marked in accordance with 548-5.3.

Ensure that each shipment of products to the job site includes a signed or stamped delivery ticket in accordance with the Materials Manual, Section 8.2 Volume II, and the required written certification statement for each product shipped. Submit these tickets and certifications to the Engineer.

When shown in the Plans or approved by the Engineer, a segmental block MSE retaining wall (SBW) system may be provided as a substitute for a reinforced concrete panel MSE wall system. All SBW systems must comprise:

1. Unreinforced dry-cast masonry facing blocks in a running bond pattern meeting the requirements of 548-5.
2. Structural backfill reinforcement:
    a. Type R-3 geosynthetic backfill reinforcement placed in sheets full length without splices normal to the facing blocks and laterally without horizontal gaps, and with a vertical spacing of not more than every other course of blocks or 30 inches, whichever is less.
    ~~b. Type R-3 geosynthetic backfill reinforcement placed in strips full length without splices normal to the facing blocks with a vertical and lateral spacing of not more than every other block or 30 inches, whichever is less.~~
    ~~c~~b. Metallic reinforcement placed full length without splices normal to the facing blocks and spaced laterally and vertically not more than every other block or 30 inches, whichever is less, with a positive mechanical or shear connection to the facing blocks.
3. A mechanical shear connection to lock adjacent blocks together horizontally or vertically.

548-2 Materials.

Provide a wall system listed on the Department's Approved Product List (APL) based on the wall type shown in the Plans. Purchase ~~the precast~~ components, soil reinforcement,

attachment devices, joint filler, filter fabric, and all necessary incidentals for each wall from the same wall supplier ~~chosen~~.

548-2.1 Concrete: Ensure that concrete utilized for all wall components ~~is as specified in the Contract and~~ is consistent with the concrete class, environmental classification and admixture requirements for durability as stated in the Contract Documents. Produce and supply concrete for all reinforced concrete wall components meeting the requirements of Section 346.

Produce and supply concrete for the leveling pad meeting the requirements of Section 347. Use Department approved mix designs.

548-2.2 Reinforcing Steel: Meet the requirements of Section 931 utilizing Grade 60 (Black) steel.

548-2.3 Backfill Reinforcement: For walls utilizing backfill reinforcement, use reinforcement consisting of steel wire mesh, metal strips or structural geosynthetics as required for the wall system chosen. Use backfill reinforcement of the same length from top to bottom of wall at any section. For tiered walls, use backfill reinforcement of the same length within the height of each tier at any section.

Use plain steel wire mesh and embedded loops shop fabricated from cold drawn steel wire and weld into the finished mesh fabric meeting the requirements of ASTM A1064. Use longitudinal and transverse wires of equal and constant diameter within a given piece of mesh reinforcement. Use steel strips hot rolled from bars to the required shape and dimensions with physical and mechanical properties meeting ASTM A572 Grade 65 or as shown in the Contract. Use shop-fabricated hot rolled steel tie straps meeting the minimum requirements of ASTM A1011/A1011 M, Grade 50, or as shown in the Contract.

Ensure that steel reinforcing strips, tie strips, reinforcing mesh and connectors used in permanent walls are galvanized in accordance with ASTM A123 or ASTM A153, as applicable. For typical applications, punch or drill holes in metal items before galvanizing. Field drilled holes for bin walls are permitted. Repair field drilled holes; field cut ends and other damage to galvanized surfaces in accordance with Section 562.

Use Type R-3 structural geosynthetics made of polypropylene, select high density polyethylene or high-tenacity polyester fibers having cross-sections sufficient to permit significant mechanical interlock with the backfill. Use geosynthetics having a high tensile modulus in relation to the backfill. Use geosynthetics having high resistance to deformation under sustained long term design load while in service and resistant to ultraviolet degradation, to damage under normal construction practices and to all forms of biological or chemical degradation normally encountered in the material being reinforced. Do not use uncoated polyester (PET) reinforcements or reinforcements weakened or damaged by high pH environments within any portion of the flowable fill, or within coarse aggregate backfill below the design high water elevation (DHW) shown in the Plans.

Store the geosynthetics in conditions above 20ºF and not greater than 140ºF. Prevent mud, wet cement, epoxy, and like materials from coming into contact with and affixing to the geosynthetic material. Rolled geosynthetic may be laid flat or stood on end for storage. Cover the geosynthetic and protect from sunlight prior to placement in the wall system.

Carefully inspect all reinforcement, steel and geosynthetics to ensure they are the proper size and free from defects that may impair their strength and durability.

548-2.4 Attachment Devices: Use backfill reinforcement attachment devices as required by the wall system chosen.

548-2.5 Joint Materials and Filter Fabrics:

548-2.5.1 Horizontal Joint Pads: Use elastomeric or polymeric pads in all horizontal joints between precast components as recommended by the wall manufacturer. Ensure that the pads are of sufficient size and hardness to limit vertical stresses on the pad and concrete surface and to prevent concrete to concrete contact at the joints.

548-2.5.2 Joint Covers for Non-SBW Walls: For walls supporting bridge abutments on spread footings, cover joints and other wall openings within a horizontal distance equal to the larger of:

1. the length of the reinforcement under the footing plus 25 feet, or
2. twice the maximum height of the footing above the leveling pad,

measured from the nearest edge of the footing, surrounding the reinforced backfill for the abutment with Type D-2 geotextile fabric meeting the requirements of Section 985.

Cover all joints and wall openings in portions of the wall backfilled with coarse aggregate with Type D-2 geotextile fabric meeting the requirements of Section 985. Cover all other joints and wall openings with Type D-2 or D-53 geotextile fabric with a maximum apparent opening size (AOS)= equal to US Sieve No. 70 meeting the requirements of Section 985. Apply an adhesive approved by the Engineer to the back of the precast component for attachment of the fabric material.

548-2.5.3 Alignment Pins: Ensure that pins used to align the precast components during construction are of the size, shape and material required for the wall system chosen.

548-2.5.4 Separation Geotextile: Provide a separation Type D-2, D-3, or D-35 separation geotextile meeting the requirements of Section 985 between the coarse aggregate and the select backfill/embankment at the bottom, top and sides of the coarse aggregate.

548-2.6 Backfill Material:

548-2.6.1 General: Provide compacted select backfill or coarse aggregate backfill within the retaining wall volume as shown in the Plans. For permanent walls, provide coarse aggregate backfill in lieu of compacted select backfill to an elevation at least one foot above the DHW shown in the Plans when the DHW is above the lowest adjacent ground surface. Provide flowable fill within the retaining wall volume in lieu of compacted select backfill or coarse aggregate backfill only when the option for flowable fill is shown in the Plans. The retaining wall volume is defined to extend from the top of the leveling pad or footing, or bottom of walls which do not have footing or leveling pads, to the finish grade line and from the face of the wall to a vertical plane passing through the end of the extreme wall component (straps, counterforts, etc.) plus one foot.

548-2.6.2 Compacted Select Backfill: Meet the requirements of Sections 105 and 120 except as noted within this Section. Have the backfill material tested for every soil type for pH, resistivity, sulfate and chloride content by a Department approved independent testing laboratory prior to placement. Submit a signed and sealed certification, signed and sealed by a Professional Engineer registered in the State of Florida, that the results have met the requirements of this Section.

The pH, as determined by FM 5-550, shall not be lower than 5.0 and not higher than 9.0. Sources of select backfill material having a pH between 4.5 and 5.0 for wall utilizing metallic reinforcement and between 3.0 and 5.00 for walls utilizing geosynthetic reinforcement with no metallic elements or pipes placed within the backfill, as determined by FM 5-550, may be used provided the interior face of the MSE wall panels have three inches of

concrete cover over the reinforcement and the concrete used in the panels contains the following ingredients and proportions:

1. The quantity of cement replaced with Type F fly ash is 10% to 20% by weight.
2. The quantity of cement replaced with slag is 50% to 60% by weight.
3. Portland cement is 30% by weight of total cementitious material.
4. The total weight of the Type F fly ash and slag does not exceed 70% of total cementitious material.

In lieu of the mix design described above, a mix design with a fast pozzolanic material meeting the requirements of 346-2.3(6) silica fume, metakaolin and ultrafine fly ash, can be substituted. Examples of mix designs meeting this requirement are:

1. 8% silica fume plus 20% fly ash
2. 10% metakaolin plus 20% fly ash.

Provide proper curing for these materials to prevent surface cracking.

Do not place metallic pipe in backfill materials having a pH less than 5.0.

In addition, for permanent walls utilizing metallic soil reinforcement, use backfill that meets the following electro-chemical test criteria for determining corrosiveness:

Criteria	Test Method
Resistivity: > 3000 ohm -·cm	FM 5-551
Soluble sulfate content: < 200 PPM	FM 5-553
Soluble chloride content < 100 PPM	FM 5-552

For constructing the retaining wall volume, do not use backfill material containing more than 2.0% by weight of organic material, as determined by FM 1-T267 and by averaging the test results for three randomly selected samples from each stratum or stockpile of a particular material. If an individual test value of the three samples exceeds 3%, the stratum or stockpile will not be suitable for constructing the retaining wall volume.

Ensure that the material is non-plastic as determined by AASHTO T90 and the liquid limit as determined by AASHTO T89 is less than 15.

For walls using soil reinforcement, use backfill that meets the following gradation limits determined in accordance with AASHTO T27 and FM 1-T011:

Sieve Size	Percent Passing
3-1/2 inches	100
3/4 inch	70-100
No. 4	30-100
No. 40	15-100
No. 100	0-65
No. 200	0-12

For walls not using soil reinforcement, use backfill that meets the following gradation limits determined in accordance with AASHTO T27 and FM 1-T 011:

Sieve Size	Percent Passing
3-1/2 inches	100
No. 200	0-12

548-2.6.3 Flowable Fill: Meet the requirements of Section 121 except as noted within this Section and the Plans.

548-2.6.4 Coarse Aggregate Backfill and Drainage Aggregate: Provide coarse aggregate comprised of natural stones meeting the requirements of Section 901 with a size distribution of any of the listed aggregate gradations from Size No 57 through Size No 89, inclusive, except as noted on the Plans. Have all coarse aggregate backfill materials tested for pH, resistivity, sulfate and chloride content by a Department approved independent testing laboratory prior to placement. Submit a ~~signed and sealed~~ certification, signed and sealed by a Professional Engineer registered in the State of Florida, that the results of these tests meet the requirements of 548-2.6.2.

For SBW systems, provide drainage aggregate comprised of coarse aggregate backfill and a drainage geotextile to separate the drainage aggregate from the reinforced backfill as specified for each approved wall system.

548-3 Approved Product List (APL).

All proprietary retaining wall systems shall be listed on the APL. Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6, independently certified test reports, and calculations and drawings in accordance with the latest edition of the AASHTO LRFD Bridge Design Specifications and the Department's Structures Design Guidelines (SDG) signed and sealed by a Professional Engineer registered in the State of Florida. Submit calculations and drawings showing details, notes, materials, dimensions, sizes, and other information as described below for a complete description of the retaining wall system.

1. Soil ~~R~~reinforcement durability and/or corrosion data;
2. Differential settlement the wall system can tolerate without exceeding normal stress range of the soil reinforcement and wall facing, or the construction tolerances in this Section;
3. The effects of water flow;
4. Applicable environmental classifications as outlined in the SDG;
5. S~~ubmit s~~igned and sealed design calculations. Design calculations may be either by hand or by a wall company program with hand calculations verifying the program output. It is only necessary to include sample hand calculations for a 20 foot height for each soil condition.
6. Corrosion and durability design procedures for soil reinforcement elements;
7. Provide 11 inch x17 inch drawings showing:
    a. Notes specific to the wall system;
    b. Panel sizes and reinforcing;
    c. Soil reinforcement connection to wall facings;
    d. Wall panel abutment interfacing;
    e. Slip joints;

f. Steps in leveling pad;

g. Soil reinforcing details around all vertical obstructions;

h. Filter fabric placement at panel joints and around all obstructions;

i. Details for skewing soil reinforcement (15 degrees maximum) without cutting;

j. Corner elements (required at all angle breaks greater than 5 degrees);

k. Bin wall details for acute corners (required at all acute corners where interior corner angle is less than 70 degrees);

l. Details showing how to accommodate long term (post construction) wall settlement in excess of four inches without attaching soil reinforcement to the abutment; and,

m. Details of how to ground the wall system.

8. Pull-out test data for the proposed wall/reinforcement connection, and size and type of soil reinforcement for wall system. Testing shall be done by an independent soil testing laboratory or testing agency certified by the Department. Ensure test data includes all sizes and types of soil reinforcement to be utilized on Department projects. Default AASHTO values may be used for conventional soil reinforcement. For soil reinforcement grids, include all various configurations and combinations of longitudinal and transverse wires.

9. Other information pertinent to the design and performance of the wall system as necessary.

10. A field construction manual describing construction requirements and sequencing for the wall system. Submit manual in 8-1/2 inch x 11 inch format in either pdf or MS Word format.

548-4 Shop Drawings.

~~Provide~~Submit shop drawings and calculations in accordance with Section 5. Provide calculations and drawings showing details, notes, materials, dimensions, sizes and other information necessary for the complete fabrication and erection of the retaining wall system. As a minimum, provide the following:

1. Elevation view showing the final ground line and elevations of the top and bottom of wall at the begin and end of wall, all breaks in vertical alignment and all whole stations and 25 foot station increments.

2. Sections showing the length, size and designation of soil reinforcement.

3. Plan view showing the horizontal alignment and offsets from the horizontal control line to the exterior face of the wall; the location of utilities, drainage structures and other items that impact the wall; the limits of the reinforced soil volume; and, the location of piles within the reinforced earth volume.

4. Details for construction around utilities, drainage structures and other items that impact the wall; for placement of soil reinforcement at acute corners; for addressing conflicts between soil reinforcement and obstructions in the reinforced soil volume; for addressing different wall types intersecting and impacting each other.

5. General notes and design parameters including design soil characteristics; factored bearing resistance and factored bearing pressure for each wall height increment and other notes required for construction of the walls.

6. Design calculations for each wall height increment detailed in the shop drawings.

7. When the friction angle depicted in the shop drawings exceeds 30 degrees for sand backfill or 34 degrees for limerock backfill, provide laboratory test results in accordance with 548-9.5 verifying the backfill to be used for the wall meets the design soil characteristics for the shop drawings.

8. For SBW systems, include details for the placement of drainage aggregate, drainage pipes and separation geotextile. Drawings should be similar to details for Type II or Type III underdrains in Design Standards, Index No. 286. Do not directly cover perforated drainage pipes with a geotextile filter fabric (such as a filter sock).

9. When SBW systems use friction or semi-friction connections between geosynthetic reinforcement and the facing blocks, include the results of connection capacity testing. Tests must be performed using the materials to be used on the project and tested in accordance with ASTM D6638 to justify the short-term ultimate connection strength reduction factor (CR_u) used to determine the long-term connection strength reduction factor (CR_{cr}) value in the design calculations for each wall height increment detailed in the shop drawings.

548-5 Concrete Component Construction.

Construct reinforced concrete components in accordance with Section 400. Precast wall components are produced using certification acceptance; therefore, assume responsibility for performance of all quality control testing and inspections required by Sections 346 and 400 for the precast component construction. Perform all quality control (QC) inspection and testing using Construction Training and Qualification Program (CTQP) qualified personnel. Perform compressive strength testing in a laboratory meeting and maintaining at all times the qualification requirements listed in Section 105. The minimum time for form removal is 12 hours. Unless otherwise indicated in the Contract, apply a Class 3 finish to the concrete surface for the front face, and roughly screed the rear face to eliminate open pockets of aggregate and surface distortions in excess of 1/4 inch.

Construct unreinforced concrete SBW components (facing blocks) with a minimum compressive strength of 4,000 psi at 28 days and a maximum absorption of 6.5% in accordance with ASTM C140. Units must have a normal weight density classification meeting the requirements of ASTM C1372, except as modified in this Section.

548-5.1 Curing: Cure reinforced concrete components in accordance with Section 400.

548-5.2 Tolerances: Meet the following manufactured tolerances:

548-5.2.1 Reinforced Concrete Components:

1. Precast component dimensions: lateral position of soil reinforcement attachment devices - within 1 inch. ~~a~~All other dimensions - within 3/16 inch.

2. Precast component squareness: angular distortion of the component ~~shall~~must not exceed 0.2 inches in 5 feet.

3. Precast component surface finish: surface defects on smooth formed surfaces measured on a length of 5 feet ~~shall~~must not exceed more than 0.1 inches. Surface defects on textured finished surfaces measured on a length of 5 feet ~~shall~~must not exceed 5/16 inch.

548-5.2.2 Unreinforced Concrete SBW Components:

1. Length, width and height of each individual block must be within 1/16 inch of the specified dimension. Hollow units must have a minimum wall thickness of 1-1/4 inches.

2. All units must be free of defects that would interfere with proper placing of the unit or impair the integrity of the wall construction. Minor cracks with a width less than 1/32 inch and a length less than 25% of the unit height may be acceptable.

3. Exposed facing blocks must be split face texture with a uniform wheat or tan color, unless shown otherwise in the Plans.

548-5.3 Marking of Precast Components:

548-5.3.1 Reinforced Concrete Components: Permanently and legibly mark the following information on the back of each reinforced precast wall panel by etching: the panel number or type, piece mark, project number (if applicable), date cast and precast manufacturer's name or symbol with the approved producer's QC stamp affixed.

548-5.3.2 Unreinforced Concrete SBW Components: Label each pallet of dry-cast unreinforced concrete SBW facing blocks with the component identification number or type, project number (if applicable), lot number, date cast, and the manufacturer's name or symbol. Labels must be clearly legible until the component is installed.

548-6 Repairs or Rejection of Precast Components.

548-6.1 Reinforced Concrete Components: For precast concrete wall components that have not been installed, evaluate cracks, spalls and other deficiencies in accordance with 450-12. Repair deficiencies in accordance with 450-13 or the plant's approved repair methods that are included as part of the Producer Quality Control Plan. ~~Ensure that t~~The original performance and durability of repaired wall components ~~are~~must be maintained. Use materials for concrete repair that ~~will~~ meet or exceed the strength requirement for the class of concrete used. Materials meeting the requirements of Section 930 may be substituted for non shrink grout when required by 450-13.

For precast concrete wall components that have been installed, the disposition of concrete cracks ~~sha~~will be determined in accordance with 400-21.

The Department will reject all precast concrete wall components not meeting the quality standard of this Section and referenced Specifications. In addition, any of the following defects will be sufficient cause for rejection by the Department:

1. Defects that indicate unsatisfactory molding.
2. Defects indicating honeycombed or open texture concrete.
3. Defects in the physical characteristics such as:
    a. Signs of aggregate segregation~~;~~
    b. Broken or cracked corners~~;~~
    c. Soil reinforcement attachment devices improperly installed/damaged~~;~~
    d. Lifting inserts not useable~~;~~
    e. Exposed reinforcing steel~~;~~
    f. Insufficient cover over reinforcing steel~~;~~
    g. Cracks at the alignment pipe or pin~~;~~
    ~~f~~h. Insufficient concrete compressive strength~~;~~
    ~~g~~i. Precast component thickness in excess of plus or minus 3/16 inch from that shown in the Contract~~;, o~~r
    ~~h~~j. Stained front face, due to excess form oil or other reasons.

If the face of the precast component is stained or discolored to the point of rejection, the stain or discoloration may be removed, or a Department approved stain or a Class 5 finish may be applied to attain a uniform appearance for the entire structure, to the satisfaction of the Engineer.

548-6.2 Unreinforced Concrete SBW Components: The Department will reject all segmental retaining wall blocks not meeting the requirements of this Section and the Contract Documents. In addition, any of the following defects will be sufficient cause for rejection of SBW facing blocks by the Department:

1. Defects that indicate unsatisfactory molding.
2. Defects indicating honeycombed or open texture concrete.
3. Defects in the physical characteristics such as:
   a. Signs of aggregate segregation
   b. Broken or cracked corners
   c. Insufficient concrete compressive strength
   d, Excessive concrete absorption
   e. Exceeding dimensional tolerances, or
   f. Discoloration.

Correct cracks or spalls occurring after installation in accordance with 400-21.

548-7 Handling Storage and Shipping.

Handle, store and ship all components in a manner that prevents chipping, cracks, fractures, excessive bending stresses, mud, dirt and debris. Support precast panel wall and counterfort components in storage on firm blocking located immediately adjacent to the attachment device.

Do not ship precast concrete wall components to the project site prior to the completion of the 72 hour curing period and attainment of the required 28 day strength.

The Contractor is permitted to verify the shipping strength test, before 28 days, by testing compressive strength cylinders that are cured under the conditions similar to the product or by testing temperature match cured cylinders. The shipping strength test is the average compressive strength of two test cylinders. Do not ship reinforced concrete products until accepted and stamped by the QC Manager or the inspectors under the direct observation of the QC Manager.

548-8 Construction Requirements.

548-8.1 General: Due to the unique nature of the structure and concept, procure from the wall supplier fully detailed shop drawings, technical instructions, guidance in preconstruction activities and on-site technical assistance during construction. Closely follow any instructions from the wall supplier, unless otherwise directed by the Engineer. Submit any instructions from the wall supplier to the Engineer. Verify all pertinent retaining wall information (soil parameters, wall alignment, utility locations, conflicting structures) prior to the wall supplier finalizing shop drawings. Bring any conflicts not shown in the Contract to the Engineer's attention.

548-8.2 Wall Excavation: Excavate to the limits shown in the Contract and in conformance with Section 125.

548-8.3 Foundation Preparation: Grade the foundation for the structure level for a width equal to or exceeding the limits of the retaining wall volume or as shown in the Contract. Prepare the foundation in conformance with Section 125.

In addition to the compaction requirements of Section 125, compact the graded area with an appropriate vibratory roller weighing a minimum of ~~8~~ eight tons for at least five

passes or as directed by the Department's District Geotechnical Engineer. Remove and replace any soft or loose foundation subsoils incapable of sustaining the required compaction to the Engineer's satisfaction.

For permanent MSE wall systems, provide an unreinforced concrete leveling pad as shown in the Contract Documents. Cure the leveling pad a minimum of 12 hours before placement of precast wall components.

For SBW MSE wall systems, a geogrid reinforced, geotextile wrapped, compacted aggregate leveling pad may be used in lieu of the unreinforced concrete leveling pad. The compacted aggregate leveling pad must be at least 24 inches wide and at least 8 inches thick after compacting, and the geogrid must be at least 6 inches below the top of the leveling pad. Wrap the aggregate leveling pad with a D-2, D-3, or D-5 separation geotextile. The geotextile may run up the front and back of the first block course or between the aggregate leveling pad and the first block course.

548-8.4 Wall Erection: Assemble, connect and support wall components as recommended by the wall supplier. As backfill material is placed behind the wall face of MSE wall systems utilizing reinforced concrete panels, maintain the wall in the vertical position or slightly battered into the backfill to provide a final vertical alignment (by means of bracing, temporary wooden wedges placed in the joint at the junction of the two adjacent precast components on the external side of the wall or other alignment aids). Remove wooden wedges as soon as the precast component above the wedged precast component is completely erected and backfilled. External bracing is required for the initial lift of MSE systems.

For SBW systems, carefully place the first course of concrete block units on the leveling pad. Up to 1/2 inch of sand may be placed between the concrete leveling pad and the buried first course of blocks to provide a level and stable base. A one inch gap between the first course of facing units is allowed, provided a suitable filter fabric is placed behind the foundation units as specified for each approved wall system. Each unit must be in full contact with the base and checked for level and horizontal alignment. Voids must be kept to a minimum to prevent point loading and cracking, unless otherwise indicated in the shop drawings. Place units side by side for the full length of wall alignment. Fill the hollow cores or cells and the space within blocks with drainage aggregate. Sweep away excess material from top of units and install the next course.

Place soil reinforcement normal to the face of the wall, unless otherwise shown in the Contract or as directed by the Engineer. Do not cut or kink soil reinforcement. Do not connect soil reinforcement to piles or allow soil reinforcement to bear against piles. Field cut soil reinforcement only at locations as shown in the approved shop drawings. Prior to placement of the reinforcement, compact the backfill in accordance with 548-8.5.

For SBW systems, shims made of non-degradable materials may be used as specified for each approved wall system. The shim thickness per course of block must not exceed 1/8 inch and must not be installed on reinforcement elevations when the reinforcement connection relies on any friction.

548-8.4.1 Tolerances for Permanent Walls: Walls that do not meet the following tolerances will not be accepted by the Department and must be removed and reconstructed at no cost to the Department.

548-8.4.1.1 Reinforced Concrete MSE Wall Systems: ~~Ensure that~~ ~~v~~Vertical tolerances (plumbness) and horizontal alignment tolerances ~~do~~must not exceed 3/4 inch

when measured with a 10 foot straightedge. The maximum allowable offset in the joint between precast components is 3/4 inch. The final overall vertical tolerance of the completed wall (plumbness from top to bottom) ~~shall~~must not exceed 1/2 inch per 10 feet of wall height. Horizontal and vertical joints between precast components ~~shall~~must not be less than 1/2 inch or more than 1-1/4 inches. ~~Walls which do not meet these tolerances will not be accepted by the Department and must be removed and reconstructed at no cost to the Department.~~

548-8.4.1.2 SBW Systems: Horizontal alignment tolerances must not exceed 3/4 inch per10 feet of wall length. The maximum allowable gap between segmental retaining wall blocks above the first course must not exceed 1/16 inch. The final overall vertical tolerance of the completed wall (deviation from plumbness from top to bottom or batter shown in the Plans) must not exceed 1/2 inch per 10 feet of wall height.

548-8.4.2 Tolerances for Temporary Walls: ~~Ensure that v~~Vertical tolerances (plumbness) and horizontal alignment tolerances ~~do~~must not exceed three inches when measured with a 10 foot straightedge. The final overall vertical tolerance of the completed wall (plumbness from top to bottom) ~~shall~~must not exceed one inch per three feet of wall height, not to exceed a total of six inches. ~~Walls which do not meet these tolerances will not be accepted by the Department and must be removed and reconstructed at no cost to the Department.~~

548-8.5 Backfill Placement:

548-8.5.1 Compacted Select and Coarse Aggregate Backfill: A LOT is defined as a single lift of finished embankment not to exceed 500 feet in length or cumulative length of continuous, interconnected walls. Backfill within three feet from the panels and backfill beyond three feet from the panels are separate LOTs. Overlapping retaining wall volumes may be considered one LOT, excluding the three feet width behind the panels. Strips up to eight feet wide between two retaining wall volumes constructed with the same material in one operation may be considered as one LOT with the retaining wall volumes. Isolated compaction operations will be considered as separate LOTs. For multiple phase construction, a LOT will not extend beyond the limits of the phase. When bridge abutments on spread footings are shown in the Plans, the material within three feet behind the wall face and within the limits defined in 548-9.4.2 are considered as separate LOTs.

Remove wrinkles in geotextile reinforcement prior to covering with backfill. Place the backfill closely following the erection of each course of precast components or soil reinforcement layers and spread by moving the machinery parallel to the wall face. Do not allow equipment heavier than eight tons closer than three feet behind the wall face. Place backfill in a manner to avoid any damage or disturbance to the wall materials or misalignment of the facing materials. Remove and replace any wall materials which become damaged or disturbed during backfill placement at no cost to the Department, or correct as directed by the Engineer. Remove and reconstruct any misalignment or distortion of the wall facing due to placement of backfill outside the limits of this specification at no cost to the Department.

~~Perform all~~Compact coarse aggregate ~~compaction operations using~~backfill with a minimum of three passes of a vibratory compactor ~~(roller or plate compactor) with an operating~~ weigh~~t~~ing ~~of at least~~between 600 and 1000 pounds ~~and which produces a centrifugal force of not less than 7,500~~or two passes of vibratory compactor weighing over 1000 pounds. Use the highest vibration level that does not cause excessive fracture of the aggregate in the opinion of the Engineer. Continue compaction until there is no additional movement. Sheepsfoot, grid rollers or other types of equipment employing a foot are not allowed for any backfill type.

Achieve compaction of all backfill types within three feet of the back of the wall face using a power operated roller or plate weighing less than 1,000 pounds. At a distance greater than three feet from the back of the wall, a vibratory roller may be used, provided that the frequency and amplitude combined with bulk weight of the roller has performed satisfactorily at a trial section of the same type of wall. For select backfill, a smooth wheel or rubber tire roller is considered adequate. Ensure that the maximum lift thickness after compaction does not exceed six inches. Decrease the lift thickness if necessary, to obtain specified density.

~~Ensure a~~All transitions from coarse aggregate backfill to select backfill must occur at least six inches above and below any layers of backfill reinforcement. Place a separation geotextile in accordance with 548-2.5.4 between the coarse aggregate backfill and select backfill and embankment.

Perform backfill compaction in a way that the compactor moves in a direction parallel to the wall face and proceeds from a distance not less than three feet behind the wall face toward the end of the soil reinforcement element.

When placing select backfill, ~~ensure that~~ the moisture content of the backfill material prior to and during compaction ~~is~~must be uniformly distributed throughout each layer of material. Use backfill material having a placement moisture content at the dry side of the optimum moisture content. To achieve the required compaction moisture content, use water that meets the requirements of Section 923. Do not transport excessively moist backfill materials to the site for any reason. Determine the optimum moisture content in accordance with the test method used to determine maximum density in 548-9.

At the end of each day's operation, shape the last level of backfill to permit runoff of rainwater away from the wall face or provide a positive means of controlling run off away from the wall such as temporary pipe~~, etc~~.

548-8.5.2 Flowable Fill: Metallic wall components (including metallic soil reinforcements) must not be in partial contact with the flowable fill. If the metallic components contact the flowable fill, the metallic components must be completely encapsulated by the flowable fill.

548-8.6 Compressible Free Draining Seal: Seal all joints between panels of reinforced concrete panel MSE walls with compressible free draining material to prevent plant growth from seeds or spores that may be in the joints or transported to the joints by wind or rain. The installation must be secure and free draining to keep the seal in place until uninstalled and to prevent hydrostatic forces from building up behind the panel.

548-9 Acceptance Program.

548-9.1 General Requirements: Meet the requirements of 120-10 except delete the requirements of 120-10.1.4.1, 120-10.1.4.3, 120-10.1.6, 120-10.2 and 120-10.3.

548-9.2 Maximum Density Determination: For select backfill, determine the maximum QC density in accordance with FM 1-T180, Method D. When compacting A-3 or A-2-4 materials to meet the alternate acceptance criteria in 548-9.4.1, determine the maximum density in accordance with AASHTO T99, Method C.

Perform gradation tests on the sample collected in accordance with AASHTO T27 and FM 1-T011. Classify soils in accordance with AASHTO M145 in order to determine compliance with embankment utilization requirements.

548-9.3 Density Testing Requirements: Ensure compliance with the requirements of nuclear density testing in accordance with FM 1-T238. Determine the in-place moisture content for each density test. Use FM 1-T238, FM 5-507 (Determination of Moisture Content by Means of a Calcium Carbide Gas Pressure Moisture Tester), or FM 5-535 (Laboratory Determination of Moisture Content of Granular Soils by Use of a Microwave Oven) for moisture determination.

Perform these tests at a minimum frequency of one set of tests per LOT.

Determine test locations including stations and offsets, using the random number generator provided by the Engineer. Do not use note pads or work sheets to record data for later transfer to the density log book. Notify the Engineer upon successful completion of QC testing on each LOT.

548-9.4 Acceptance Criteria: For select backfill, obtain a minimum density of 90% of the maximum dry density as determined by FM 1-T180 within three feet behind the wall face and obtain a minimum density of 95% of the maximum dry density as determined by FM 1-T180 from beyond three feet behind the wall face.

For flowable fill, meet the requirements of 121-6. For coarse aggregate backfill, compact with a minimum of three passes of a vibratory compactor weighing between 600 and 1000 pounds or two passes of a vibratory compactor weighing over 1000 pounds. Use the highest vibration level that does not cause excessive fracture of the aggregate in the opinion of the Engineer. Continue compaction until there is no additional movement.

548-9.4.1 Optional Acceptance Criteria for A-3 and A-2-4 Materials: Obtain a minimum density of 95% of the maximum dry density as determined by AASHTO T99 within three feet behind the wall face and obtain a minimum density of 100% of the maximum dry density as determined by AASHTO T99 beyond three feet behind the wall face.

The combined width from both MSE wall backfill (excluding the three f~~ee~~oot zone from the panels) and embankment material may be considered the same LOT if the same material is used; the material in both wall backfill and embankment is compacted with the same procedure, equipment and compacting effort; and the maximum lift thickness after compaction in both wall backfill and embankment is six inches.

548-9.4.2 Acceptance Criteria for Wall Backfill Supporting Spread Footings: When spread footings at bridge abutments are shown in the Plans, obtain a minimum of 95% of the maximum dry density as determined by FM 1-T180 on the material within three feet behind the wall face, and underneath the footing as defined by the following limits:

1. All lifts below the bottom of the footing for a depth equal to at least the footing width

2. A minimum distance of three feet beyond the edges of the footing width

If the optional criteria specified in 548-9.4.1 is used, compact the backfill material within the limits specified above to obtain a minimum density of 100% of the maximum dry density as determined by AASHTO T99. Compact the remainder of the backfill in accordance with 548-9.4 or 548-9.4.1 as applicable. Do not use compaction equipment larger than permitted in 548-6.5 within three feet behind the wall face; decrease the lift thickness if necessary.

548-9.5 Friction Angle: When the friction angle depicted in the shop drawings exceeds 30 degrees for sand backfill or 34 degrees for limerock backfill, ensure the friction angle of the backfill material tested in accordance with FM 3-D3080 equals or exceeds the backfill friction angle depicted in the shop drawings.

548-9.6 Frequency: Conduct sampling and testing at a minimum frequency listed in the table below. The Engineer will perform verification sampling and tests at a minimum frequency listed in the table below.

Test Name	Quality Control (QC)	Verification
Maximum Density	One per soil type	One per soil type
Density	One per LOT	One per four LOTs for each type of QC test
Gradation	One per Maximum Density	One per Maximum Density
LL&PI	One per Maximum Density	One per Maximum Density
Soil Classification	One per Maximum Density	One per Maximum Density
Organic Content	One per soil type	One per soil type
pH	One per soil type	One per soil type
Direct Shear	Three per soil type when required by 548-9.5	One per soil type
*Verification testing for pH will be performed on samples taken at the point of placement.		

In addition, for permanent walls utilizing metallic soil reinforcement, test for corrosiveness at a minimum frequency of one test per soil type at point of placement according to the electro-chemical table in 548-2.6. The Engineer will collect enough material to split and create two separate samples and retain one for resolution at point of placement until LOTs represented by the samples are accepted. The Engineer will perform verification tests for corrosiveness at a minimum frequency of one test per soil type.

548-9.7 Verification Comparison Criteria and Resolution Procedures:

548-9.7.1 Maximum Density Determination: The Engineer will collect enough material to split and create two separate samples and retain one for resolution until LOTs represented by the samples are accepted.

The Engineer will meet the requirements of 120-10.4.1 except replace AASHTO T99, Method C with FM 1-T180, Method D. If the Contractor selects the Optional Acceptance Criteria, the Engineer will verify the QC results of AASHTO T99, Method C in accordance with 120-10.4.1.

548-9.7.2 Density Testing: Meet the requirements of 120-10.4.2.

548-9.7.3 Soil Classification: The Engineer will meet the requirements of 120-10.4.3 except test the sample retained in 548-9.7.1 instead of taking the additional one.

548-9.7.4 Gradation: The Engineer will verify the QC results if the verification result meets the gradation limits set forth in the gradation table of 548-2.6. Otherwise, the Engineer will test the sample retained in 548-9.7.1. The State Materials Office (SMO) or an AASHTO accredited laboratory designated by the SMO will perform resolution testing. The material will be sampled and tested in accordance with AASHTO T27 and FM 1-T011.

If the resolution test result satisfies the required gradation limits, the LOTS will be verified. If the resolution test results do not meet the required gradation limits, reconstruct the LOTS with acceptable material. The Engineer will perform new verification testing.

548-9.7.5 Liquid Limit and Plasticity Index (LL&PI): The Engineer will verify the QC results if the verification result satisfies the plasticity index and liquid limit criteria set

forth in 548-2.6. Otherwise, the Engineer will test the sample retained in 548-9.7.1. The SMO or an AASHTO accredited laboratory designated by the SMO will perform resolution testing. The material will be sampled and tested in accordance with AASHTO T90 and AASHTO T89, respectively.

If the resolution test result satisfies the required criteria, LOTS of that soil type will be verified. If the resolution test results do not meet the required criteria, reconstruct the corresponding LOTS with acceptable material. The Engineer will perform new verification testing.

548-9.7.6 Corrosiveness: The Engineer will verify the QC results if the verification result satisfies the electro-chemical and pH test criteria set forth in 548-2.6. Otherwise, the Engineer will test the sample retained in 548-9.7.1. The SMO or an AASHTO accredited laboratory designated by the SMO will perform resolution testing. The material will be sampled and tested in accordance with FM 5-550, FM 5-551, FM 5-552 and FM 5-553.

If the resolution test result satisfies the required criteria, material of that soil type will be verified and accepted. If the resolution test results do not meet the required criteria, reject the material and reconstruct with acceptable material.

548-9.7.7 Organic Content: The Engineer will verify the QC results if the verification result satisfies the organic content test criteria set forth in 548-2.6. Otherwise, the Engineer will collect three additional samples. The material will be sampled and tested in accordance with FM 1-T267 and by averaging the test results for three randomly selected samples from at least one lift per soil type. The SMO or an AASHTO accredited laboratory designated by the SMO will perform resolution testing.

If the resolution test result satisfies the required criteria, material of that soil type will be verified and accepted. If the resolution test results do not meet the required criteria, reject the material and reconstruct with acceptable material.

548-9.7.8 Friction Angle: When the friction angle depicted in the shop drawings exceeds 30 degrees for sand backfill or 34 degrees for limerock backfill, the Engineer will take a verification sample at the point of placement to perform a direct shear verification test in accordance with FM 3-D3080. The SMO or a consultant qualified to perform geotechnical specialty lab testing (Type of Work 9.5), per Rule 14-75 of the Florida Administrative Code will perform the verification testing. If the test verifies the material has a friction angle greater than or equal to the friction angle depicted in the shop drawings, the material in the LOTs will be verified. If the verification test does not meet the required friction angle, reconstruct the LOTs with acceptable material.

The Contractor may request to redesign the wall and resubmit the shop drawings with the lower friction angle indicated by the verification test. Employ a Professional Engineer to redesign and submit signed and sealed drawings and computations. Do not begin any reconstruction until the proposed redesign has been reviewed and approved by the Engineer. The Contractor shall bear the costs of the redesign and any work resulting from the design changes.

548-10 Certification.

Submit all test reports to the Engineer ~~which are~~ necessary to document compliance with the Specifications, at least ten days prior to wall construction.

Also submit ~~to the Engineer~~ a certificate of compliance certifying that the retaining wall materials, backfill and construction practices comply with this Section.

For SBW systems, the Engineer will randomly select samples of each type of block used in the segmental block retaining wall system and review a copy of the certified test report corresponding the sample at a frequency of one sample per type of block for each wall.

Acceptance of furnished material will be based on the certificate of compliance, accompanying test reports, and visual inspection by the Engineer.

548-11 Method of Measurement.

The quantity to be paid for will be the plan quantity, in square feet, completed and accepted, of the area bounded by the following:

For permanent retaining wall systems: the top of the coping, the top of the leveling pad or top of structural footings and the begin and end wall limits as shown on the wall control drawings.

For temporary retaining wall systems: the top of wall, the ground line and the begin and end wall limits as shown on the wall control drawings.

548-12 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including the design of the wall system, excavation required specifically for wall construction below the normal roadway template, backfill reinforcement, leveling pad, footings, copings, light pole pedestals, fabric material, horizontal joint materials, alignment pins, repairs, labor, equipment, and other materials necessary to complete the wall in an acceptable manner as shown in the Contract. The cost of backfill for the normal roadway template will be included in the cost of embankment or borrow excavation, as applicable.

Payment will be made under:

Item No. 548-12-	Retaining Wall System (Permanent) - per square foot.
Item No. 548-13-	Retaining Wall System (Temporary) - per square foot.