

## 6-13 STRUCTURAL EARTH WALLS

### 6-13.1 Description

This Work consists of constructing structural earth walls (SEW).

### 6-13.2 Materials

Materials shall meet the requirements of the following sections:

Cement	9-01
Aggregates for Portland Cement Concrete	9-03.1
Premolded Joint Filler	9-04.1(2)
Steel Reinforcing Bar	9-07.2
Epoxy-Coated Steel Reinforcing Bar	9-07.3
Concrete Curing Materials and Admixtures	9-23
Fly Ash	9-23.9
Water	9-25

Other materials required shall be as specified in the Special Provisions.

### 6-13.3 Construction Requirements

Proprietary structural earth wall systems shall be as specified in the Special Provisions.

#### 6-13.3(1) Quality Assurance

The structural earth wall manufacturer shall provide a qualified and experienced representative to resolve wall construction problems as approved by the Engineer. The structural earth wall manufacturer's representative shall be present at the beginning of wall construction activities, and at other times as needed throughout construction. Recommendations made by the structural earth wall manufacturer's representative and approved by the Engineer shall be followed by the Contractor.

The completed wall shall meet the following tolerances:

1. Deviation from the design batter and horizontal alignment, when measured along a 10-foot straight edge, shall not exceed the following:
  - a. Welded wire faced structural earth wall: 2-inches
  - b. Precast concrete panel and concrete block faced structural earth wall:  $\frac{3}{4}$ -inch
2. Deviation from the overall design batter of the wall shall not exceed the following per 10-feet of wall height:
  - a. Welded wire faced structural earth wall:  $1\frac{1}{2}$ -inches
  - b. Precast concrete panel and concrete block faced structural earth wall:  $\frac{1}{2}$ -inch
3. The maximum outward bulge of the face between welded wire faced structural earth wall reinforcement layers shall not exceed 2-inches. The maximum allowable offset in any precast concrete facing panel joint shall be  $\frac{3}{4}$ -inch. The maximum allowable offset in any concrete block joint shall be  $\frac{3}{4}$ -inch.
4. The base of the structural earth wall excavation shall be within 3-inches of the staked elevations, unless otherwise approved by the Engineer.
5. The external structural earth wall dimensions shall be placed within 2-inches of that staked on the ground.

6. The backfill reinforcement layers shall be located horizontally and vertically within 1-inch of the locations shown in the structural earth wall Working Drawings as approved by the Engineer.

At least 5-working days prior to the Contractor beginning any structural earth wall Work at the site, a structural earth wall preconstruction conference shall be held to discuss construction procedures, personnel, and equipment to be used, and other elements of structural earth wall construction. Those attending shall include:

1. (representing the Contractor) The superintendent, on site supervisors, and all foremen in charge of excavation, leveling pad placement, concrete block and soil reinforcement placement, and structural earth wall backfill placement and compaction.
2. (representing the Structural Earth Wall Manufacturer) The qualified and experienced representative of the structural earth wall manufacturer as specified at the beginning of this Section.
3. (representing the Contracting Agency) The Project Engineer, key inspection personnel, and representatives from the WSDOT Construction Office and Materials Laboratory Geotechnical Services Branch.

#### **6-13.3(2) Submittals**

The Contractor, or the supplier as the Contractor's agent, shall furnish to the Engineer a Manufacturer's Certificate of Compliance in accordance with Section 1-06.3, certifying that the structural earth wall materials conform to the specified material requirements. This includes providing a Manufacturer's Certificate of Compliance for all concrete admixtures, cement, fly ash, steel reinforcing bars, reinforcing strips, reinforcing mesh, tie strips, fasteners, welded wire mats, backing mats, construction geotextile for wall facing, drainage geosynthetic fabric, block connectors, and joint materials. The Manufacturer's Certificate of Compliance for geogrid reinforcement shall include the information specified in Section 9-33.4(4) for each geogrid roll, and shall specify the geogrid polymer types for each geogrid roll.

A copy of all test results, performed by the Contractor or the Contractor's supplier, which are necessary to assure compliance with the Specifications, shall be submitted to the Engineer along with each Manufacturer's Certificate of Compliance.

Before fabrication, the Contractor shall submit a field construction manual for the structural earth walls, prepared by the wall manufacturer, to the Engineer for approval in accordance with Section 6-01.9. This manual shall provide step-by-step directions for construction of the wall system.

The Contractor, or the supplier as the Contractor's agent, shall submit detailed design calculations and Working Drawings to the Engineer for approval in accordance with Section 6-01.9.

The design calculation and Working Drawing submittal shall include detailed design calculations and all details, dimensions, quantities, and cross-sections necessary to construct the wall. The calculations shall include a detailed explanation of any symbols, design input, material property values, and computer programs used in the design of the walls. All computer output submitted shall be accompanied by supporting hand calculations detailing the calculation process. If MSEW 3.0, or a later version, is used for the wall design, hand calculations supporting MSEW are not required.

The design calculations shall be based on the current AASHTO Standard Specifications for Highway Bridges including current interims, and also based on the following:

1. The factor of safety for overturning and sliding are 2.0 and 1.5 respectively for AASHTO Load Group I, and 1.5 and 1.1 respectively for AASHTO Load Group VII.
2. The wall surcharge conditions (backfill slope) shown in the Plans.
3. If a Highway is adjacent to and on top of the wall, a 2-foot surcharge shall be used in the design.
4. If the Plans detail a traffic barrier on top of the wall, the barrier and wall shall be capable of resisting a 10,000-pound horizontal load applied at the top of the barrier.
5. The geotechnical design parameters for the wall shall be as specified in the Special Provisions.
6. The minimum soil reinforcement length shall be the greater dimension of the following:
  - a. 0.7 times the wall design height H.
  - b. 6-feet 0-inches.
  - c. That required by design to meet internal stability design requirements, soil bearing pressure design requirements, and constructability requirements.

A minimum of 6 sets of Working Drawings shall be fully detailed and shall include, but not be limited to, the following items:

1. A plan and elevation sheet or sheets for each wall, containing the following:
  - a. An elevation view of the wall that includes the following:
    - i. the elevation at the top of the wall, at all horizontal and vertical break points, and at least every 50-feet along the wall;
    - ii. elevations at the base of welded wire mats or the top of leveling pads and foundations, and the distance along the face of the wall to all steps in the welded wire mats, foundations and leveling pads;
    - iii. the designation as to the type of panel, block, or module;
    - iv. the length, size, and number of geogrids or mesh or strips, and the distance along the face of the wall to where changes in length of the geogrids or mesh or strips occur; or
    - v. the length, size, and wire sizes and spacing of the welded wire mats and backing mats, and the distance along the face of the wall to where changes in length, size, and wire sizes and spacing of the welded wire mats and backing mats occur; and
    - vi. the location of the original and final ground line.
  - b. A plan view of the wall that indicates the offset from the construction centerline to the face of the wall at all changes in horizontal alignment; the limit of the widest module, geogrid, mesh, strip or welded wire mat, and the centerline of any drainage Structure or drainage pipe which is behind or passes under or through the wall.
  - c. General notes, if any, required for design and construction of the wall.

- d. All horizontal and vertical curve data affecting wall construction.
  - e. A listing of the summary of quantities provided on the elevation sheet of each wall for all items including incidental items.
  - f. Cross-section showing limits of construction. In fill sections, the cross-section shall show the limits and extent of select granular backfill material placed above original ground.
  - g. Limits and extent of reinforced soil volume.
2. All details including steel reinforcing bar bending details. Bar bending details shall be in accordance with Section 9-07.1.
  3. All details for foundations and leveling pads, including details for steps in the foundations or leveling pads, as well as allowable and actual maximum bearing pressures for AASHTO Load Groups I and VII.
  4. All modules and facing elements shall be detailed. The details shall show all dimensions necessary to construct the element, all steel reinforcing bars in the element, and the location of reinforcement element attachment devices embedded in the precast concrete facing panel or concrete block.
  5. All details for construction of the wall around drainage facilities, sign, signal, luminaire, and noise barrier wall foundations, and structural abutment and foundation elements shall be clearly shown.
  6. All details for connections to traffic or pedestrian barriers, coping, parapets, noise barrier walls, and attached lighting shall be shown.
  7. All details for the traffic or pedestrian barrier attached to the top of the wall (if shown in the Plans) including interaction with bridge approach slabs.

The Contractor shall not begin wall construction (including precast concrete facing panel or block fabrication) until receiving the Engineer's written approval of the material certifications and test results, design calculations and Working Drawing submittals.

### **6-13.3(3) Excavation and Foundation Preparation**

Excavation shall conform to Section 2-09.3(4) and to the limits and construction stages shown in the Plans. Foundation soils found to be unsuitable shall be removed and replaced in accordance with Section 2-09.3(1)C. The foundation for the Structure shall be graded level for a width equal to or exceeding the length of reinforcing as shown in the structural earth wall Working Drawings as approved by the Engineer and, for walls with geogrid reinforcing, in accordance with Section 2-12.3. Prior to wall construction, the foundation, if not in rock, shall be compacted as approved by the Engineer.

At the foundation level of the bottom course of precast concrete facing panels and concrete blocks, an unreinforced concrete leveling pad shall be provided as shown in the Plans. The leveling pad shall be cured a minimum of 12-hours and have a minimum compressive strength of 1500-psi before placement of the precast concrete facing panels or concrete blocks.

### **6-13.3(4) Precast Concrete Facing Panel and Concrete Block Fabrication**

Concrete for precast concrete facing panels shall meet the following requirements:

1. Have a minimum 28-day compressive strength of 4,000-pounds per square inch, unless otherwise specified in the Special Provisions for specific proprietary wall systems.
2. Contain a water-reducing admixture meeting AASHTO M 194 Type A, D, F, or G.

3. Be air-entrained, 6-percent  $\pm$  1½-percent.
4. Have a maximum slump of 4-inches, or 6-inches if a Type F or G water reducer is used.

Concrete for dry cast concrete blocks shall meet the following requirements:

1. Have a minimum 28-day compressive strength of 4,000-psi.
2. Conform to ASTM C 1372, except as otherwise specified.
3. The lot of blocks produced for use in this project shall conform to the following freeze-thaw test requirements when tested in accordance with ASTM C 1262. Minimum acceptable performance shall be defined as weight loss at the conclusion of 150 freeze-thaw cycles not exceeding 1-percent of the block's initial weight for a minimum of 4 of the 5 block specimens tested.
4. The concrete blocks shall have a maximum water absorption of 1-percent above the water absorption content of the lot of blocks produced and successfully tested for the freeze-thaw test specified in item 3 above.

Precast concrete facing panels and concrete blocks will be accepted based on successful compressive strength tests, WSDOT "Approved for Shipment" stamp or tag, and visual inspection at the jobsite. The precast concrete facing panels and concrete blocks shall be considered acceptable regardless of curing age when compressive test results indicate that the compressive strength conforms to the 28-day requirements and when the visual inspection is satisfactorily completed. Fabrication of precast concrete facing panels and blocks shall conform to Section 6-02.3(28). Testing of dry cast concrete blocks shall conform to ASTM C 140.

All precast concrete facing panels shall be 5-feet square, except:

1. for partial panels at the top, bottom, and ends of the wall, and
2. as otherwise shown in the Plans.

All precast concrete facing panels shall be manufactured within the following tolerances:

1. All dimensions  $\pm$   $\frac{3}{16}$ -inch.
2. Squareness, as determined by the difference between the 2 diagonals, shall not exceed ½-inch.
3. Surface defects on smooth formed surfaces measured on a length of 5-feet shall not exceed ⅛-inch. Surface defects on textured-finished surfaces measured on a length of 5-feet shall not exceed  $\frac{5}{16}$ -inch.

All concrete blocks shall be manufactured within the following tolerances:

1. Vertical dimensions shall be  $\pm$   $\frac{1}{16}$ -inch of the Plan dimension, and the rear height shall not exceed the front height.
2. The dimensions of the grooves in the top and bottom faces of the concrete blocks shall be formed within the tolerances specified by the proprietary wall manufacturer, for the fit required for the block connectors.
3. All other dimensions shall be  $\pm$  ¼-inch of the Plan dimension.

Tie attachment devices, except for geosynthetic reinforcement, shall be set in place to the dimensions and tolerances shown in the Plans prior to casting.

The forms forming precast concrete facing panels, including the forms for loop pockets and access pockets, and the forms forming the concrete blocks, shall be removed in accordance with the recommendations of the wall manufacturer, without damaging the concrete.

The concrete surface for the precast concrete facing panel shall have the finish shown in the Plans for the front face and an unformed finish for the rear face. The rear face of the precast concrete facing panel shall be roughly screeded to eliminate open pockets of aggregate and surface distortions in excess of 1/4-inch.

The concrete surface for the front face of the concrete block shall be flat, and shall be a conventional "split face" finish in accordance with the wall manufacturer's Specifications. The concrete surface of all other faces shall be Class 2 in accordance with Section 6-02.3(14)B. The finish and appearance of the concrete blocks shall also conform to ASTM C 1372. The color of the concrete block shall be concrete gray, unless otherwise shown in the Plans.

The date of manufacture, production lot number, and the piece-mark, shall be clearly marked on the rear face of each precast concrete facing panel, and marked or tagged on each pallet of concrete blocks.

All precast concrete facing panels and concrete blocks shall be handled, stored, and shipped in accordance with Sections 6-02.3(28)G and 6-02.3(28)H to prevent chipping, cracks, fractures, and excessive bending stresses.

Precast concrete facing panels in storage shall be supported on firm blocking located immediately adjacent to tie strips to avoid bending the tie strips.

#### **6-13.3(5) Precast Concrete Facing Panel and Concrete Block Erection**

The precast concrete facing panels shall be placed vertically. During erection, precast concrete facing panels shall be handled by means of a lifting device set into the upper edge of the panels.

Concrete blocks shall be erected in a running bond fashion in accordance with the wall manufacturer's field construction manual, and may be placed by hand. The top surface of each course of concrete blocks, including all pockets and recesses, shall be cleaned of backfill and all extraneous materials prior to connecting the reinforcing strips or geosynthetic reinforcing, and placing the next course of concrete blocks. Concrete blocks receiving geosynthetic reinforcement shall be connected as specified in the Special Provisions. Cap block top courses shall be bonded to the lower course of concrete blocks as specified below. All other concrete blocks shall be connected with block connectors or pins placed into the connector slots.

Precast concrete facing panels and concrete blocks shall be placed in successive horizontal lifts as backfill placement proceeds in the sequence shown in the structural earth wall Working Drawings as approved by the Engineer.

External bracing is required for the initial lift for precast concrete facing panels.

As backfill material is placed behind the precast concrete facing panels, the panels shall be maintained in vertical position by means of temporary wooden wedges placed in the joint at the junction of the 2 adjacent panels on the external side of the wall.

Reinforcing shall be placed normal to the face of the wall, unless otherwise shown in the Plans or directed by the Engineer. Prior to placement of the reinforcing, backfill shall be compacted.

Geosynthetic reinforcing shall be placed in accordance with Section 2-12.3 and as follows:

1. The Contractor shall stretch out the geosynthetic in the direction perpendicular to the wall face to remove all slack and wrinkles, and shall hold the geosynthetic in place with soil piles or other methods as recommended by the geosynthetic manufacturer, before placing backfill material over the geosynthetic to the specified cover.

2. The geosynthetic reinforcement shall be continuous in the direction perpendicular to the wall face from the back face of the concrete panel to the end of the geosynthetic or to the last geogrid node at the end of the specified reinforcement length. Geosynthetic splices parallel to the wall face will not be allowed.

At the completion of each course of concrete blocks and prior to installing any block connectors or geosynthetic reinforcement at this level, the Contractor shall check the blocks for level placement in all directions, and shall adjust the blocks by grinding or rear face shimming, or other method as recommended by the structural earth wall manufacturer's representative and as approved by the Engineer, to bring the blocks into a level plane.

For concrete block wall systems receiving a cap block top course, the cap blocks shall be bonded to the lower course with mortar, or with an adhesive capable of bonding the concrete block courses together.

#### **6-13.3(6) Welded Wire Faced Structural Earth Wall Erection**

The Contractor shall erect the welded wire wall reinforcement in accordance with the wall manufacturer's field construction manual and as approved by the Engineer. Construction geotextile for wall facing shall be placed between the backfill material within the reinforced zone and the coarse granular material immediately behind the welded wire wall facing, as shown in the Plans and the structural earth wall Working Drawings as approved by the Engineer. Geosynthetic reinforcing, when used, shall be placed in accordance with Sections 2-12.3 and 6-13.3(5).

#### **6-13.3(7) Backfill**

Backfill placement shall closely follow erection of each course of welded wire mats and backing mats, precast concrete facing panels, or concrete blocks. Backfill shall be placed in such a manner as to avoid any damage or disturbance to the wall materials or misalignment of the welded wire mats and backing mats, precast concrete facing panels, or concrete blocks. Backfill shall be placed in a manner that segregation does not occur.

The Contractor shall place wall backfill over geosynthetic reinforcement, or construction geotextile for wall facing, in accordance with Section 2-12.3 and as follows:

1. The Contractor shall ensure that 6-inches minimum of backfill shall be between the geogrid reinforcement, or construction geotextile for wall facing, and any construction vehicle or equipment tires or tracks at all times.

Misalignment or distortion of the precast concrete facing panels or concrete blocks due to placement of backfill outside the limits of this Specification shall be corrected in a manner as approved by the Engineer.

The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer of material. The moisture content of all backfill material shall conform to Sections 2-03.3(14)C and 2-03.3(14)D.

Backfill shall be compacted in accordance with Method C of Section 2-03.3(14)C, except as follows:

1. The maximum lift thickness after compaction shall not exceed 10-inches.
2. The Contractor shall decrease this lift thickness, if necessary, to obtain the specified density.

3. The Contractor shall not use sheepsfoot rollers or rollers with protrusions for compacting backfill reinforced with geosynthetic layers, or for compacting the first lift of backfill above the construction geosynthetic for wall facing for each layer of welded wire mats. Rollers shall have sufficient capacity to achieve compaction without causing distortion to the face of the wall in accordance with the tolerances specified in Section 6-13.3(1).
4. The Contractor shall compact the zone within 3-feet of the back of the wall facing panels without causing damage to or distortion of the wall facing elements (welded wire mats, backing mats, construction geotextile for wall facing, precast concrete facing panels, and concrete blocks) by using a plate compactor as approved by the Engineer. No soil density tests will be taken within this area.
5. For wall systems with geosynthetic reinforcement, the minimum compacted backfill lift thickness of the first lift above each geosynthetic reinforcement layer shall be 6-inches.

At the end of each day's operation, the Contractor shall shape the last level of backfill to permit runoff of rainwater away from the wall face. In addition, the Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

Wall materials damaged or disturbed during backfill placement shall be either removed and replaced, or adjusted and repaired, by the Contractor as approved by the Engineer at no additional expense to the Contracting Agency.

#### **6-13.3(8) Guardrail Placement**

Where guardrail posts are required, the Contractor shall not begin installing guardrail posts until completing the structural earth wall to the top of wall elevation shown in the Plans. The Contractor shall install the posts in a manner that prevents movement of the precast concrete facing panels or concrete blocks, and prevents ripping, tearing, or pulling of the wall reinforcement.

The Contractor may cut welded wire reinforcement of welded wire faced structural earth walls to facilitate placing the guardrail posts, but only in the top 2 welded wire reinforcement layers and only with the approval of the Engineer in a manner that prevents bulging of the wall face and prevents ripping or pulling of the welded wire reinforcement. Holes through the welded wire reinforcement shall be the minimum size necessary for the post. The Contractor shall demonstrate to the Engineer prior to beginning guardrail post installation that the installation method will not rip, tear, or pull the wall reinforcement.

The Contractor shall place guardrail posts between the reinforcing strips, reinforcing mesh, and tie strips of the non-geosynthetic reinforced precast concrete panel or concrete block faced structural earth walls. Holes through the reinforcement of geosynthetic reinforced walls, if necessary, shall be the minimum size necessary for the guardrail post.

#### **6-13.3(9) SEW Traffic Barrier and SEW Pedestrian Barrier**

The Contractor, in conjunction with the structural earth wall manufacturer, shall design and detail the SEW traffic barrier and SEW pedestrian barrier in accordance with Section 6-13.3(2) and the above ground geometry details shown in the Plans. The barrier Working Drawings and supporting calculations shall include, but not be limited to, the following:

1. Complete details of barrier cross section geometry, including the portion below ground, and accommodations necessary for bridge approach slabs, PCCP, drainage facilities, underground utilities, and sign support, luminaire pole, traffic signal standard, and other barrier attachments.
2. Details of the steel reinforcement of the barrier, including a bar list and bending diagram in accordance with Section 6-02.3(24), and including additional reinforcement required at sign support, luminaire pole, traffic signal standard, and other barrier attachment locations.
3. Details of the interface of, and the interaction between, the barrier and the top layers of structural earth wall reinforcement and facing.
4. When the Plans specify placement of conduit pipes through the barrier, details of conduit pipe and junction box placement.

SEW traffic barrier and SEW pedestrian barrier shall be constructed in accordance with Sections 6-02.3(11)A and 6-10.3(2), and the details in the Plans and in the structural earth wall Working Drawings as approved by the Engineer.

#### 6-13.4 Measurement

Structural earth wall will be measured by the square foot of completed wall in place. The bottom limits for vertical measurement will be the bottom of the bottom mat, for welded wire faced structural earth walls, or the top of the leveling pad (or bottom of wall if no leveling pad is present) for precast concrete panel or concrete block faced structural earth walls. The top limit for vertical measurement will be the top of wall as shown in the Plans. The horizontal limits for measurement are from the end of the wall to the end of the wall.

Backfill for structural earth wall including haul will be measured by the cubic yard in place determined by the limits shown in the Plans.

SEW traffic barrier, and SEW pedestrian barrier will be measured as specified in Section 6-10.4 for cast-in-place concrete barrier.

Structure excavation Class B, Structure excavation Class B including haul, and shoring or extra excavation Class B, will be measured in accordance with Section 2-09.4.

#### 6-13.5 Payment

Payment will be made in accordance with Section 1-04.1 for each of the following Bid items when they are included in the Proposal:

“Structural Earth Wall”, per square foot.

All costs in connection with furnishing materials for, and constructing, structural earth walls, including constructing leveling pads when specified, shall be included in the unit Contract price per square foot for “Structural Earth Wall”.

“Backfill for Structural Earth Wall Incl. Haul”, per cubic yard.

All costs in connection with furnishing and placing backfill for structural earth wall, including hauling and compacting the backfill, and furnishing and placing the wall facing backfill for welded wire faced structural earth walls, shall be included in the unit Contract price per cubic yard for “Backfill for Structural Earth Wall Incl. Haul”.

“SEW Traffic Barrier”, per linear foot.

“SEW Pedestrian Barrier”, per linear foot.

The unit Contract price per linear foot for “SEW \_\_\_ Barrier” shall be full pay for constructing the barrier on top of the structural earth wall, except that when these Bid items are not included in the Proposal, all costs in connection with performing the Work as specified shall be included in the unit Contract price per square foot for “Structural Earth Wall”.

“Structure Excavation Class B”, per cubic yard.

“Structure Excavation Class B Incl. Haul”, per cubic yard.

“Shoring Or Extra Excavation Class B”, per square foot.