

ITEM 423  
**RETAINING WALLS**

**423.1. Description.** Furnish, construct, and install retaining walls.

**423.2. Materials.**

**A. General.** Furnish materials in accordance with the following:

- Item 420, “Concrete Structures”
- Item 421, “Hydraulic Cement Concrete”
- Item 440, “Reinforcing Steel”
- Item 445, “Galvanizing”
- Item 458, “Waterproofing Membranes for Structures”
- Item 556, “Pipe Underdrains.”

Unless otherwise shown on the plans, use concrete for retaining walls that conforms to the requirements of Table 1.

**Table 1**  
**Concrete for Retaining Walls**

Application	Concrete
Cast-in-place, non-reinforced	Class A
Cast-in-place, reinforced	Class C
Precast	Class H, $f'_c = 4,000$ psi

Furnish concrete for machine-made concrete block units in accordance with ASTM C 90, Class 1, Type II, except that the minimum 28-day compressive strength must be 4,000 psi with maximum moisture absorption of 7%.

Provide Type 1 filter fabric in accordance with DMS-6200, “Filter Fabric.” Provide filter fabric rated as UV-resistant when used as part of the exposed facing for a temporary wall.

Joint fillers, pads, waterstops, and other incidental materials must be as shown on the plans or approved by the Engineer.

When the plans call for epoxy coating of steel earth reinforcements, epoxy coat all steel used in concrete panels and coping including connectors, dowels, stirrups, and reinforcing steel.

**B. Fabrication.**

1. **Cast-in-Place.** Meet Item 420, “Concrete Structures.”
2. **Formed Precast.** Meet Item 424, “Precast Concrete Structures (Fabrication).”
3. **Machine-Made Precast.** Furnish machine-made concrete block units in accordance with ASTM C 90, sampled and tested in accordance with ASTM C 140. Furnish units with molded dimensions within 1/8 in. of specified dimensions, except height must be within 1/16 in.

**C. Backfill.**

1. **Non-Select.** Furnish backfill meeting Item 132, “Embankment,” of the type specified in the plans. If no type is specified, provide material with a maximum plasticity index of 30 as determined by Tex-106-E.
2. **Select.** Select backfill is required in specific areas of permanent and temporary MSE and concrete block-type retaining walls. Provide select backfill that is free from organic or otherwise deleterious materials and that conforms to the gradation limits in Table 2 as determined by Tex-110-E.

Provide backfill that does not contain shale, caliche, or other soft, poor-durability coarse aggregate particles. Backfill appearing to contain such particles will be tested for soundness. Backfill with

5-cycle magnesium sulfate soundness of more than 30% when tested in accordance with Tex-411-A will be rejected.

Type A, B, and D particles larger than 1/4 in. must be angular or crushed. Rounded rock or gravel is not allowed.

**Table 2**  
**Select Backfill Gradation Limits**

Type	Sieve Size	Percent Retained
A	3 in.	0
	1/2 in.	50–100
	No. 4	See Note
	No. 40	85–100
B	3 in.	0
	No. 4	See Note
	No. 40	40–100
	No. 200	85–100
C	3 in.	0
	No. 4	See Note
	No. 200	70–100
D	3 in.	0
	3/8 in.	85–100

Note: Use No. 4 sieve for determination of rock backfill as described in Section 423.C, "Backfill."

When the backfill gradation results in 85% or more material retained on the No. 4 sieve, the backfill will be considered rock backfill. All Type D backfill is considered rock backfill.

Unless otherwise shown on the plans, furnish Type B backfill for permanent walls. Furnish Type C backfill for temporary walls. Furnish Type D backfill for areas of walls subject to inundation or below the 100-year flood elevation as noted in the plans.

When nonmetallic or epoxy-coated earth reinforcements are used, furnish backfill meeting the requirements of this Section but with a maximum particle size of 3/4 in.

- 3. Drainage Aggregate.** Use drainage aggregate to fill the void within concrete block units and in the zone 1 ft. behind the units. Provide drainage aggregate that is free from organic or otherwise deleterious materials and that conforms to the gradation limits in Table 3 as determined by Tex-110-E.

**Table 3**  
**Drainage Aggregate Gradation Limits**

Sieve Size	Percent Retained
1 in.	0
3/4 in.	25–50
1/2 in.	50–100
No. 4	75–100

- 4. Cement-Stabilized Backfill.** Use cement-stabilized backfill when required or as approved. Stabilize Type C backfill with 5% hydraulic cement by dry weight of the backfill material. Use a stationary plant to thoroughly mix the backfill material, cement, and water. Place and compact the backfill within 2 hours of mixing. When cement-stabilized backfill is used, provide special drainage provisions as shown on the plans.
- 5. Electrochemical.** Provide backfill meeting the following additional requirements for permanent retaining wall systems using galvanized metallic earth reinforcements:
  - The pH is between 5.5 and 10.0 as determined by Tex-128-E.
  - Resistivity is more than 3,000 ohm-cm as determined by Tex-129-E.
  - Material with resistivity between 1,500 and 3,000 ohm-cm may be used if the chloride content is less than 100 ppm and the sulfate content is less than 200 ppm as determined by Tex-620-J.

When cement-stabilized backfill is used, perform electrochemical testing on the raw, unstabilized backfill material.

- D. Earth Reinforcements.** Furnish earth reinforcements that meet the design requirements. For permanent walls, galvanize or epoxy coat all steel elements in contact with soil. Epoxy coat in accordance with Item 440, "Reinforcing Steel," except provide a minimum 18-mil coating thickness. Epoxy coat the reinforcing only when shown in the plans or as approved. When using nonmetallic or epoxy coated earth reinforcements, use connection hardware that is likewise nonmetallic or epoxy coated.

#### **423.3. Construction.**

- A. General.** Construct retaining walls in accordance with details shown on the plans, on the approved working drawings, and to the pertinent requirements of the following Items:

- Item 110, "Excavation"
- Item 132, "Embankment"
- Item 400, "Excavation and Backfill for Structures"
- Item 420, "Concrete Structures"
- Item 458, "Waterproofing Membranes for Structures"
- Item 556, "Pipe Underdrains."

Construct required piling or drilled shafts in accordance with the pertinent specification.

- B. Definitions.** This Item uses the following terms:

- Permanent Wall – A retaining wall with a design service life of 75 years. All walls are presumed to be permanent walls unless otherwise specified in the plans.
- Temporary Wall – A retaining wall so designated by description, with a design service life of 3 years.
- Mechanically Stabilized Earth (MSE) Wall – A wall consisting of a volume of select backfill with tensile earth reinforcement elements distributed throughout. Permanent MSE walls use a precast concrete panel as a facing element. Temporary MSE walls use welded wire fabric with filter fabric backing as a facing element.
- Concrete Block Wall – A retaining wall that uses machine-made, precast concrete block units as facing elements. The walls may use a volume of select fill with tensile earth reinforcements distributed throughout, or may use only the facing unit and unit fill weight for support.

- C. Options.** When optional design details are shown on the plans, the Contractor is required to use the same facing design within an area of continuous retaining walls.

When proposing the use of 2 or more systems, provide drawings for review indicating the proposed design arrangement.

- D. Working Drawings.** When proprietary wall systems are used, submit casting drawings, construction drawings, and design calculations bearing the seal of a licensed professional engineer for review and approval. For permanent walls, submit 7 sets of casting and construction drawings and 2 sets of design calculations. Upon completion of construction, submit 1 set of reproducible as-built drawings to the Engineer. For temporary walls, submit 5 sets of construction drawings, and 2 sets of design calculations.

- 1. Casting Drawings.** Include all information necessary for casting wall elements, including railing and coping when prefabricated. Show shape and dimensions of panels; size, quantity, and details of the reinforcing steel; quantity, type, size, and details of connection and lifting hardware; and additional necessary details.
- 2. Construction Drawings.** Include a numbered panel layout showing horizontal and vertical alignment of the walls as well as the existing and proposed groundlines. Include all information needed to erect the walls, including the proposed leveling pad elevations; the type and details of the soil reinforcing system (if applicable); the details and manufacturer of all pads, fillers, and filter fabric; the limits and dimensions of structural backfill; details necessary to incorporate coping, railing, inlets, drainage, and electrical conduit; and additional necessary details.

Leveling pad elevations may vary from the elevations shown on the plans. Unless a different minimum cover or a specified minimum leveling pad elevation is shown, provide at least 1 ft. of cover from the top of the leveling pad to finish grade.

- 3. Design Calculations.** Include calculations covering the range of heights and loading conditions on the project. Calculations for both internal and external stability as described in the plans will be required. Include a summary of all design parameters used; material types, strength values, and assumed allowables; loads and loading combinations; and factor-of-safety parameters.

- E. Permanent MSE Walls.** Grade the foundation for the structure level for a width equal to or exceeding the length of the reinforcing system. Compact the foundation with a smooth-wheel vibratory roller or other approved roller. Remove and replace unsuitable foundation soils.

Place drilled shafts and piling located within the MSE volume prior to construction of the wall. Place any required pipe underdrain before construction of the wall.

Place the concrete leveling pad as shown on the construction drawings. Provide a wood float finish, and wait a minimum of 24 hours before beginning panel erection. No curing or strength testing of the leveling pad concrete is required.

Shim the first row of panels as necessary to achieve correct alignment. Use plastic shims or other material that will not deteriorate. If the required shim height exceeds 1 in., remove and replace the leveling pad or provide a grout level-up as directed.

Place filter fabric behind the wall along the joint between the leveling pad and the panels. At leveling pad steps, grout areas where filter fabric spans more than 6 in.

After backfilling the first row of panels, place and compact fill material over the leveling pad to an elevation even with or above the surrounding ground. Do not allow water to accumulate and stand at the base of the wall.

Place filter fabric behind all wall joints and at the intersection of retaining walls with other structures, including riprap. Cover joints at least 6 in. on each side and use adhesive to hold the filter fabric in place.

Exercise care while lifting, setting, and aligning panels to prevent damage to the panels. Discontinue any operation that results in chipping, spalling, or cracking of panels. Remove and replace damaged panels, or repair as approved by the Engineer.

Provide external bracing for the initial row of panels. Use wooden wedges, clamps or other means necessary to maintain position and stability of panels during placement and compaction of backfill. Remove wooden wedges as soon as the panel or coping above the wedged element is erected and backfilled. Remove all wedges after completing the wall.

Review plumbness and position of each row of panels before placing the subsequent row. Remove and rebuild any portion of the wall that is out of tolerance. Modify panel batter and bracing, and backfill material, placement, and compaction methods as required to maintain wall tolerances.

Construct walls to a vertical and horizontal alignment tolerance of 3/4 in. when measured along a 10-ft. straightedge. Construct walls to an overall vertical tolerance (plumbness from top to bottom) of 1/2 in. per 10 ft. of wall height. Construct walls so that the maximum out-of-plane offset at any panel joint is less than 3/4 in.; no joint is open to the extent that the filter fabric is visible from the front of the wall; and no joint is closed to the extent that there is concrete-to-concrete contact.

Place backfill to closely follow the erection of each row of panels. Place the select and embankment backfill to the same elevation where possible, and operate the compaction equipment over the interface. Do not create a continuous, distinct, vertical joint between the select and embankment backfill. Do not complete the embankment prior to construction of the retaining wall.

When building a wall against existing ground, maintain the stability of the interface area between the existing ground and the select fill. Remove and recompact any material that loosens, caves, or fails.

Compact backfill to provide not less than 95% of density determined in accordance with Tex-114-E. Field density determination will be made in accordance with Tex-115-E.

Sprinkle backfill as required to ensure adequate uniformly distributed moisture in each lift prior to and during compaction. Place fill in lifts of 8 in. or less (loose measurement). Place fill in a manner that avoids segregation of the fill. Decrease the lift thickness if necessary to obtain the required compaction. Use hand-operated or walk-behind compaction equipment in the 3-ft. wide strip adjacent to the wall panels. Do not displace panels or distort or damage the reinforcement system during compaction. Modify backfill material, placement, and compaction methods as necessary to meet density requirements while maintaining wall tolerances.

Place rock backfill or material that the Engineer determines too coarse for density testing by the "Ordinary Compaction" method of Item 132, "Embankment."

At each earth reinforcement level, place and compact the backfill to the reinforcement level before placing the reinforcement. Place earth reinforcements perpendicular to the face of the wall. Remove slack in connections prior to placing backfill. For systems using nonmetallic earth reinforcements, pretension each layer of reinforcement to remove slack before placing backfill. Use devices capable of mechanically applying and holding the required force. Do not operate tracked equipment directly on any reinforcement.

When rock backfill is used, cover the rock backfill with filter fabric before placing the 2 ft. of backfill immediately below the pavement structure or top of wall. Overlap the fabric at least 18 in. at splices, and extend it past the edge of the rock backfill at least 18 in. Above the filter fabric, use backfill that contains sufficient fines to fill the voids in a compacted state. Place a horizontal layer of filter fabric as noted above when transitioning from rock backfill to finer grained backfill anywhere within the wall volume.

Prevent surface water or rainwater from damaging the retaining walls during construction. Shape the backfill to prevent water from ponding or flowing on the backfill or against the wall face. Remove and replace any portion of the retaining wall damaged or moved out of tolerance by erosion, sloughing, or saturation of the retaining wall or embankment backfill.

- F. Temporary MSE Walls.** Provide a facing system rigid enough to maintain a smooth and straight wall face both during and after construction.

Grade and compact the foundation for the structure as described in Section 423.3.E, "Permanent MSE Walls."

Place earth reinforcement and facing system in accordance with the approved working drawings. Backfill the 2-ft. zone immediately behind the facing with clean coarse rock meeting the requirements of Coarse Aggregate Grade 1, 2, or 3 of Item 421, "Hydraulic Cement Concrete," or of Type D backfill as described in Section 423.2.C.2, "Select." Cement-stabilized backfill as described in Section 423.2.C.4, "Cement-Stabilized Backfill," may be used in place of the coarse rock.

Place and compact backfill in accordance with the requirements of Section 423.3.E.

Construct walls to a vertical and horizontal alignment tolerance of 3 in. when measured along a 10 ft. straight edge. Construct walls to an overall vertical tolerance (plumbness from top to bottom) of 2 in. per 10 ft. of wall height. Place adjacent facing elements so that the maximum out-of-plane offset at any facing element joint is less than 1 in. Place facing elements and filter fabric with no gaps in the facing or fabric.

Prevent surface water or rainwater from damaging the retaining walls during and after construction. Place temporary berms or curbs, shape the backfill, or use other approved methods to prevent water from flowing against or over the wall face. Remove and replace any portion of the wall damaged or moved out of tolerance by erosion, sloughing, or saturation of the retaining wall or embankment backfill.

- G. Concrete Block Retaining Walls.** The concrete block units may be sampled and tested by the Engineer prior to shipment or upon delivery to the construction site. Display for approval samples of block units indicating the color, texture, and finish. Store, transport, and handle all block units carefully to prevent cracking or damage.

Grade and compact the foundation for the structure, and place the leveling pad as described in Section 423.3.E, "Permanent MSE Walls."

Place the concrete block facing units in accordance with the approved working drawings. Fill the voids within the units and fill the 1-ft. zone immediately behind the facing with drainage aggregate as described in Section 423.2.C.3, "Drainage Aggregate." Systems tested without unit fill may omit the fill as indicated on the approved drawings. Systems with approved filter fabric details may omit the drainage aggregate in the 1-ft. zone immediately behind the facing.

For walls using earth reinforcements, place reinforcements and backfill in accordance with the requirements of Section 423.3.E. Pay particular attention to the connection details of the earth reinforcements to the concrete block units.

Construct walls to a vertical and horizontal alignment tolerance of 1-1/2 in. when measured along a 10-ft. straightedge. Construct walls to an overall vertical tolerance (deviation from the vertical or battered control line, top to bottom) of 1 in. per 10 ft. of wall height. Place adjacent facing elements so that the maximum out-of-plane offset at any facing element joint is less than 1 in. Place facing elements with maximum 1/4-in. gaps between block units.

Prevent surface water or rainwater from damaging the retaining walls during construction. Shape the backfill to prevent water from ponding or flowing on the backfill or against the wall face. Remove and replace all portions of the retaining wall damaged or moved out of tolerance by erosion, sloughing, or saturation of the retaining wall or embankment backfill.

**423.4. Measurement.** This Item will be measured by the square foot of the front surface area of the wall. Unless otherwise shown on the plans, the area will be measured from 1 ft. below finished grade of the ground line on the face of the exterior wall to the top of the wall including any coping required (not including railing).

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2, "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

**423.5. Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Retaining Walls" of the type or special surface finish specified. This price is full compensation for excavation in back of retaining walls and for footings; furnishing and placing footings, leveling pads, copings, and traffic railing foundations; furnishing, placing, and compacting backfill (except in embankment areas), including cement for stabilization; furnishing and placing concrete, reinforcing steel, waterproofing material, filter material and drain pipe, joint material, water stop, and filter fabric when required; fabricating, curing, and finishing all panels; furnishing and placing earth reinforcement, anchorage systems, and fasteners; wall erection; and equipment, labor, tools, and incidentals.

Retaining wall backfill areas that are also in embankment areas will be considered part of the quantities measured and paid for under Item 132, "Embankment."

When drilled shafts are required, they will be measured and paid for as specified in Item 416, "Drilled Shaft Foundations." When piling is required, it will be measured and paid for as specified in the plans for piling of the appropriate type.