MECHANICALLY STABILIZED EARTH RETAINING WALLS

The Standard Specifications are revised as follows:

SECTION 105, AFTER LINE 46, INSERT AS FOLLOWS:

When constructing a mechanically stabilized earth retaining wall, the Contractor shall perform the necessary work to verify that the foundation is at the correct elevation, that the wall is constructed to the correct alignment, and that the work is in accordance with the specified tolerances. The checking of alignments and tolerances shall include verifying that the plumbness of the face panels is in accordance with 731.10 over the entire height of the wall. Alignment shall be checked at each layer of panels after the backfill behind the panels has been compacted, and the results shall be recorded.

SECTION 731, BEGIN LINE 1, INSERT AS FOLLOWS:

SECTION 731 - MECHANICALLY STABILIZED EARTH RETAINING WALLS

731.01 Description*. This work shall consist of furnishing materials and placement of mechanically stabilized earth retaining walls in accordance 105.03.*

731.02 General Design Requirements*. The mechanically stabilized earth wall shall consist of a non-structural leveling pad, concrete face panels, coping, and ground reinforcement elements mechanically connected to each panel. Ground reinforcement shall have sufficient strength, frictional resistance, and quantity as required by design.*

The mechanically stabilized earth retaining walls system is to be selected from the Department's list of approved Retaining Wall Systems. A Retaining Wall System manufacturer may be included on the Department's list by following procedure J of ITM 806. The quantities shown in the Schedule of Pay Items will be the same for all mechanically stabilized earth wall systems. All mechanically stabilized earth walls shall be constructed in accordance with the approved plans and panel shop drawings based on the requirements herein. The recommendations of the wall system suppliers shall not override the minimum performance requirements contained herein.

If the wall manufacturer needs additional information to complete the design, the Contractor shall be responsible for obtaining such information.

All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other appurtenances shown on the plans shall be accounted for in the stability design of the wall.

The mechanically stabilized earth wall design shall follow the general dimensions of the wall envelope shown on the plans. The plans will locate the leveling pad at or below the theoretical leveling pad. The top of the face panel shall be at or above the top of the panel elevation shown on the plans.

Where coping or barrier is utilized, the wall face panel shall extend up into the coping or barrier a minimum of 50 mm (2 in.). The top of the face panels may be level

or sloped to meet the top of the face panel line noted. Cast-in-place concrete will not be an acceptable replacement for panel areas noted by the wall envelope.

Where walls or wall sections intersect with an included angle of 130 degrees or less, a vertical corner element separate from the standard panel face shall abut and interact with the opposing standard panels. The corner element shall have ground reinforcement connected specifically to that panel and shall be designed to preclude lateral spread of the intersecting panels.

Face panels shall be designed to accommodate differential settlement of 1 linear unit in 100. Face panels of greater than 3.0 m^2 (32 sq ft) up through 6.0 m^2 (64 sq ft) in area shall be designed to accommodate differential settlement of 1 linear unit in 200. Where shown on the plans, slip joints to accommodate excessive or differential settlement shall be included.

A project that is part of a contract with multiple projects or contracts containing MSE walls shall only use rectangular face panels.

***731.03 Design Criteria**. The design by the manufacturer shall consider the internal and the external stability of the wall mass including the applied bearing pressure, overturning, sliding, and stability of temporary construction slopes. The design shall be in accordance with the design, construction, and commentary divisions of the AASHTO Standard Specifications for Highway Bridges, unless specified otherwise herein. The analysis of settlement, bearing capacity, and overall slope stability will be the responsibility of the Engineer.*

The theoretical failure plane within the soil mass shall be analyzed so that the soil stabilizing component extends sufficiently beyond the failure plane to stabilize the material. External loads which affect the internal stability such as those applied through piling, bridge footings, traffic, and slope surcharge, shall be accounted for in the design. The size of all structural elements shall be determined such that the design load stresses do not exceed the allowable stresses found in the AASHTO Standard Specifications for Highway Bridges, unless otherwise shown on the plans.

The maximum allowable yield stress for reinforcement shall be 450 MPa (65,000 psi).

The phi (φ) angle for the internal design of the volume shall be assumed to be 34 degrees. The φ angle of the backfill behind the mechanically stabilized earth mass shall be assumed to be 30 degrees.

The wall shall be defined by the wall envelope as shown on the plans. For design purposes, the height of wall H shall be measured from the theoretical top of the leveling pad to the top of the wall. For a level surcharge situation, the top of the wall shall be measured to the top of the coping or to the gutter line of the traffic barrier. The top of the wall shall be the theoretical top of the face panels only when a coping or barrier is not used. For an abutment face, the design height H shall be defined as the height measured from the top of the leveling pad to the top of the roadway surface. For

a wall with a sloping surcharge the top of the wall shall be measured at a point 0.3H back from the face where the design height is H and the actual wall height is H.

For aesthetic considerations and to make differential settlement unnoticeable, the panels shall be erected such that the horizontal site line is discontinuous at every other panel. This shall be accomplished by starting erection with the lower panel level of each wall by alternating full height and half height panels. Panels above the lowest level shall be of a standard size except as required to top out the wall to be in accordance with the plan elevations.

The connections of the ground reinforcing steel to the panels shall be in two elevations for standard panels. The connections shall not be more than 750 mm (30 in.) apart vertically. To prevent out-of-plane rotation, standard face panels shall be connected to ground reinforcement on at least three different points in two different planes. However, preapproved systems utilizing a horizontal stabilizing leg to prevent rotation shall only require ground reinforcement attachments in one plane. Partial panels shall have three different connection points, but only one plane shall be attached to ground reinforcement. Panels, which are located at the top of the wall, shall not be attached to the coping or the traffic barrier.

The ground reinforcement shall be the same length from the bottom to the top of each wall section whether bar mats, grids, or strips steel are used. Differing ground reinforcement elements shall be clearly marked for ease of construction. This element may be used individually or in a prefabricated grouping. The minimum length of the ground reinforcement shall be 2.5 m (8 ft) or 0.7H in accordance with the AASHTO Standard Specifications for Highway Bridges for an abutment on a spread footing.

The ground reinforcement for the mechanically stabilized earth volume shall be sized using the lesser of the allowable forces for each specific connection and each specific reinforcing element. The connection's allowable force shall be taken as 2/3 of the connection test load at the allowable pullout deformation limit of 13 mm (1/2 in.) or one half of the ultimate load, whichever is less.

The ground reinforcement length shall be as required for internal design or as shown on the plans. The length shall exceed the minimum noted as required for design consideration. One hundred percent of the ground reinforcement, which is designed and placed in the reinforced earth volume shall extend to and shall be connected to the face panels.

For mats, grids, or strip steel, the minimum zinc coating thickness shall be 610 g/m^2 (2 oz/sq ft). Such thickness shall be assumed to be 86:m for purpose of calculation of reduced structural section.

The actual applied bearing pressures under the stabilized mass for each reinforcement length shall be clearly indicated on the shop drawings and shall be equal to or less than the maximum allowable soil pressure shown on the plans. Passive pressure in front of the wall mass will be assumed to be zero for design purposes.

731.04 Submittals. *The Contractor shall submit one copy of the design computations for approval. The Contractor shall submit eight sets of design drawings for approval after the design computations are approved and before beginning wall construction operations. Design computations and design drawings shall be signed and sealed by a professional engineer.*

(a) The design drawings shall include all details, dimensions, quantities and cross-sections necessary to construct the wall and shall include but shall not be limited to the following:

1. A plan and elevation sheet or sheets for each wall

2. An elevation view of the wall which shall include the elevation at the top of the wall at all horizontal and vertical break points at least every 15 m (50 ft) along the face of the wall, all steps in the leveling pads, the designation as to the type of panel, the length of soil reinforcing systems, the distance along the face of the wall to where changes in length of the soil reinforcing systems occur, and an indication of the original and final ground lines and maximum bearing pressures

3. A plan view of the wall that indicates the offsets from the construction centerline to the face of the wall at all changes in horizontal alignment. A plan view and elevation view which detail the placing position and connection of all steel ground reinforcing elements in areas where piling, utility, or other structures are near the wall.

4. A typical cross section or cross sections showing elevation relationship between ground conditions and proposed grades

5. All general notes required for constructing the wall

6. All horizontal and vertical curve data affecting the wall

7. A listing of the summary of quantities on the elevation sheet for each wall

(b) All panel details shall show all dimensions necessary to construct the element, all reinforcing steel in the element, and the location of soil reinforcing system devices embedded in the panels.

(c) The details for construction of walls around drainage facilities and the outletting of underdrains.

(d) All details of the architectural treatment.

(e) The details for diverting strips or mesh around obstructions such as piles, catch basins, and other utilities shall be submitted for approval.

(f) The details for each connection between the concrete panel and the mesh or strip.

(g) Calculations for the φ angle of the internal design and backfill.

Design calculations and drawings shall be submitted to the Engineer for review and approval.

MATERIALS

731.05 Materials. *The Contractor shall make arrangements to purchase the materials described herein, including concrete face panels, retaining strips or mesh, tie strips, fasteners, joint materials, and all necessary incidentals, from a mechanically stabilized earth wall system manufacturer on the Departments list of approved Retaining Wall Systems.*

Materials shall be in accordance with the following:

B Borrow	*211.02*
Coarse Aggregate, Class A or Higher, Size No. 8 or 91	*904*
Concrete Admixtures	*912.03*
Concrete, Class A	*702*
Fine Aggregate, Size No. 23	*904*
Fly Ash	*901.02*
Geotextile	*913.18*
Portland Cement	*901.01(b)*
Rapid Set Patching Materials	*901.07*
Reinforcing Steel	*910.01*
*Structure Backfill **	*904*
Water	*913.01*

** No slags other than ACBF will be permitted. ACBF shall be Class A or Higher, Size No. 8 in accordance with 904.*

Backfill material used in the mechanically stabilized earth wall volume shall be structure backfill.

The internal friction or φ angle of the structure backfill in the reinforced soil mass shall be not less than 34 deg in accordance with AASHTO T 236 under consolidated drained conditions. Testing for the φ angle and permeability shall be performed on the portion finer than No. 8 sieve, using a sample of the material compacted to 95% in accordance with AASHTO T 99, methods C, or D. No testing for the φ angle is required when 80% of the materials are greater than 4.75 mm (No. 4) sieve. An approved geotechnical laboratory shall perform the tests.

Structure backfill criteria shall be as follows:

Property	*Criteria*	*Test Method*
pH	*5 < pH < 10*	*AASHTO T 289*
Chlorides	*< 100 ppm*	*AASHTO T 291*
Sulfates	*< 200 ppm*	*AASHTO T 290*
Organic Content	*1 % max.*	*AASHTO T 267*
Resistively	*3000 Ω - cm (min.)*	*AASHTO T 288*
Permeability	*30 m/day (100 ft/day) (min.)*	*AASHTO T 215*

If the minimum resistivity exceeds 5000 Ω cm, the requirement of the testing for Chlorides and Sulfates may be waived. The resistivity shall be tested at 100% saturation.

ACBF shall be in accordance with the pH, Chlorides, Sulfates, Organic Content, Resistively and Permeability requirements of structural backfill as noted above and ITM 212. Total sulfides shall also be determined in accordance with EPA 376.1, using the 100 mL pH water samples obtained during ITM 212, and shall not exceed 400 ppm. The ACBF shall have a uniform corrosion rate as follows for steel and zinc when tested in accordance with ASTM G 59.

1. *Zinc Corrosion Rate First 2 years…… 15 µm/yr./side*
2. *Zinc corrosion to depletion…… 4 µm/yr./side*
3. *Carbon steel rate …… 12 µm/yr./side*

If ACBF is used, and B borrow, structural backfill, or coarse aggregate No. 53's are to be placed above the ACBF aggregate, a single layer of geotextile shall be placed on top of the ACBF aggregate in accordance with 616.10. A type A certification in accordance with 916 for the geotextile materials shall be furnished to the Engineer prior to use.

The structure backfill shall be supplied in accordance with 904 and a type A certification in accordance with 916 for the above additional testing of the structure backfill shall be furnished to the Engineer prior to use. One copy of all test results performed by the Contractor, which are necessary to demonstrate compliance with the specifications, shall also be furnished to the INDOT Geotechnical Section. An approved geotechnical laboratory shall perform the tests.

(a) Concrete Face Panels. *Concrete shall be in accordance with the applicable requirements of 702. Concrete shall have a compressive strength equal to or greater than 27.5 MPa (4000 psi) at 28 days.*

Retarding agents, accelerating agents, or additives containing chloride shall not be used without approval. Air-entraining and slump requirements shall be in accordance with 702.05.

Ground reinforcement connecting hardware and rebar lifting devices shall be set in place and secured prior to beginning casting, in accordance with the dimensions and tolerances shown on the design drawings.

1. Testing and Inspection. *Acceptability of the panels will be determined on the basis of compressive strength tests and visual inspection. The panels shall be considered acceptable regardless of curing age when compressive test results indicate that the compressive strength is in accordance with 731.05(a). The wall manufacturer of the panels shall provide for all testing and inspection services during the production of the panels. Services shall be completed by a Department approved testing laboratory. An American Concrete Institute certified concrete field testing technician, grade 1, shall be present during production of the face panels to direct all sampling and testing.*

2. Casting. *The panels shall be cast on a flat area, with the front face of the form at the bottom, and the back face at the upper part. Tie strip guides shall be set on the rear face. The concrete in each unit shall be placed without interruption and shall be consolidated as necessary to prevent the formation of stone pockets of cleavage planes. Clear form oil of one manufacture shall be used throughout the casting operation.*

3. Curing. *The panels shall be cured for a sufficient length of time such that the concrete develops the specified compressive strength.*

4. Removal of Forms. *The forms shall remain in place until they may be removed without damage to the unit.*

5. Concrete Finish. *The concrete surface for the front panel face shall have a surface finish produced from contact with the form. The rear face of the panel shall be roughly screeded to eliminate open pockets of aggregate and surface distortions in excess of 6 mm (1/4 in.).*

6. Tolerances. *All panels shall be manufactured within the tolerances as follows:*

a. Panel Dimensions. *Lateral position of tie strips shall be within 25 mm (1 in.). All other dimensions shall be within 5 mm (3/16 in.).*

b. Panel Squareness. *Squareness, as determined by the difference between the two diagonals, shall not exceed 13 mm (1/2 in.).*

c. Panel Surface Finish. *Surface defects on smooth formed surfaces measured on a length of 1.5 m (5 ft) shall not exceed 3 mm (1/8 in.). Surface defects on textured finished surfaces measured on a length of 1.5 m (5 ft) shall not exceed 5 mm (5/16 in.).*

7. Compressive Strength. *Acceptance of the concrete panels with respect to compressive strength will be determined on the basis of lots and sublots. Lots will be defined as five sublots. One sublot will consist of 40 panels. Partial sublots of 10 or*

less panels will be added to the previous sublot. Partial sublots greater than 10 panels constitute a full sublot.

During the production of the concrete panels, the wall manufacture will sample the concrete from each sublot in accordance with AASHTO T 141 and prepare a minimum of four cylinders in accordance with AASHTO T 23. Curing of the cylinders shall be in the same manner as the sublot panels are being cured. A minimum of seven days cure shall be completed prior to testing or until the required strength is in accordance with 731.05(a).

When the average results of two cylinders tested in accordance with AASHTO T 22, meet or exceeds the requirements of 731.05(a), the sublot panels may be shipped to the project.

When the cylinder test results are less than the requirements of 731.05(a) and additional cylinders for testing are not available, the manufacture may core the panels. The wall manufacture will randomly select two panels within the sublot for core testing in accordance with AASHTO T 24. The wall manufacture shall obtain two cores on the backside of each panel with a device that produces uniform test samples without coring completely through the panel. Coring shall not be located within 150 mm (6 in.) of the panel fasteners or the edges of the panels. The wall manufacture shall fill the core holes with equivalent concrete materials or rapid set patching materials and trowel to produce a smooth finish. Excess material removed during troweling shall not be reused. If rapid set patching material is used, mixing and curing shall be in accordance with the manufacture's recommendations. If the average strength test results from the cores meet or exceed the requirements of 731.05(a), the sublot panels may be shipped to the project.

All sublot panels not meeting the requirements of 731.05(a) in 28-days shall not be shipped to the project.

A type A certification in accordance with 916 shall be furnished for each sublot prior to use of the panels. All cylinder results shall be reported on the certification. The wall manufacture will state the age of the cylinders or core at the time of the testing.

Field verification of compressive strengths of the panels will be conducted by the Department. The Engineer will randomly select two sublots per lot. Two panels will be randomly selected from the sublot and two core locations selected on each panel for coring. The Contractor shall obtain two 100 mm (4 in.) cores on the backside of the panel in the presence of the Engineer with a device that produces uniform cores for testing. The Contractor shall refill the core holes with rapid set patching materials and trowel to produce a smooth finish. Excess material removed during troweling shall not be reused. Mixing and curing of the patching materials shall be in accordance with the manufacture's recommendations.

The Engineer will take immediate possession of the cores. One core per panel will be utilized for verification testing and the second for back up in case the first core is damaged.

The Department will test the sublot cores in accordance with AASHTO T 24. The sublot verification cores will be averaged and the results compared to the supplier's results reported on the certification for the sublot. If the sublot comparison is not within 1.2 MPa (200 psi) but the strength exceeds the requirements of 731.05(a), the sublot will be accepted and the supplier will be contacted to determine the cause of the non-comparison. If the strength requirement of the sublot verification cores does not meet the requirements of 731.05(a), the sublot will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03 and the Department will direct testing on every sublot and those results will be used for acceptance until the manufactures results indicate satisfactory comparisons.

8. Rejection. *Units shall be subject to rejection due to failure to be in accordance with the requirements specified above. In addition, the following defects may be sufficient cause for rejection:*

a. *Defects which indicate imperfect molding*

b. *Defects which indicate honeycombed or open texture concrete*

c. *Defects in the physical characteristics of the concrete, such as broken or chipped concrete, or color variations or dunnage marks on the front face due to excessive form oil or other reasons.*

The Engineer will determine whether spalled, honeycombed, chipped, or otherwise defective concrete shall be repaired or be cause for rejection. Repair of concrete, if permitted, shall be completed in a satisfactory manner. Repair to concrete surfaces that are to be exposed to view after completion of construction shall be subject to approval.

9. Marking. *The place and date of manufacture, and the production lot and sublot number shall be clearly scribed on the rear face of each panel.*

10. Handling, Storage, and Shipping. *All panels shall be handled, stored, and shipped so as to eliminate the danger of chipping, cracks, fractures, and excessive bending stresses. Panels in storage shall be supported on firm blocking located immediately adjacent to tie strips to avoid bending the tie strips.*

(b) Concrete Leveling Pad. *Concrete, Class A, for the leveling pad shall be placed in accordance with the applicable requirements of 702.*

(c) Concrete Coping. *Concrete, Class A, for the coping shall be in accordance with the applicable requirements of 702. Reinforcing steel in the coping shall be in accordance with the applicable requirements of 703. The coping may be precast or cast-in-place.*

(d) Reinforcing Mesh, Clevis Connector, and Connector Bar. *The reinforcing mesh shall be shop fabricated of cold drawn steel wire in accordance with*

ASTM A 82 and shall be welded into the finished mesh fabric in accordance with ASTM A 185. Galvanization shall be in accordance with ASTM A 123.

Clevis connectors, if used, shall be attached to the alignment templates using the bars provided with the forms. The vertical and horizontal alignment of the connectors shall be +3 mm (+1/8 in.). The holes inside the loops shall be free of all concrete and debris, loose or otherwise.

The clevis connector shall be fabricated of cold drawn steel wire in accordance with ASTM A 82 and welded in accordance with ASTM A 884. Loops shall be galvanized in accordance with ASTM A 153 Class B-3 or ASTM A 123.

The connector bar, if used, shall be fabricated of cold drawn steel wire in accordance with ASTM A 884 and galvanized in accordance with ASTM A 123.

A type A certification in accordance with 916 for reinforcing mesh, clevis connector, and connector bars shall be furnished prior to use of the materials.

(e) Ground Reinforcement. *The ground reinforcement may be a deformed steel strip or a welded wire grid. The grid or strip used shall be consistent with that used in the pullout test and shall be consistent throughout the project.*

The grid shall consist of not less than two longitudinal wires, perpendicular to the wall, welded to equally spaced cross ribs capable of developing passive pressure with the fill. The deformed strip shall be of constant width. The strip thickness shall vary only from the standard underformed section to the standard deformed section as required to produce the pullout resistance.

All longitudinal wires of each welded wire grid shall be of the same diameter. All transverse wires of each welded wire grid shall be of the same diameter, but not necessarily the same as the longitudinal wire diameter.

The face panel edges shall be configured to conceal the joints. All horizontal and vertical joints shall be covered with a joint cover to prevent backfill leakage while passing water.

Reinforcing strips shall be hot rolled from bars to the required shape and dimensions. Physical and mechanical properties of the strips shall be in accordance with ASTM A 572M Grade 450 (A 572 Grade 65). Tie strips shall be shop fabricated with hot rolled steel in accordance with the minimum requirements of ASTM A 709M Grade 345 (A 570 Grade 50). Galvanization for reinforcing strips and tie strips shall be in accordance with ASTM A 123 and the minimum zinc coating thickness shall be 0.64 L/m^2 (2 oz/sq ft). All reinforcing strips and tie strips will be inspected to ensure that they are true to size and free from defects which may impair their strength and durability.

A type A certification in accordance with 916 for ground reinforcement shall be furnished prior to use of the materials.

*(f) **Reinforcing Steel.** Mill certificates for reinforcing steel as shown on the plans shall be furnished for approval. All reinforcing steel shall be in accordance with ASTM A 709M Grade 400 (A 615 Grade 60).*

A type A certification in accordance with 916 for reinforcing steel shall be furnished prior to use of the materials.

*(g) **Fasteners.** Fasteners shall consist of 13 mm (1/2 in.) diameter, hexagonal cap screw bolts and nuts, which shall be galvanized and in accordance with ASTM A 325M (A 325).*

A type A certification in accordance with 916 for fasteners shall be furnished prior to use of the materials.

*(h) **Alignment Pins.** The rods used to align the face panels during construction shall be 19 mm (3/4 in.) diameter, 300 mm (12 in.) long. The rods shall be mild steel, polyvinyl chloride, or fiberglass. A sample shall be submitted prior to use to the Materials and Tests Division for approval.*

*(i) **Joint Materials.** Bearing pads shall be rubber, neoprene, polyvinyl chloride, or polyethylene, and of the type and grade recommended by the supplier of the mechanically stabilized earth wall system.*

The joint cover shall be either a non-woven needle punch polyester geotextile or a woven monofilament polypropylene. The joint cover shall be attached to the rear face of the panels with a suitable adhesive.

Horizontal and vertical joints shall be provided between adjacent face panels to prevent concrete-to-concrete contact and chipping when differential settlement occurs. The horizontal and vertical joints shall contain compression blocks, pins, or other approved means as recommended by the manufacturer to provide a uniform joint. Panels without an uninterrupted vertical joint shall have a minimum joint thickness of 19 mm (3/4 in.).

A type A certification in accordance with 916 for joint materials shall be furnished prior to use of the materials.

CONSTRUCTION REQUIREMENTS

***731.06 General Requirements.** The wall manufacturer representative shall provide technical instruction, guidance in pre-construction activities including the preconstruction conference, and on-site technical assistance to the Contractor during construction.*

***731.07 Foundation Preparation.** The foundation for the structure shall be graded level for a width equal to or exceeding the length of the reinforcing strips or as shown on the plans. Prior to wall construction, the foundation, if not in rock, shall be*

compacted in accordance with 203. The base of the wall excavation shall be proofrolled with a vibratory roller weighing no less than 9 Mg (10 t), or with other approved compacting equipment. If unsuitable foundation material is encountered, it shall be removed and replaced with B borrow in accordance with 211.02 and compacted in accordance with 211.04.

At each foundation level, an unreinforced concrete leveling pad shall be provided as shown on the plans. The leveling pad shall be cured in accordance with 702.22 a minimum of 12 h before placement of concrete face panels.

731.08 Retaining Wall Excavation. *This work shall consist of the excavation of material whose removal is necessary for the construction of the mechanically stabilized earth walls in accordance with the plans, the requirements herein, or as directed. Excavation shall include the construction and subsequent removal of all necessary bracing, shoring, sheeting, cribbing, and all pumping, bailing, and draining.*

Prior to starting excavation operations at the wall site, clearing and grubbing shall be in accordance with 201.03. The Contractor shall clear and grub the area to the excavation in accordance with the limits shown on the plans. All timber, stumps, and debris shall be disposed of in accordance with 201.03.

The Contractor shall notify the Engineer a sufficient time before beginning the excavation so that measurements may be taken of the undisturbed ground.

Where necessary for safety, the excavation shall be shored or braced in accordance with State and local safety standards. Excavation and related work shall be performed such that no portion of the wall is endangered by subsequent operations.

Where excavation for the wall is adjacent to a traveled way, the method for shoring, sheeting, or bracing the excavation opening shall be approved before beginning the excavation. The Contractor shall submit five copies of drawings in accordance with 206.09 showing details of the proposed method of excavation protection.

After the excavation for each wall location has been performed, the Contractor shall notify the Engineer. Concrete for the leveling pad shall not be placed until the Engineer has approved the depth of the excavation and the foundation material.

All sheeting and bracing shall be removed as the backfilling progresses.

All material for backfill shall be subject to approval and shall be free from large or frozen lumps, wood, or other undesirable material. All backfill shall be compacted in accordance with 203.

731.09 Wall Erection. *Concrete face panels shall be handled by means of a lifting device set into the upper edge of the panels. Panels shall be placed in successive horizontal lifts in the sequence shown on the plans as backfill placement proceeds. As backfill material is placed behind the panels, the panels shall be maintained in vertical*

position by means of temporary wooden wedges placed in the joint at the junction of the two adjacent panels on the external side of the wall. External bracing will be required for the initial lift.

Panels placed in contact with the ground or covered by standing water shall have face discoloration removed by means of a chemical wash. Panels shall be stored on blocking to minimize contact with the ground or being covered by standing water.

Plumbness, vertical tolerances, and horizontal alignment tolerances shall not exceed 19 mm (3/4 in.) when measured with a 3 m (10 ft) straightedge. The maximum allowable offset in panel joints shall be 19 mm (3/4 in.). The overall plumbness from top to bottom to the wall shall not exceed 13 mm per 3 m (1/2 in. per 10 ft) of wall height.

Ground reinforcing shall be placed normal to the face of the wall, unless otherwise shown on the plans or as directed. Prior to placement of the ground reinforcing strips, backfill shall be compacted in accordance with 731.10.

731.10 Backfill Placement. *Backfill placement shall closely follow erection of each course of panels and ground reinforcing. Backfill shall be placed so as to avoid damage or disturbance to the wall materials or misalignment of the concrete face panels. Wall materials that become damaged or disturbed during backfill placement shall be removed and replaced or corrected as directed. All misalignment or distortion of the concrete face panels due to placement of backfill outside the limits described herein shall be corrected as directed.*

The work shall also include B borrow backfilling above a theoretical 1:1 slope behind the ground reinforcement in accordance with the details shown on the plans and the disposal of surplus of unsuitable excavated materials as permitted.

Structure backfill shall be compacted to 95% of the maximum dry density in accordance with AASHTO T 99. Compaction equipment shall be in accordance with 409.03(d). Density of the compacted aggregate will be determined in accordance with 203.24(b). If No. 8 backfill materials are used, compaction shall consist of four passes with a vibratory roller, and one pass with the same roller in static mode. A vibratory roller shall be equipped with a variable amplitude system, a speed control device, and have a minimum vibration frequency of 1000 vibrations per min. A roller in accordance with 409.03(d)4 may be used. All displacement or rutting of the aggregate shall be repaired prior to placing subsequent material.

The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer. Backfill material with placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniformly acceptable through the entire lift.

The maximum loose lift thickness shall not exceed 200 mm (8 in.) except that lifts 1 m (3 ft) from the wall or closer shall not exceed 125 mm (5 in.) in loose

thickness. This lift thickness shall be decreased if necessary, to obtain the specified density.

Compaction within 1 m (3 ft) of the back face of the concrete face panels shall be achieved by means of a minimum of five passes with a lightweight mechanical tamper, roller, or an alternative vibratory system.

At the end of each day's operation, the last level of backfill shall be sloped away from the concrete face panels. In addition, surface runoff from adjacent areas shall not be permitted to enter the wall construction site.

Cutting or altering of the basic structural section of ground reinforcing at the site will be prohibited, unless the cutting is preplanned and detailed on the approved design drawings. Cutting shall only be considered if adequate additional ground reinforcing is provided to produce the required strength shown in the approved calculations. If the grid or strip is shortened in the field, the cut ends shall be covered with a galvanized paint or Bitumastic 50 coal tar to prevent corrosion of the metal.

731.11 Method of Measurement. *Concrete face panels and wall erection will be measured by the square meter (square foot) of wall surface area. The concrete leveling pad will be measured by the meter (linear foot). Structure backfill and B borrow will be measured in accordance with 211.09. Geotextile materials if used in accordance with 731.05 will not be measured.*

The pay quantities for concrete face panels, and wall erection will be based on the neat line limits of the wall envelope as shown on the plans and not that of the wall system supplier. The wall envelope limits will be considered to be the vertical distance from the top of the leveling pad to the top of the coping, and the horizontal distance from the beginning to the end of the leveling pad.

Precast or cast-in-place concrete coping will not be measured. Drainage of the backfill including piping, aggregates and geotextile materials will not be measured.

731.12 Stockpiled Concrete Face Panels. *Partial payment will be made for panels stockpiled on the project site or at the Contractor's approved storage location. Partial payment will be based on the delivered cost of the wall panels, as verified by invoices that include freight charges. The Contractor shall furnish the invoices and Type A certification. The partial payment will not exceed 75% of the contract unit price for concrete face panels. Prior to construction, the Engineer will verify that the panels are in accordance with 731.05(a).*

731.13 Basis of Payment. *Concrete face panels and wall erection will be paid for at the contract unit price per square meter (square foot). The concrete leveling pad, complete and in place, will be paid for at the contract unit price per meter (linear foot) for leveling pad. Structure backfill and B borrow will be paid for at the contract unit price per cubic meter (cubic yard) in accordance with 211.10.*

Payment will be made under:

Pay Item	*Metric Pay Unit Symbol (English Pay Unit Symbol)*
Face Panels, Concrete	*m2 (SFT)*
Leveling Pad, Concrete	*m (LFT)*
Wall Erection	*m2 (SFT)*

The cost of services including the testing laboratory, certified testing personnel, and the testing and inspection of the concrete panels shall be included in the cost of concrete face panels.

The cost of all mechanically stabilized earth wall materials including concrete face panels, ground reinforcing, tie strips, fasteners, joint materials, concrete coping, repair or replacement of face panels damaged or removed due to backfill placement, and incidentals shall be included in the cost of concrete face panels.

The cost of all labor and materials required to prepare the wall foundation, place the ground reinforcing, and erect the concrete face panels shall be included in the cost of wall erection.

The cost of labor and materials required to provide for the outletting of underdrains including piping, and aggregates shall be included in the cost of concrete face panels.

The cost for verification coring, refilling, and refinishing of the core holes shall be included in the cost of concrete face panels.

The cost of performing the laboratory tests by an approved geotechnical laboratory for structural backfill or ACBF slag shall be included in the cost of other pay items in this section.

The cost of all excavation required shall be included in the costs of other pay items in this section.

The cost of all labor and materials for geotextile materials, used, shall be included in the cost of other structural backfill.

The cost of cutting, altering, and recoating of the ground reinforcing at the site shall be included in the cost of wall erection.