

MODULAR CONCRETE BLOCK RETAINING WALL WITH GROUND REINFORCING

The Standard Specifications are revised as follows:

SECTION 105, AFTER LINE 48, INSERT AS FOLLOWS:

When constructing a modular block 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 modular block wall units is in accordance with 732.09 over the entire height of the wall. Alignment shall be checked at each layer of modular block wall units after the backfill behind the modular block wall units has been compacted, and the results shall be recorded.

SECTION 732, BEGIN LINE 1, INSERT AS FOLLOWS:

***SECTION 732 - MODULAR CONCRETE BLOCK RETAINING WALL
WITH GROUND REINFORCING***

732.01 Description. *This work shall consist of furnishing materials and placement of modular block wall constructed in accordance with 105.03.*

732.02 General Design Requirements. *The modular block wall shall consist of a non-structural leveling pad and concrete modular block wall units. Ground reinforcement shall have sufficient strength, frictional resistance, and quantity as required by design.*

The wall shall be constructed in accordance with the approved plans and shop drawings based on the requirements herein. The recommendations of the wall system supplier shall not override the minimum performance requirements shown 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 modular block 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 modular block wall unit shall be at or above the top of the wall elevation shown on the plans.

The top of the modular block wall shall be designed to prevent the removal of the top course of blocks.

Modular block wall units shall be designed to accommodate differential settlement of 1 linear unit in 100. Where shown on the plans, continuous vertical slip joints to accommodate excessive or differential settlement shall be included.

732.03 Design Criteria. *The design by the manufacturer shall be in accordance with the requirements for the internal stability of the wall mass, the bearing pressure, and overturning. The design shall be in accordance with the applicable requirements of the AASHTO Standard Specifications for Highway Bridges unless otherwise specified herein. The analysis of settlement, sliding, bearing capacity, and overall slope stability will be the responsibility of the Engineer.*

External loads which affect the internal stability 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 steel reinforcement shall be 450 MPa (65,000 psi).

The maximum standard modular block wall unit face area shall be 0.09 m² (1 sq ft). The minimum horizontal depth of modular block wall units shall be 225mm (9 in.).

The ϕ angle of the aggregate leveling pad shall be assumed to be 30 deg. The ϕ angle of the structure backfill behind the modular blocks shall be assumed to be 34 deg.

The wall shall be defined by the wall envelope 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 modular block wall units only when a coping or barrier is not used. 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 .

Modular block wall units shall be dry stacked in a running bond configuration. Vertically adjacent units shall be connected with shear pins.

The ground reinforcement shall be mats, grids or strip steel, or geogrid materials and shall be the same length from the bottom to the top of each wall section. 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 $0.7H$ for a wall without sloping surcharges, $0.7H$ for a wall with sloping surcharges, or in accordance with the AASHTO Standard Specifications for Highway Bridges for an abutment on a spread footing.

The ground reinforcement for modular block units 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 modular block wall units.

Where the presence of opposing walls limits the length of ground reinforcing, the design shall account for the reduced length and internal and external stability calculations shall be made to check for adequate factor of safety.

For mats, grids, or strip steel, the minimum zinc coating thickness shall be 0.64 L/m² (2 oz/sq ft). Such thickness shall be assumed to be 86 : m for purpose of calculation of reduced structural section. Geogrid shall be a regular network of integrally connected polymer tensile elements with aperture geometry sufficient to permit mechanical interlock with the surrounding material.

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.

732.04 Submittals. *The Contractor shall submit one copy of the design computations for approval. If the computations are computer generated, one sample set of hand calculations, for one wall location, shall also be submitted. The Contractor shall then 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 modular block wall unit, 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 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 modular block wall units shall show all dimensions necessary to construct the element, any reinforcing steel in the element, and the location of soil reinforcing system devices embedded in the unit.*
- (c) Clearly indicated details for construction of walls around drainage facilities.*
- (d) All details of the architectural treatment.*
- (e) The details for diverting strips or mesh around obstructions such as piles, catch basins, landscape plantings where the bottom of the root ball extends below the top level of ground reinforcement, and other utilities shall be submitted for approval.*
- (f) The details for each connection between the modular block wall unit and the ground reinforcement, and the details for alignment pins or other interlocking system between blocks.*

Shop drawings, design calculations, and design drawings shall be submitted to the Engineer for review and approval.

MATERIALS

732.05 Materials. *The Contractor shall make arrangements to purchase the materials described herein, including concrete modular block wall units, fasteners, joint materials, and all necessary incidentals. The Contractor shall make arrangements with the Materials and Tests Division for all required offsite testing.*

Materials shall be in accordance with the following:

Coarse Aggregate, Class E or Higher, Size No. 8 or 53..904*
*Structure Backfill **.....904*

** Coarse aggregate No. 8 used as drainage fill shall consist of 100% crushed stone.*

*** Slag will not be permitted.*

(a) Concrete Modular Block Wall Units. Units shall be in accordance with the applicable requirements of ASTM C 140. Concrete shall have a compressive strength of 27.5 MPa (4000 psi) at 28 days. Wall units shall be dry cast.

1. Testing and Inspection. Acceptability of the modular block wall units will be determined on the basis of compressive strength, absorption, freeze-thaw tests, and visual inspection. The modular block wall units shall be considered acceptable regardless of curing age when compressive test results indicate that the average compressive strength is in accordance with 28-day requirements. Modular block wall units utilizing type I or II cement will be considered acceptable for placement in the wall when 7-day initial strengths exceed 85% of the 28-day requirements. Modular block wall units utilizing type III cement will be considered acceptable for placement in the wall prior to 28 days only when compressive strength test results indicate that the average strength exceeds the 28-day requirements.

2. Tolerances. All modular block wall units shall be manufactured within the tolerances as follows:

a. Modular Block Wall Unit Dimensions. Block unit dimensions, including minimum rear and side shell thickness, shall be within 3 mm (1/8 in.) of those shown on the approved shop drawings. The minimum face shell and side shell thickness shall be 75 mm (3 in.).

b. Modular Block Wall Unit Squareness. Squareness, as determined by the difference between the two diagonals, shall not exceed 6 mm (1/4 in.)

3. Compressive Strength. Acceptance of the concrete modular block wall units with respect to compressive strength will be determined on the basis of production lots. A production lot will consist of a single day's production.

During the production of the concrete modular block wall units, the Engineer will randomly sample the concrete in accordance with AASHTO T 141. A single compressive strength sample, consisting of a minimum of four wall unit specimens, will be randomly selected from each production lot.

Cylinders for compressive strength tests shall be prepared in accordance with AASHTO T 23 on specimens of 150 mm x 300 mm (6 in. x 12 in.). For each compressive strength sample, a minimum of two specimens will be cured in the same manner as the block units and tested at seven days. The average compressive strength of these specimens, when tested in accordance with AASHTO T 22, will provide a test result that will determine the initial strength of the concrete. In addition, two specimens will be cured in accordance with AASHTO T 23 and tested at 28 days. The average compressive strength of these two specimens, when tested in accordance with AASHTO T 22, will provide a compressive strength test result that will determine the compressive strength of the production lot.

If the compressive strength test result is less than 27.5 MPa (4000 psi), retesting will be permitted and will be based on four cores taken from the block wall units within the production lot. The Engineer will randomly select four units within the lot for testing. The Contractor shall obtain cores in the presence of the Engineer with a device to produce cores for testing in accordance with AASHTO T 24. The block wall units to be retested will be selected by the Engineer. The average of the four-retest cores will determine the final compressive strength of the production lot. A production lot which is not in accordance with the compressive strength requirements will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.

If the initial seven-day strength test results exceed the compressive strength requirements then the testing at 28 days will be waived for that particular production lot.

4. Moisture Content. *The moisture content of modular block wall units shall be 6% or less when tested in accordance with ASTM C 140.*

5. Freeze-Thaw. *Freeze-thaw durability testing is required in accordance with ASTM C 1372 once per contract. If identical mixtures have been used within the previous 12 months, testing may be accepted by the Engineer upon receipt of all applicable test results performed by an accredited independent laboratory.*

6. 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, which are to be exposed to view after completion of construction shall be subject to approval.

7. Handling, Storage, and Shipping. *All modular block wall units shall be handled, stored, and shipped so as to eliminate the danger of chipping, cracks, fractures, and excessive bending stresses.*

(b) Aggregate Leveling Pad. *Compacted aggregate size No. 53 for the leveling pad shall be placed in accordance with the applicable requirements of 904, and shall be crushed stone.*

(c) Ground Reinforcement. *Steel ground reinforcement may be a deformed steel strip or a welded wire grid. Geogrid ground reinforcement shall be a Type I geogrid in accordance with 913.21. The ground reinforcement used shall be consistent with that used in the pullout test and shall be consistent throughout the project.*

The steel 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 steel strip shall be of constant width. The steel strip thickness shall vary only from the standard undeformed section to the standard deformed section as required to produce the pullout resistance.

Longitudinal and transverse steel wires shall be of the same diameter.

Steel 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 steel reinforcing strips and tie strips shall be in accordance with ASTM A 123. All reinforcing strips and tie strips shall 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 mats, grids or strips steel, or geogrids for ground reinforcement shall be furnished prior to use of the materials.

(d) Backfill Material. *Backfill material used in the modular block wall structure volume shall be structure backfill.*

A type A certification in accordance with 916 for the backfill materials shall be furnished prior to use. One copy of all test results performed by the Contractor, which are necessary to demonstrate compliance with the specifications, shall be furnished.

Drainage fill used behind the modular block wall shall be coarse aggregate size No. 8.

CONSTRUCTION REQUIREMENTS

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

732.07 Foundation Preparation. *The foundation for the structure shall be graded level for the width 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 aggregate leveling pad shall be provided as shown on the plans. The leveling pad shall be of minimum 150 mm (6 in.) depth.

732.08 Retaining Wall Excavation. *This work shall consist of the excavation of material whose removal is necessary for the construction of the modular block 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; and 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 for 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 have been 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. Aggregate for the leveling pad shall not be placed until the Engineer has approved the depth of the excavation and the choice of foundation material.

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

All material for random 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.

732.09 Wall Erection. *Modular block wall units shall be placed in successive horizontal lifts in the sequence shown on the plans as backfill placement proceeds.*

Modular block wall units placed in contact with the ground or covered by standing water shall have face discoloration removed by means of a chemical wash. Modular block wall units 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 modular block wall unit 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 reinforcement shall be placed normal to the face of the wall, unless otherwise shown on the plans. Geogrid ground reinforcement shall be constructed in accordance with 214.04.

732.10 Backfill Placement. *Backfill placement shall closely follow erection of each course of modular block wall units and ground reinforcement. Backfill shall be placed so as to avoid damage or disturbance to the wall materials or misalignment of the modular block wall units. 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 modular block wall units due to placement of backfill outside the limits described herein shall be corrected as directed.*

Structure backfill shall be compacted to 95% of the maximum dry density in accordance with 203.23.

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 modular block wall units shall be achieved by means of a minimum of three passes with a lightweight mechanical

tamper, roller, or vibratory system.

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

Where using geogrids, backfilling operations need to be monitored closely to minimize wrinkles in the materials.

Cutting or altering of the basic structural section of the 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 reinforcement is provided to produce the required ground reinforcement strength shown in the approved calculations. If the steel grid or strip is shortened in the field, the cut ends shall be covered with a galvanized paint or coal tar to prevent corrosion of the metal.

732.11 Method of Measurement. *Modular block wall units and wall erection will be measured by the square meter (square foot) of wall surface area. Aggregate for the leveling pad will be measured by the meter (linear foot). Structure backfill will be measured in accordance with 211.09. Unsuitable foundation materials, if found, will be measured in accordance with 211.09. Coarse aggregate will be measured by the megagram (ton) in accordance with 109.01(b).*

The pay quantities for modular block wall units, wall erection, and the coarse aggregate for the drainage backfill will be based on the neat line limits of the wall envelope 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 wall, and the horizontal distance from the beginning to the end of the leveling pad.

732.12 Stockpiled Modular Block Units. *Partial payment will be made for block wall units stockpiled on the project site or at the Contractor's approved storage location. Partial payment will be based on the delivered cost of the units, as verified by invoices that include freight charges. The Contractor shall furnish the invoices. The partial payment will not exceed 75% of the contract unit price for block wall units. Prior to authorizing partial payment, the Engineer will verify that the units are in accordance with 732.04(a), after testing.*

732.13 Basis of Payment. *Modular block wall units and wall erection will be paid for at the contract unit price per square meter (square foot). Aggregate leveling pad, complete and in place, will be paid for at the contract unit price per meter (linear foot). Structure backfill will be paid for in accordance with 211.10. The accepted quantities of coarse aggregate for the drainage backfill will be paid for at the contract unit price per megagram (ton), complete in place. Unsuitable foundation materials will be paid for in accordance with 211.10.*

Payment will be made under:

<i>Pay Item</i>	<i>Metric Pay Unit Symbol (English Pay Unit Symbol)</i>
<i>Coarse Aggregate, No. 8</i>	<i>Mg (TON)</i>
<i>Concrete, Modular Block Wall</i>	<i>m2 (SFT)</i>
<i>Leveling Pad</i>	<i>m (LFT)</i>
<i>Wall Erection, Modular Block Wall</i>	<i>m2 (SFT)</i>

The cost of all modular block wall materials including modular block wall units, freeze-thaw durability testing, compressive strength retesting if required, and incidentals shall be included in the cost of concrete, modular block wall.

The cost of all labor and materials required to prepare the wall foundation, erect the modular block wall units, ground reinforcement, or replacement materials damaged during backfill placement if required, shall be included in the cost of wall erection.

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