

## 732-R-310 MODULAR CONCRETE BLOCK RETAINING WALL

(Revised 02-19-09)

SECTION 732, BEGIN LINE 1, INSERT AS FOLLOWS:

**SECTION 732 - MODULAR CONCRETE BLOCK RETAINING WALL****732.01 Description**

*This work shall consist of furnishing materials and placement of modular block wall units with or without ground reinforcement in accordance with 105.03.*

10 *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.*

**732.02 General Design Requirements**

*The modular block wall shall consist of an aggregate leveling pad, concrete modular block wall units and when specified, ground reinforcement elements that are to be mechanically connected to the facing units. Ground reinforcement shall have sufficient strength, frictional resistance, and quantity as required by design.*

20 *All modular block wall units 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.*

30 *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.*

40 *Cast-in-place concrete will not be an acceptable replacement for any modular block wall unit within the areas noted by the wall envelope.*

*Modular block wall units shall be designed to accommodate differential*

settlement of 1 linear unit in 100. Where shown on the plans, slip joints to accommodate excessive or differential settlement shall be included.

### 732.03 Design Criteria

50 The design by the manufacturer shall be in accordance with the requirements for the internal and the external 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.

60 The maximum standard modular block wall unit face area shall be 1 sq ft ( $0.09 m^2$ ). The minimum depth of modular block wall units shall be 9 in. (225 mm).

The phi ( $\phi$ ) angle for the internal design of the volume shall be assumed to be 34 degrees. The ( $\phi$ ) angle of the backfill behind the modular block earth mass shall be assumed to be 30 degrees. Before construction begins, the structure backfill selected shall be tested by the Contractor to confirm compliance with the frictional requirement. The wall supplier shall be furnished a copy of the testing results for the backfill. The friction angle of the foundation soils shall be assumed to be 30 degrees.

70 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 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  $H$ .

80 Modular block wall units shall be dry stacked in a running bond configuration. Vertically adjacent units shall be connected with an approved shear connections.

The ground reinforcement shall be the same length from the bottom to the top of each modular block wall section. Differing ground reinforcement elements shall be clearly marked for ease of construction. The minimum length of the ground reinforcement shall be 8 ft (2.5 m) 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.

90 The ground reinforcement for modular block wall sections 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 1/2 in. (13 mm) or one half of the ultimate load, whichever is less.

100      *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.

110      *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 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.

120      (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 50 ft (15 m) 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 ground reinforcement, the distance along the face of the wall to where changes in length of the ground reinforcement 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*

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- (b) *All modular block wall unit shall show all dimensions necessary to construct the element and the location of soil reinforcing system devices embedded in the units.*
- (c) *The details for construction of walls around drainage facilities.*
- (d) *All details of the architectural treatment.*
- (e) *The details for diverting ground reinforcement 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 mechanical connection between the modular block wall unit and the ground reinforcement.*

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

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## **MATERIALS**

### **732.05 Materials**

*The Contractor shall make arrangements to supply the materials described herein, including concrete modular block wall units, fasteners, joint materials, ground reinforcement, and all necessary incidentals.*

*Materials shall be in accordance with the following:*

<i>B Borrow .....</i>	<i>211.02</i>
<i>Coarse Aggregate, Class A or Higher, Size No. 8* or 91.....</i>	<i>904</i>
<i>Concrete Admixtures**.....</i>	<i>912.03</i>
<i>Concrete .....</i>	<i>702</i>
<i>Fine Aggregate, Size No. 23.....</i>	<i>904</i>
<i>Fly Ash .....</i>	<i>901.02</i>
<i>Geogrid, Type I .....</i>	<i>913.21</i>
<i>Geotextile .....</i>	<i>913.18</i>
<i>Portland Cement .....</i>	<i>901.01(b)</i>
<i>Structure Backfill .....</i>	<i>904.05</i>
<i>Water.....</i>	<i>913.01</i>

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

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\*\* Admixtures in accordance with ASTM C 1372 may be used for the modular block if approved by the Engineer.

Backfill material used in the modular block wall volume shall be structure backfill, type 3 in accordance with 211.

200 The internal friction or  $\phi$  angle of the structure backfill in the reinforced backfill shall be not less than 34 deg in accordance with AASHTO T 236 or AASHTO T 297 under consolidated drained conditions. Testing for the  $\phi$  angle shall be performed on the portion finer than No. 8 (2.36 mm) sieve, using a sample of the material compacted to 95% in accordance with AASHTO T 99, methods C, or D. No testing for the  $\phi$  angle is required when 80% of the materials are greater than No. 4 (4.75 mm) 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
Organic Content	1 % max.	AASHTO T 267
Permeability & Gradation	30 ft/day (9 m/day) (min.)	AASHTO T 215 AASHTO T11 & T27

210 All of the above tests shall be run a minimum of once per two calendar years per source.

ACBF shall be in accordance with the pH, organic content, and permeability requirements of structure backfill as noted above, and in ITM 212.

If ACBF or coarse aggregate No. 8's (2.36 mm) are used, and soil, B borrow, structural backfill, or coarse aggregate No. 53's are to be placed above the ACBF or No. 8 (2.36 mm) aggregate, a single layer of geotextile shall be placed on top of the ACBF or No. 8 (2.36 mm) aggregate in accordance with 616.10. A type C certification in accordance with 916 for the geotextile materials shall be furnished to the Engineer prior to use.

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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 Department's Geotechnical Section. An approved geotechnical laboratory shall perform the tests.

**(a) Concrete Modular Block Wall Units**

230 Concrete modular block retaining wall units shall be in accordance with ASTM C 1372 and shall have a minimum compressive strength of 4000 psi (27.5 MPa) at 28 days. Modular block wall units utilizing type I or II cement will be considered acceptable for placement in the wall when 7-day strengths exceed 3500 psi (24.1 MPa).

Retarding agents, accelerating agents, coloring pigments, or additives containing

chloride shall not be used without approval.

### **1. Testing and Inspection**

240           a. Material properties shall be in accordance with the requirements of 732.05 in lieu of Section 4.

250           b. Table 1, "Strength and Absorption Requirements", shall be modified to require that the average compressive strength, when sampled and tested in accordance with ASTM C 140, of a three CMU compressive strength sample shall be 4000 psi (27.5 MPa) with no individual unit less than 3500 psi (24.1 MPa). Maximum absorption shall be 6%.

260           c. The modular block wall unit's compressive strength shall be considered acceptable regardless of curing age when compressive test results indicate that the compressive strength is in accordance with 732.05(a).

270           d. Freeze-thaw durability testing shall be completed in accordance with Section 8.3 by a laboratory approved by the Department. Test results shall have been completed in accordance with ASTM C 1372 and be within 12 months prior to delivery. A type A certification in accordance with 916 for the freeze-thaw durability testing shall be submitted to the Engineer prior to use of the blocks.

280           e. Sampling and testing of the manufacturer's production lots will be conducted by the Engineer in accordance with ASTM C 140. If the compressive strength test result does not meet the requirements of 732.05(a), the production lot units may not be used. The manufacturer may resample the same production lot in the presence of the Engineer for retesting. The Engineer will test the additional samples in accordance with ASTM C 140. If the retested samples meet the requirements of 732.05(a), the production lot may be used. If the retested samples do not meet the requirements of 732.05(a), all the units from the production lot may not be used.

### **2. 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.

280           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.*

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### **3. Marking**

*The date of manufacture, the production lot number, and the place mark shall be clearly scribed on the rear face of each unit or on each shipping pallet.*

### **4. 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.*

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#### **(b) Aggregate Leveling Pad**

*Aggregate for the leveling pad shall be compacted aggregate No. 53 and shall be in accordance with the applicable requirements of 303.*

#### **(c) Ground Reinforcement**

*The ground reinforcement shall be geogrid. The ground reinforcement used shall be consistent with that used in the pullout test and shall be consistent throughout the project.*

*A type A certification in accordance with 916 for geogrids shall be submitted to the Engineer prior to use of the materials.*

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#### **(d) Backfill Material**

*Backfill material used in the modular block wall structure volume shall be structure backfill. B borrow shall be placed behind the reinforcement and the structure backfill.*

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

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*Drainage fill used behind the modular block wall, as shown on the plans shall be coarse aggregate No. 8 (2.36 mm) in accordance with 904.02.*

## **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.*

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### **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 an 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.

340 At each foundation level, an aggregate leveling pad shall be provided as shown on the plans.

### **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 wall sections in accordance with the plans and the requirements herein. Excavation shall include the construction and subsequent removal of all necessary bracing, shoring, sheeting, cribbing, all pumping, bailing, and draining.

350 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.

360 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. The aggregate leveling pad shall not be placed until the Engineer has approved the depth of the excavation and the foundation material.

370 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.

### **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. As backfill material is placed behind the units, the units shall be maintained in vertical position.

380 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 to minimize contact with the ground or being covered by standing water.

Horizontal alignment tolerances shall not exceed 3/4 in. (19 mm) when measured with a 10 ft (3 m) straightedge.

390 Ground reinforcement shall be placed normal to the face of the wall, unless otherwise shown on the plans and shall be constructed in accordance with 214.04. Backfill shall be compacted in accordance with 732.10.

### **732.10 Backfill Placement**

400 Backfill placement shall closely follow erection of each course of modular block wall units with or without 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.

The work shall also include backfilling beyond the theoretical length of the ground reinforcement in accordance with the details shown on the plans and the disposal of surplus of unsuitable excavated materials as permitted.

410 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 maximum loose lift thickness shall not exceed 8 in. (200 mm) except that lifts 3 ft (1 m) from the wall or closer shall not exceed 5 in. (125 mm) in loose thickness. This lift thickness shall be decreased if necessary, to obtain the specified density.

420 Compaction within 3 ft (1 m) of the back face of the modular block wall units shall be achieved by means of a minimum of five 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.

430 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.

### **732.11 Method of Measurement**

Modular block wall units with or without ground reinforcement will be measured by the square yard (square meter) of wall surface area. Erection of Modular block wall units will be measured by the square yard (square meter) of wall surface area. Common excavation will be measured by the cubic yard (cubic meter) in accordance with 203.27 to the neat lines shown on the plans. Structure backfill and B borrow will be measured in accordance with 211.09. Unsuitable foundation materials, if found, will be measured in accordance with 211.09.

The measurement for concrete modular block wall units and wall erection 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.

Clearing and grubbing, excavation, compacted aggregate No. 53, and compacted aggregate No. 8 will not be measured. Geotextile materials if used in accordance with 732.05 will not be measured.

### **732.12 Stockpiled Modular Block Units**

Partial payment may be made for block wall units stockpiled on the project site or at the Contractor's approved storage location. Partial payment will include 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 modular block wall with or without ground reinforcement. Prior to authorizing partial payment, the Engineer will verify that the units are in accordance with 732.05(a).

### **732.13 Basis of Payment**

Modular block wall units with or without ground reinforcement will be paid for at the contract unit price per square yard (square meter) of wall surface area. Erection of Modular block wall units will be paid for by the square yard (square meter) of wall surface area. Common excavation will be paid for at the contract unit price per cubic yard (cubic meter) in accordance with 203.28 to the neat lines shown on the plans. Structure backfill and B borrow will be paid for in accordance with 211.10. Unsuitable foundation materials will be paid for in accordance with 211.10.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit Symbol</b>
Modular Block Wall .....	SYS (m2)
Modular Block Wall with Ground Reinforcement .....	SYS (m2)
Modular Block Wall Erection .....	SYS (m2)

The cost of aggregate and geotechnical testing shall be included in the cost of wall.

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*The cost of modular blocks including ground reinforcing, fasteners, repair or replacement of units damaged or removed due to backfill placement, and incidentals shall be included in the cost of modular block wall with ground reinforcement.*

*The cost of all labor and materials required to prepare the wall foundation, place the ground reinforcing, and erect the modular block units shall be included in the cost of wall erection.*

490     *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 modular block wall with or without ground reinforcement.*

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

*The cost of cutting or altering the ground reinforcing at the site shall be included in the cost of modular block wall with ground reinforcement.*

500     *The cost of all modular block wall materials including modular block wall units, compressive strength retesting if required, and incidentals shall be included in the cost of the concrete modular block wall with or without ground reinforcement.*

*The cost of clearing and grubbing, compacted aggregate No. 53, compacted aggregate No. 8, ground reinforcement, or replacement materials damaged during backfill placement if required, shall be included in the cost of wall erection.*

*The cost of retesting or replacing failed modular block wall units will be included in the cost of the concrete modular block wall with or without ground reinforcement.*

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