

SECTION 02300

**ULTRAFLEX[®] REVETMENT SYSTEM
SPECIFICATION FOR
ARTICULATING CONCRETE BLOCK (ACB'S) SYSTEMS**

PART 1: GENERAL

1.01 SCOPE OF WORK

1.02. RELATED WORK

1.03. SUBMITTAL

- A. Manufacturer
- B. Hydraulic Performance.
- C. Manufacturer's certificates of compliance
- D. Manufacturer's specifications,

1.04. REFERENCE STANDARDS

- A. Concrete Aggregates
- B. Testing Concrete Masonry Units
- C. Portland Cement
- D. Hydrated Lime Types.
- E. Blended Hydraulic Cements
- F. Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Revetment Systems.
- G. Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems.

PART 2: PRODUCT

2.01 GENERAL

- A. Assembly of concrete blocks
- B. Configuration of Individual units within the system
- C. Interlocking surfaces and Articulation
- D. Revetment Cable and accessories.
- E. Placement of Filter Fabric
- F. Hydraulic Performance
 - i. Certification (Open-Channel Flow
 - ii. Design

PART 3: CELLULAR CONCETE BLOCKS

SECTION 02300

**ULTRAFLEX® REVETMENT SYSTEM
SPECIFICATION FOR
ARTICUALTING CONCRETE BLOCK (ACB'S) SYSTEMS**

- 1. Scope**
- 2. Materials**
 - 2.1 Cementitious Materials
 - 2.1.1 Portland Cements
 - 2.1.2 Blended Cements
 - 2.1.3 Hydrated Lime Types
 - 2.1.4 Pozzolans.
 - 2.2 Aggregates:
 - 2.2.1 Normal Weight
- 3. Casting**
 - 3.1 Dry cast method.
- 4. Physical Requirements**
 - 4.1 Concrete Strength and Absorption
 - 4.2 ASTM D 6684-04.
 - 4.3 Freeze-Thaw requirements
- 5. Visual Inspection**
 - 5.1 Defects
 - 5.2 Cracks
 - 5.3 Chipping
 - 5.4 Rejection of product
- 6. Sampling and Testing**
 - 6.1 Authorized representative
 - 6.2 Field installation procedures
 - 6.3 Design Analysis
 - 6.4 Additional Testing
- 7. Manufacturer**

SECTION 02300

**ULTRAFLEX® REVETMENT SYSTEM
SPECIFICATION FOR
ARTICUALTING CONCRETE BLOCK (ACB'S) SYSTEMS**

PART 4: REVETMENT CABLE AND FITTINGS

PART 5: FILTER FABRIC

PART 6: CELLUALR CONCRETE MAT SIZES

**PART 7: FOUNDATION PREPARATION, GEOTEXTILE AND (BLOCK) MAT
PLACEMENT**

A. Foundation Preparation

1. General
2. Grading
3. Inspection

B. Placement of Geotextile Filter Fabric

1. General
2. Placement

C. Placement of Revetment Concrete Blocks/Mats

1. General
2. Placement
3. Finishing

SECTION 02300

**ULTRAFLEX® REVETMENT SYSTEM
SPECIFICATION FOR
ARTICULATING CONCRETE BLOCK (ACB'S) SYSTEMS**

PART 1: GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, equipment, and incidentals required to perform all operations in connection with the installation of cellular concrete erosion control mats in accordance with the lines, grades, design and dimensions shown on the Contract Drawings and as specified herein.

1.05. RELATED WORK

- A. Earthwork is included in Section 02200.
- B. Granular Materials are included in Section 02230.
- C. Geotextile Filter Fabric is included in Section 02275.

1.06. SUBMITTAL

- A. The Contractor shall identify and list the manufacture of the Articulating Concrete Block System on the bid proposal.
- B. The Contractor shall submit to the Engineer all manufacturers' hydraulic performance calculations in support of the proposed cellular concrete mat system and geotextile. All calculations shall be made in accordance with Paragraph 2.01 of this specification.
- B. The Contractor shall furnish manufacturer's certificates of compliance for cellular concrete blocks/mats, revetment cable, and any revetment cable fittings and connectors.
- C. The Contractor shall also furnish the manufacturer's specifications, literature, shop drawings for the layout of the mats, and any recommendations, if applicable, that are specifically related to the project.

1.07. REFERENCE STANDARDS

- H. ASTM C33 – Standard Specifications for Concrete Aggregates
- I. ASTM C 140 – Test Methods of Sampling and Testing Concrete Masonry Units
- J. ASTM C 150 - Specification for Portland Cement
- K. ASTM C 207 - Specification for Hydrated Lime Types.
- L. ASTM C 595 - Specification for Blended Hydraulic Cements

SECTION 02300

**ULTRAFLEX[®] REVETMENT SYSTEM
SPECIFICATION FOR
ARTICULATING CONCRETE BLOCK (ACB'S) SYSTEMS**

- ASTM C 618 - Specification for Fly Ash and Raw or Calcined Natural Pozzolans for use in Portland Cement Concrete.
- M. ASTM D 6684-04 - Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Revetment Systems.
- N. ASTM D 6884-04 - Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems.

PART 2: PRODUCT

2.01 GENERAL

- A. All cellular concrete mats shall be prefabricated as an assembly of concrete blocks, with specific hydraulic capacities, laced with revetment cables. Cellular concrete mats may be assembled on-site by hand-placing the individual units either with or without subsequent insertion of cables.
- B. Individual units in the system shall be staggered and interlocked for enhanced stability. The mats shall be constructed of open and/or closed cell units as shown on the contract drawings. The open cell units have two (2) vertical openings of rectangular cross section with sufficient wall thickness to resist breakage during shipping and installation. Parallel strands of cable shall extend through two (2) cable ducts in each block allowing for longitudinal binding of the units within a mat. Each row of units shall be laterally offset by one-half of a block width from the adjacent row so that any given block is cabled to four other blocks (two in the row above and two in the row below).
- C. Each block shall incorporate interlocking surfaces that minimize lateral displacement of the blocks within the mats when they are lifted by the longitudinal revetment cables. The interlocking surfaces must not protrude beyond the perimeter of the blocks to such an extent that they reduce the flexibility or articulation capability of the cellular mats or become damaged or broken when the mats are lifted during shipment or placement. Once the mats are in place, the interlocking surfaces shall minimize the lateral displacement of the blocks even if the cables should become damaged or removed. The mats must be able to flex a minimum of 18° between any given row or column of blocks in the uplift direction and a minimum of 45° in the downward direction.

SECTION 02300

**ULTRAFLEX® REVETMENT SYSTEM
SPECIFICATION FOR
ARTICUALTING CONCRETE BLOCK (ACB'S) SYSTEMS**

- D. The cables inserted into the mats shall form lifting loops at one end of the mat with the corresponding cable ends spliced together to form a lifting loop at the other end of the mat. The Engineer shall approve appropriate sleeves for use in order to splice the lifting loop. The cables shall be inserted after sufficient time has been allowed for the concrete to complete the curing process.
- E. The cellular concrete mats shall be placed on a filter fabric as specified herein. Under no circumstances shall the filter fabric be affixed (i.e. chemically bonded to the blocks) to the mattress in a manner in which would jeopardize the functionality of the filter fabric.

F. Hydraulic Performance

1. Certification (Open-Channel Flow): Cellular concrete mats will only be accepted when produced and derived from tests under controlled flow conditions. Testing guidelines should conform to U.S. Federal Highway Administration and U.S. Bureau of Reclamation Testing Protocol as documented in "Minimizing Embankment Damage During Overtopping Flow", Report No. FHWA-RD-88-181 and all hydraulic performance testing shall be performed in a 2H:1V flume.

2. Performance (Open-Channel Flow): The design of the cellular concrete mats shall be in accordance with the Factor-of-Safety design methodology as described in "Erosion and Sedimentation" by Pierre Julien, Cambridge University Press, 1995. The minimum designed safety factor shall be 1.5 by utilizing the following equation.

$$SF = ((\vartheta_2 / \vartheta_1) \alpha_0) / ((1 - \alpha_0^2)^{0.5} \cos \beta + \eta (\vartheta_2 / \vartheta_1) + (\vartheta_3 F_d' \cos \delta + \vartheta_4 F_1') / \vartheta_1 W_s)$$

The analysis shall be performed based upon the stability of the mat due to gravity forces alone, neglecting conservative forces added by cabling, mechanical anchorage, contact with adjacent blocks, or other restraints not attributable to gravity based forces. The analysis must account for a 0.5 inch block projection.

PART 3: CELLULAR CONCRETE BLOCKS

1. Scope

1.1 This specification covers erosion control mats used in revetments for soil stabilization.

SECTION 02300

**ULTRAFLEX® REVETMENT SYSTEM
SPECIFICATION FOR
ARTICULATING CONCRETE BLOCK (ACB'S) SYSTEMS**

Note 1 - Concrete units covered by this specification are made from lightweight or normal weight aggregates, or both.

Note 2 - The values stated in U.S. customary units are to be regarded as the standard.

2. Materials

2.1 Cementitious Materials - Materials shall conform to the following applicable ASTM specifications:

2.1.1 Portland Cements - Specification C 150, for Portland Cement.

2.1.2 Blended Cements - Specification C 595, for Blended Hydraulic Cements.

2.1.3 Hydrated Lime Types - Specification C 207, for Hydrated Lime Types.

2.1.4 Pozzolans - Specification C 618, for Fly Ash and Raw or Calcined Natural Pozzolans for use in Portland Cement Concrete.

2.2 Aggregates shall conform to the following ASTM specifications, except that grading requirements shall not necessarily apply:

2.2.1 Normal Weight - Specification C 33, for Concrete Aggregates.

3. Casting

3.1 The concrete units shall be produced by a dry cast method. The dry cast units obtain strength in a shorter duration as well as an increase in the durability and overall quality of product.

4. Physical Requirements

4.1 At the time of delivery to the work site, the units shall conform to the physical requirements prescribed in Table 1 listed below.

TABLE 1: PHYSICAL REQUIREMENTS

SECTION 02300

**ULTRAFLEX® REVETMENT SYSTEM
SPECIFICATION FOR
ARTICULATING CONCRETE BLOCK (ACB'S) SYSTEMS**

Compressive Strength Net Area Min. psi (mPa)		Water Absorption Max. lb/ft ³ (kg/m ³)	
Avg. of 3 units	Individual Unit	Avg. of 3 units	Individual Unit
4,000 (27.6)	3,500 (24.1)	10 (160)	12 (192)

4.2 Units shall be in accordance with ASTM D 6684-04, Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Revetment Systems.

4.3 When applicable, the manufacturer shall meet all requirements pertaining to a concrete unit's durability pertaining to a freeze-thaw environment.

5. Visual Inspection

5.1 All units shall be sound and free of defects that would interfere with either the proper placement of the unit or impair the performance of the system. Surface cracks incidental to the usual methods of manufacture, or surface chipping resulting from customary methods of handling in shipment and delivery, shall not be deemed grounds for rejection.

5.2 Cracks exceeding 0.25 inches (.635 cm) in width and/or 1.0 inch (2.54 cm) in depth shall be deemed grounds for rejection.

5.3 Chipping resulting in a weight loss exceeding 10% of the average weight of a concrete unit shall be deemed grounds for rejection.

5.4 Blocks rejected prior to delivery from the point of manufacture shall be replaced at the manufacturer's expense. Blocks rejected at the job site shall be repaired with structural grout or replaced at the expense of the contractor.

6. Sampling and Testing

6.1 The purchaser or their authorized representative shall be accorded proper access to facilities to inspect and sample the units at the place of manufacture from lots ready for delivery.

6.2 Field installation procedures shall comply with the procedures utilized during the hydraulic testing procedures of the recommended system. All system restraints and ancillary components (such as synthetic

SECTION 02300

**ULTRAFLEX® REVETMENT SYSTEM
SPECIFICATION FOR
ARTICUALTING CONCRETE BLOCK (ACB'S) SYSTEMS**

drainage mediums) shall be employed as they were during testing. For example, if the hydraulic testing installations utilize a drainage layer then the field installation must utilize a drainage layer; an installation without the drainage layer would not be permitted.

6.3 The theoretical force-balance equation used for performance extrapolation tends for conservative performance values of thicker concrete units based on actual hydraulic testing of thinner units. When establishing performance values of thinner units based on actual hydraulic testing of thicker units, there is a tendency to overestimate the hydraulic performance values of the thinner units. Therefore, all performance extrapolation must be based on actual hydraulic testing of a thinner unit then relating the values to the thicker units in the same "family" of blocks.

6.4 Additional testing, other than that provided by the manufacturer, shall be borne by the purchaser.

7. Manufacturer

The individual blocks comprising the mat shall have the nominal characteristics, such as the unit weight, density and open area as listed by the manufacturer.

The Cellular Concrete Units shall be ULTRAFLEX® as manufactured by:

SUBMAR, INC.
805 Dunn Avenue
Houma, Louisiana 70360
Phone: 800.978.2627
Phone: 985.868.0001
Fax: 985.851.0108

PART 4: REVETMENT CABLE AND FITTINGS

Galvanized Steel Revetment Cable and Fittings. Revetment cable shall be constructed of preformed galv aircraft cable. The cables shall be made from individual wires and strands that have been formed during the manufacture into the shape they have in finished cable.

Cable shall consist of a core construction comprised of six (6) or seven (7) wires wrapped within seven (7) or nineteen (19) wire strands. The revetment cable shall have the following physical properties:

SECTION 02300

**ULTRAFLEX® REVETMENT SYSTEM
SPECIFICATION FOR
ARTICUALTING CONCRETE BLOCK (ACB'S) SYSTEMS**

Nominal Cable Diam.	Approx. Avg. Strength		Lbs./100 ft (kg/m)			
	Lbs.	(kN)	Min. Lbs.(kg)		Max Lbs.(kg)	
1/8"	1,700	(7.5)	2.8	(.04)	2.9	(.04)
3/16"	3,700	(16.4)	6.2	(.09)	6.5	(.10)
1/4"	6,100	(27.1)	10.6	(.16)	11.0	(.16)
3/8"	13,300	(59.2)	23.6	(.35)	24.3	(.36)

Fittings such as sleeves and stops shall be aluminum, and the washers shall be galvanized steel.

PART 4: FILTER FABRIC

The geotextile filter shall meet the minimum physical requirements listed in Table No. 3 of these Specifications. Consultation with the manufacturer is recommended.

The geotextile must be permitted to function properly by allowing relief of hydrostatic pressure; therefore concrete shall not be allowed to clog the filter fabric.

The geotextile fiber shall consist of a long-chain synthetic polymer composed of at least 85 percent by weight of propylene, ethylene, ester, or amide, and shall contain stabilizers and/or inhibitors added to the base plastic, if necessary, to make the filaments resistant to deterioration due to ultraviolet and heat exposure. The edges of the geotextiles shall be finished to prevent the outer fiber from pulling away from the geotextiles.

The Contractor shall furnish the Engineer, in duplicate, manufacturer's certified test results showing actual test values obtained when the physical properties are tested for compliance with the specifications.

During all periods of shipment and storage, the filter fabric shall be protected from direct sunlight, ultraviolet rays and temperatures greater than 140 degrees Fahrenheit. To the extent possible, the fabric shall be maintained wrapped in its protective covering. The geotextile shall not be exposed to sunlight, ultraviolet rays until the installation process begins.

TABLE 3: PHYSICAL REQUIREMENTS

Physical Property	Test Procedure	Minimum Value
Grab Tensile Strength (Unaged Geotextile)	ASTM D4632	200 Lbs. (in any principal direction)

SECTION 02300

**ULTRAFLEX® REVETMENT SYSTEM
SPECIFICATION FOR
ARTICULATING CONCRETE BLOCK (ACB'S) SYSTEMS**

Breaking Elongation (Unaged Geotextile)	ASTM D4632	30% max. (in any principal direction)
Burst Strength	ASTM D3786	400 psi
Puncture Strength	ASTM D4833	115 lbs.
A.O.S., U.S. Std. Sieve	ASTM D4751	see Design Manual
% Open Area	CWO-22125-86	5%
Permittivity	ASTM D4491	0.5 sec ⁻¹

Final acceptance of the filtration geotextile by the Engineer shall be dependent upon the geotextile performance when tested in accordance with ASTM D5105, Standard Test Method for Measuring the Soil-Geotextile System Clogging by the Gradient Ratio test or the Hydraulic Conductivity Ratio test. Soil characteristics such as grain size analysis, and plasticity shall be determined for every 200,000 square feet of geotextile installed, or for each source of borrow material used during construction. Significant differences in soil characteristics shall require further performance testing by either the Gradient Ratio or the Hydraulic Conductivity Ratio tests at the discretion of the Engineer. The locations for which the material to be tested is extracted shall be approved by the Engineer. The Contractor shall provide the site-specific soil and modified proctor curves for the site-soil, at his own expense, to the manufacturer. The manufacturer shall be responsible for the performance of the test by a certified independent laboratory experienced in performing such test. The test shall be performed under the actual field soil conditions or as otherwise required by the Engineer.

At the time of installation, the filter fabric shall be rejected if it has been removed from its protective cover for over 72 hours or has defects, tears, punctures, flow deterioration, or damage incurred during manufacture, transportation or storage. With the acceptance of the Engineer, a torn or punctured section of fabric shall be repaired by placing a filter fabric patch over the damaged area prior to placing the mats. The patch shall be large enough to overlap a minimum of three (3) feet in all directions.

In the event pre-assembled panels of fabric are required, the panels of filter fabric shall be sewn together at the manufacturer or another approved location.

PART 5: CELLULAR CONCRETE MAT SIZES

SECTION 02300

**ULTRAFLEX® REVETMENT SYSTEM
SPECIFICATION FOR
ARTICULATING CONCRETE BLOCK (ACB'S) SYSTEMS**

General. The cellular concrete blocks, cables and fittings shall be fabricated at the manufacturer or another approved location into mats with a width of up to eight (8) feet and a length up to forty (40) feet, which is approved by the Engineer.

Mat Length: The cellular concrete mats shall have the ability for fabrication in various lengths, widths, and in combinations of length and/or widths. Special mats are a combination of two opposing dimensions either in the longitudinal or transverse direction of the mats. The special mats are available in various dimensions that allow for a custom fit to a site-specific project.

PART 7: FOUNDATION PREPARATION, GEOTEXTILE AND (BLOCK) MAT PLACEMENT

A. Foundation Preparation

General. Areas on which filter fabric and cellular concrete blocks are to be placed shall be constructed to the lines and grades shown on the Contract Drawings and to the tolerances specified in the Contract Documents, and approved by the Engineer.

Grading. The slope shall be graded to a smooth plane surface to ensure that intimate contact is achieved between the slope face and the geotextile (filter fabric), and between the geotextile and the entire bottom surface of the cellular concrete blocks. All slope deformities, roots, grade stakes, and stones which project normal to the local slope face must be re-graded or removed. No holes, "pockmarks", slope board teeth marks, footprints, or other voids greater than 1.0 inch in depth normal to the local slope face shall be permitted. No grooves or depressions greater than 0.5 inches in depth normal to the local slope face with a dimension exceeding 1.0 foot in any direction shall be permitted. Where such areas are evident, they shall be brought to grade by placing compacted homogeneous material. The slope and slope face shall be uniformly compacted, and the depth of layers, homogeneity of soil, and amount of compaction shall be as required by the Engineer.

Excavation and preparation for anchor trenches, side trenches, and toe trenches or aprons shall be done in accordance to the lines, grades and dimensions shown in the Contract Drawings. The anchor trench hinge-point at the top of the slope shall be uniformly graded so that no dips or bumps greater than 0.5 inches over or under the local grade occur. The width of the anchor trench hinge-point shall also be graded uniformly to

SECTION 02300

ULTRAFLEX® REVETMENT SYSTEM SPECIFICATION FOR ARTICULATING CONCRETE BLOCK (ACB'S) SYSTEMS

assure intimate contact between all cellular concrete blocks and the underlying grade at the hinge-point.

Inspection. Immediately prior to placing the filter fabric and cellular concrete blocks, the prepared subgrade shall be inspected by the Engineer as well as the owner's representative. No fabric or blocks shall be placed thereon until that area has been approved by each of these parties.

B. Placement of Geotextile Filter Fabric

General. Filter Fabric, or filtration geotextile, as specified elsewhere, shall be placed within the limits shown on the Contract Drawings.

Placement. The filtration geotextile shall be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile shall not be walked on or disturbed when the result is a loss of intimate contact between the cellular concrete block and the geotextile or between the geotextile and the subgrade. The geotextile filter fabric shall be placed so that the upstream strip of fabric overlaps the downstream strip. The longitudinal and transverse joints shall be overlapped at least two (2) feet. The geotextile shall extend at least one foot beyond the top and bottom revetment termination points. If cellular concrete blocks are assembled and placed as large mattresses, the top lap edge of the geotextile should not occur in the same location as a space between cellular concrete mats unless the space is concrete filled.

C. Placement of Revetment Concrete Blocks/Mats

General. Placement of the Articulating Concrete Revetment system shall be in accordance with ASTM D 6884-04, Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems. Cellular concrete block/mats, as specified in Part 2:A of these Specifications, shall be constructed within the specified lines and grades shown on the Contract Drawings.

Placement. The cellular concrete blocks shall be placed on the filter fabric in such a manner as to produce a smooth plane surface in intimate contact with the filter fabric. No individual block within the plane of placed cellular concrete blocks shall protrude more than one-half inch or as otherwise specified by the Engineer. To ensure that the cellular concrete blocks are flush and develop intimate contact with the subgrade, the blocks shall be "seated" with a roller or other means as approved by the Engineer.

If assembled and placed as large mattresses, the cellular concrete mats

SECTION 02300

ULTRAFLEX® REVETMENT SYSTEM SPECIFICATION FOR ARTICUALTING CONCRETE BLOCK (ACB'S) SYSTEMS

shall be attached to a spreader bar or other approved device to aid in the lifting and placing of the mats in their proper position by the use of a crane or other approved equipment. The equipment used should have adequate capacity to place the mats without bumping, dragging, tearing or otherwise damaging the underlying fabric. The mats shall be placed side-by-side and/or end-to-end, so that the mats abut each other. Mat seams or openings between mats greater than two (2) inches shall be filled with 4000 psi grout. Whether placed by hand or in large mattresses, distinct changes in grade that results in a discontinuous revetment surface in the direction of flow shall require a grout seam at the grade change location so as to produce a continuous surface.

Anchor trenches and side trenches shall be backfilled and compacted flush with the top of the blocks. The integrity of a soil trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the cellular concrete blocks for its entire service life. Toe trenches shall be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches shall be completed in a timely fashion. No more than 500 linear feet of placed cellular concrete blocks with non-completed anchor and/or toe trenches shall be permitted at any time.

Finishing. The cells or openings in the cellular concrete blocks shall be backfilled and compacted immediately with suitable material to assure there are no voids and so that compacted material extends from the filter fabric to one-inch above the surface of the cellular concrete block. Backfilling and compaction shall be completed in a timely manner so that no more than 500 feet of exposed mats exist at any time.