**ARMORFLEX® ARTICULATING CONCRETE BLOCK (ACB)**

**SYSTEM SPECIFICATION - HAND PLACED**

**GENERAL**

**Scope of Work**

The contractor shall furnish all labor, materials, equipment, and incidentals required for, and perform all operations in connection with, the installation of the ArmorFlex® Articulating Concrete Block (ACB) system in accordance with the lines, grades, design and dimensions shown on the Contract Drawings and as specified herein.

**Submittal**

The Contractor shall submit to the Engineer of Record (EOR) evidence of full-scale hydraulic testing in accordance with ASTM D-7277, and if necessary, Factor of Safety (FoS) calculations in support of the proposed ACB system stamped and signed by a Professional Engineer licensed to practice in the state where the project is located. The Contractor shall also submit to the EOR an appropriate geotextile, selected for the site being protected on the basis of the gradation and permeability of the surface soils, which information shall have been provided by the EOR or the designated geotechnical engineer.

The Contractor shall furnish manufacturer's certificates of compliance for the ACB, geotextile, and any other components that are required. The Contractor shall also furnish the manufacturer's specifications, literature, installation instructions, and any recommendations, if applicable, that are specifically related to the project. If a color has been specified for the block, the Contractor shall submit a color chart indicating the specified standard color.

Alternative materials from qualified suppliers may be considered; to qualify, proposed alternative suppliers must own and operate their own manufacturing facility, and shall directly employ a minimum of five (5) registered Professional Engineers. Full documentation consistent with the foregoing must be submitted in writing to the EOR a minimum of twenty (20) business days prior to bid date, and must be pre-approved in writing as an addendum to the bid documents and drawings by the EOR at least ten (10) business days prior to bid date. Submittal packages must also include, as a minimum, the following:

1. Evidence of satisfactory full-scale laboratory testing in accordance with *ASTM D 7277,* *Standard Test Method for Performance Testing of Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow*, performed on behalf the submitting manufacturer on a qualifying test flume of sufficient length for the test flows to achieve normal depth in all cases, and associated engineered calculations quantifying the FoS of the proposed ACB system under the design conditions of the specific project, stamped and signed by a registered Professional Engineer residing in and licensed to practice in the state where the project is located;
2. A list of 5 comparable projects, in terms of size and applications, in the United States, where the satisfactory performance of the specific alternate ACB system can be verified after a minimum of five (5) years of service life;
3. Information about, or certifications of, all materials associated with the ACB system as detailed above, including (but not limited to) geotextile and any other materials required for satisfactory installation in accordance with *ASTM D 6884, Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems*;
4. The names and contact information (phone numbers and e-mail addresses, at a minimum) for the suppliers’ representatives, for technical, production or logistics questions, at least one of whom must reside in the state where the project is located.

**PRODUCT**

**General**

All ACB’s shall be provided on pallets or other suitable method for shipping to prevent damage to the individual blocks. The ACB system may be hand-placed individually, either with or without subsequent insertion of cables.

Individual units in the system shall be staggered and interlocked for enhanced stability. The open cell units have two (2) vertical openings of rectangular cross section with sufficient wall thickness to resist cracking during shipping and installation. Optionally, parallel strands of cable may be inserted through two (2) cable ducts in each block allowing for longitudinal binding of the units within the system. Each row of units shall be laterally offset by one-half of a block width from the adjacent row. Each block shall incorporate interlocking surfaces that minimize lateral displacement of the blocks.

The ACB’s shall be placed on a filter fabric as specified herein. Under no circumstances shall the filter fabric be permanently affixed or otherwise adhered to the blocks; i.e., the filter fabric shall be independent of the block system.

**Certification (Open-Channel Flow):** ACB’s will only be accepted when accompanied by documented hydraulic performance characteristics that are derived from tests under controlled flow conditions. Testing shall conform to *ASTM D 7277, Standard Test Method for Performance Testing of Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow*, as amended and updated. Note that all hydraulic performance testing shall be performed in a 2H:1V flume, and that the tested length be long enough that the test flows achieve normal depth in all cases. Analysis and interpretation of the test data shall conform to the guidance contained in *ASTM D 7276, Standard Guide for Analysis and Interpretation of Test Data for Articulating Concrete Block (ACB) Revetment Systems in Open Channel Flow*, as amended and updated.

**Performance (Open-Channel Flow):** The design of the ACB system shall be in accordance with the Factor-of-Safety design methodology as described in "Erosion and Sedimentation" by Pierre Julien, Cambridge University Press, Second Ed. 2010. The minimum designed safety factor shall be 1.5 by utilizing the following equation.

SF = ((2 / 1) ) / ((1 - 2)0.5 cos  +  (2 / 1) + (3 Fd’ cos  + 4 Fl’) / 1Ws) ≥ 1.5

where 1, 2, 3, & 4 are geometric properties of the block, , are angles characteristic of the site and application,  is the stability number for a sloped surface, Fd & Fl are the drag and lift forces, respectively, and Ws is the submerged weight of the block. ArmorFlex block geometric parameters are available upon request.

The analysis shall be performed based upon the stability of the ACB’s 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, in accordance with *ASTM D 6884, Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems,* Section 6.3.3. **Site grading requirements may not be used to omit this requirement for standard (non-tapered) block.**

In order to analyze the performance of the unit, the hydraulic information listed below is required:

**ACB HYDRAULIC INFORMATION**

|  |  |  |
| --- | --- | --- |
| Design Volumetric Flow Rate (ft3/sec) |  | ***Specified by EOR*** |
| Minimum Shear Stress (lb/ft2) |  |
| Channel Friction or Bed Slope (ft/ft) |  |
| Channel Side Slopes (\_H:1V) |  |
| Channel Bottom Width (ft) |  |
| Allowable Unit Protrusion (in) | 0.5 |  |

**Articulating Concrete Blocks**

**Scope:** This specification covers articulating concrete blocks used in revetments for soil stabilization. Installations may be exposed to infrequent and/or light-duty vehicular loading, such as for low-water crossings or boat ramps, by specifying a minimum thickness of 6”. Concrete units covered by this specification are made from lightweight or normal weight aggregates, or both. The values stated in U.S. customary units are to be regarded as the standard.

**Materials:** Cementitious Materials shall conform to the following applicable ASTM specifications:

* + - 1. Portland Cements - Specification C 150, for Portland Cement.
      2. Blended Cements - Specification C 595, for Blended Hydraulic Cements.
      3. Hydrated Lime Types - Specification C 207, for Hydrated Lime Types.
      4. Pozzolans - Specification C 618, for Fly Ash and Raw or Calcined Natural Pozzolans for use in Portland Cement Concrete.
      5. Aggregates – Specification C 33, for Concrete Aggregates, except that grading requirements shall not necessarily apply.

**Casting:** The ACB units shall be produced by a dry cast method. Dry cast units obtain strength more quickly than wet cast blocks, and will also achieve a greater uniformity of quality and greater durability.

**Physical Requirements:** At the time of delivery to the work site, the units shall conform to the physical requirements prescribed in Table 1 below.

**TABLE1. PHYSICAL REQUIREMENTS**

|  |  |  |  |
| --- | --- | --- | --- |
| **Compressive Strength Net Area**  **Min. p.s.i (mPa)** | | **Water Absorption**  **Max. lb/ft3 (kg/m3)** | |
| Avg. of 3 units | Individual Unit | Avg. of 3 units | Individual Unit |
| 4,000 (27.6) | 3,500 (24.1) | 9.1 (160) | 11.7 (192) |

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

**Visual Inspection:** 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.

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

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.

**Sampling and Testing:** The purchaser (or their authorized representative) shall be accorded access to the relevant manufacturing facility or facilities, if desired, in order to inspect and/or sample the ACB units from lots ready for delivery prior to release for delivery to the job site. Such inspections are at the sole expense of the requesting entity.

Field installation shall be consistent with the way the system was installed in preparation for hydraulic testing pursuant to ASTM D 7277, *Standard Test Method for Performance Testing of Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow*. Any external restraints, anchors, or other ancillary components (such as synthetic drainage mediums) shall be employed as they were during testing; e.g., if the hydraulic testing installation utilized a drainage layer, then the field installation must also utilize a drainage layer. This does not preclude the use of other section components for other purposes, e.g., a geogrid for strengthening the subgrade for vehicular loading, or an intermediate filter layer of sand to protect very fine-grained native soils.

Hydraulic testing shall be conducted on the thinnest block in a “family” of similar blocks (i.e., same footprint but different thicknesses), with the tested critical shear value then converted to a critical shear at 0° before extrapolation to thicker blocks within the same family. Such extrapolation may not be made from a thicker block to a thinner block. The extrapolation method is detailed in the National Concrete Masonry Association (NCMA) *“Design Manual for Articulated Concrete Block (ACB) Revetment Systems”*, section 4.2.

Purchaser may request additional testing other than that provided by the manufacturer as needed. Such requested testing will extend any stated lead times for manufacturing and delivery, if the results of such testing are a prerequisite to approval (i.e., approval for release to manufacturing). Costs associated with such testing shall be borne by the purchaser.

**Manufacturer:** ACB’s shall be **ArmorFlex®** as manufactured and sold by:

ARMORTEC, A Contech Company Phone: 1-800-645-7000

9025 Centre Pointe Dr., Suite 400 Fax: 1-513-645-7993

West Chester, OH 45269

URL: <http://www.conteches.com/Products/Erosion-Control/Hard-Armor/ArmorFlex>

The selected ARMORFLEX® blocks shall have the following nominal characteristics:

**STANDARD SIZES OF ARMORFLEX® BLOCKS**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CLASS** | **TYPE** | **MIN. WEIGHT**  **(lbs)** | **BLOCK SIZE** | | | **OPEN AREA %** |
| **Length**  **(in)** | **Width**  **(in)** | **Height\***  **(in)** |
| 30S | Open | 32 | 13.0 | 11.6 | 4.75 | 20 |
| 50S | Open | 42 | 13.0 | 11.6 | 6.0 | 20 |
| 45S | Closed | 39 | 13.0 | 11.6 | 4.75 | 10 |
| 55S | Closed | 50 | 13.0 | 11.6 | 6.0 | 10 |
| 40 | Open | 59 | 17.4 | 15.5 | 4.75 | 20 |
| 50 | Open | 76 | 17.4 | 15.5 | 6.0 | 20 |
| 60 | Open | 93 | 17.4 | 15.5 | 7.5 | 20 |
| 70 | Open | 113 | 17.4 | 15.5 | 8.5 | 20 |
| 45 | Closed | 71 | 17.4 | 15.5 | 4.75 | 10 |
| 55 | Closed | 91 | 17.4 | 15.5 | 6.0 | 10 |
| 75 | Closed | 112 | 17.4 | 15.5 | 7.5 | 10 |
| 85 | Closed | 135 | 17.4 | 15.5 | 8.5 | 10 |
| 40L | Open | 97 | 17.4 | 23.6 | 4.75 | 20 |
| 50L | Open | 115 | 17.4 | 23.6 | 6.0 | 20 |
| 70L | Open | 174 | 17.4 | 23.6 | 8.5 | 20 |
| 45L | Closed | 109 | 17.4 | 23.6 | 4.75 | 10 |
| 55L | Closed | 138 | 17.4 | 23.6 | 6.0 | 10 |
| 85L | Closed | 207 | 17.4 | 23.6 | 8.5 | 10 |
| *\*Block height may vary based on local manufacture’s capabilities.* | | | | | | |

**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 standard for sizing geotextile for these applications is AASHTO M-288, Permanent Erosion Control. Either woven or non-woven geotextile are acceptable, as long as they meet the other project requirements.

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 geotextile shall be finished to prevent the outer fiber from pulling away from the geotextile.

The Contractor shall furnish manufacturer's certified test results to the EOR, 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, UV radiation, and temperatures greater than 140°F. To the extent possible, the fabric shall be maintained wrapped in its protective covering. The geotextile shall not be exposed to sunlight or UV radiation until the installation process begins.

## TABLE 2. PHYSICAL REQUIREMENTS

|  |  |  |  |
| --- | --- | --- | --- |
| **Physical Property** | **Test Procedure** | **Minimum Value** |  |
| Grab Tensile Strength  (Unaged Geotextile) | ASTM D4632 | *IAW AASHTO M288 Class 2* |  |
| Breaking Elongation  (Unaged Geotextile) | ASTM D4632 | 50% max.  (in any principal direction) |  |
| Burst Strength | ASTM D3786 | *IAW AASHTO M288 Class 2* |  |
| Puncture Strength | ASTM D4833 | *IAW AASHTO M288 Class 2* |  |
| A.O.S., U.S. Std. Sieve | ASTM D4751 |  | *Specified by EOR* |
| Permittivity | ASTM D4491 |  |

Final acceptance of the filtration geotextile must be made by the EOR based on project specific soil information. Soil characteristics such as grain size distribution, permeability, 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 may require the performance of further sieve and possible hydrometer testing at the discretion of the EOR. The locations for which the material to be tested is extracted shall be approved by the EOR. The Contractor shall provide the site-specific soil and modified proctor curves for the site soil, at his own expense, to the manufacturer. Also, the contractor 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 EOR.

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, placing a filter fabric patch over the damaged area prior to placing the mats shall repair a torn or punctured section of fabric. The patch shall be large enough to overlap a minimum of three (3) feet in all directions.

**FOUNDATION PREPARATION, GEOTEXTILE AND PLACEMENT**

**Subgrade Preparation**

**General:** All subgrade preparation shall be performed in accordance with *ASTM D 6884, Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems*, as updated and amended.

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

**Inspection:** Immediately prior to placing the filter fabric and articulating 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.

**Placement of Geotextile Filter Fabric**

**General:** All placement and preparation should be performed in accordance with *ASTM D 6884, Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems,* as updated and amended. Filter Fabric, or filtration geotextile, as specified elsewhere, will be placed within the limits of ACBs 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 articulating 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 three (3) feet. The geotextile shall extend at least one foot beyond the top and bottom revetment termination points. If articulating 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 articulating concrete mats unless the space is concrete filled.

**Placement of Articulating Concrete Blocks**

**General:** ACB placement and preparation should be performed in accordance with *ASTM D 6884, Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems*, as amended and updated. Articulating concrete blocks, as specified in Part 2 of these Specifications, shall be constructed within the specified lines and grades shown on the Contract Drawings.

**Placement:** The articulating 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 articulating concrete blocks shall protrude more than one-half inch or as otherwise specified by the Engineer. To ensure that the articulating 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.

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 articulating 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 articulating concrete blocks with non-completed anchor and/or toe trenches shall be permitted at any time.

**Finishing:** The cells or openings in the articulating 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 articulating 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.

**Consultation:** The manufacturer of the articulating concrete blocks shall provide design and construction advice during the design and initial installation phases of the project when required. The ACB supplier shall provide, at a minimum, one full day or two half-days of on-site project support upon request.