

ARTICULATING CONCRETE BLOCK (ACB) SYSTEM SPECIFICATIONS - ARMORFLEX®

NOTE TO SPECIFIERS:

THE PURPOSE OF THIS GUIDE SPECIFICATION IS TO ASSIST THE SPECIFIER IN DEVELOPING A PROJECT SPECIFICATION FOR THE USE OF ARTICULATING CONCRETE BLOCK SYSTEMS. THIS GUIDE DOCUMENT IS INTENDED TO BE PART OF A COMPLETE PROJECT MANUAL; IT IS NOT INTENDED TO BE A "STAND ALONE" DOCUMENT.

THIS GUIDE SPECIFICATION WILL NEED TO BE CAREFULLY REVIEWED FOR APPROPRIATENESS FOR THE GIVEN PROJECT AND EDITED ACCORDINGLY TO COMPLY WITH PROJECT-SPECIFIC REQUIREMENTS. PLEASE CONTACT AN ARMORTEC REPRESENTATIVE WITHIN CONTECH FOR ASSISTANCE IN EDITING THIS DOCUMENT.

DELETE THE FOREGOING TEXT PRIOR TO PUBLISHING IN A PROJECT DESIGN MANUAL.

PART 1 GENERAL

1.1 SCOPE OF WORK

- A. 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.

1.2 RELATED SECTIONS

- A. Section 03 61 00 – Cementitious Grouting
- B. Section 31 22 00 – Grading
- C. Section 31 35 19.16 – Geotextile Slope Protection

1.3 SUBMITTALS

- A. Submit under provisions of Section 01 30 00 - Administrative Requirements.
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Certification of successful completion of full-scale laboratory testing in accordance with the current version of ASTM D 7277, *Standard Test Method for Performance Testing of Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow*. This certification shall comprise a final test report from the testing facility, or a summary test report from the testing facility providing the test procedure and the obtained Critical Shear Stress parameters of the tested block. Third-party testimonies of compliance shall not be sufficient to satisfy this requirement.
 - 2. Certified analysis and interpretation of the test data shall conform to the guidance contained in the current version of ASTM D 7276, *Standard Guide for Analysis and Interpretation of Test Data for Articulating Concrete Block (ACB) Revetment Systems in Open Channel Flow*.
 - 3. The following information obtained from the above testing, analysis, and interpretation:
 - a. Tested bed slope
 - b. Maximum discharge attained prior to failure
 - c. Measured water surface elevation
 - d. Calculated energy grade line (EGL)
 - e. Plot of the applied shear and velocity by station
 - f. An illustration of the selected control volume on a profile of the test slope
 - g. Calculated design Manning's n
 - h. Calculated block system coefficient of Lift
 - i. Characteristic block properties including weight and moment arms
 - j. Extrapolation of tested values to thicker block (if required)

C. Factor of Safety (FoS) calculations in support of the proposed ACB system

1. In accordance with the Factor-of-Safety design methodology as described in *"Moment Stability Analysis Method for Determining Safety Factors for Articulated Concrete Blocks"*, by Amanda L. Cox, 2010.
2. Stamped and signed by a Professional Engineer licensed to practice in the state where the project is located.
3. The following project specific hydraulic requirements are to be utilized:

Property	Value
Channel Bottom Width (ft)	
Channel Side Slopes (H:1V)	
Channel Bed Slope (ft/ft)	
Design Volumetric Flow Rate (cfs)	

4. The analysis shall be performed based upon the stability of the ACBs due to gravity alone, conservatively neglecting any stabilizing forces potentially provided by cabling, mechanical anchorage, contact with adjacent blocks, or other restraints not attributable to gravity alone.
 5. 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. For block that is tapered (i.e., the block thickness is greater on the downstream edge than on the upstream edge, by at least 0.5"), this block projection value may be 0 inches for analysis purposes.
- D. An appropriate geotextile, selected for the site being protected on the basis of the gradation and permeability of the surface soils.
- E. Manufacturer's certificates of compliance for ACB/mats, revetment cable, geotextile, and any revetment cable fittings and connectors in accordance with the current version of *ASTM D 6884, Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems*.
- F. Shop Drawings for the layout of the mats, installation, and safety instructions, and any recommendations, if applicable, that are specifically related to the project.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Suppliers must own and operate their own manufacturing facility.
2. Suppliers shall directly employ a minimum of five (5) registered Professional Engineers.
3. A list of five (5) comparable projects, in terms of size and applications, in the United States, where the satisfactory performance of the specific ACB system can be verified after a minimum of five (5) years of service life.
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.

B. Installer Qualifications: Minimum 2 year experience installing similar products.

1.5 PRE-INSTALLATION MEETINGS

- A. Supplier's representative shall be available for pre-installation meeting a minimum two weeks prior to starting work of this section.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Materials delivered to the site shall be inspected for damage, unloaded and stored with the minimum of handling. Material shall be kept free of dirt and debris.
- B. Storage shall be in accordance with manufacturer's requirements.
- C. Handling: Materials shall be handled in such a manner as to ensure delivery to the site in sound, undamaged condition.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturers:
 ArmorFlex® as manufactured and sold by:
 ARMORTEC, a Contech Company
 9025 Centre Pointe Dr., Suite 400
 West Chester, OH 45069
 P: 800-645-7000
 F: 513-645-7993
www.conteches.com/Products/Erosion-Control/Hard-Armor/ArmorFlex
- B. Substitutions: Not permitted.

2.2 MATERIALS

- A. Articulating Concrete Blocks
 - 1. Manufacturing shall conform to the current version of ASTM D-6684, *Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Revetment Systems*.
 - 2. Cementitious Materials - Materials shall conform to the following applicable ASTM specifications:
 - a. Portland Cements - Specification C 150, for Portland Cement.
 - b. Blended Cements - Specification C 595, for Blended Hydraulic Cements.
 - c. Hydrated Lime Types - Specification C 207, for Hydrated Lime Types.
 - d. Pozzolans - Specification C 618, for Fly Ash and Raw or Calcined Natural Pozzolans for use in Portland Cement Concrete.
 - e. Aggregates – Specification C 33, for Concrete Aggregates, except that grading requirements shall not necessarily apply.
 - 3. Casting: The ACB units shall be produced using 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.
 - 4. Physical Requirements: At the time of delivery to the work site, the ACB units shall conform to the physical requirements prescribed in Table listed below.

PHYSICAL REQUIREMENTS

Compressive Strength Net Area Min. p.s.i (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)	9.1 (160)	11.7 (192)

- 5. Visual Inspection
 - a. All units shall be sound and free of defects which would interfere with the proper placement of the unit, or which would 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.
 - b. 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.
 - c. 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 upon request at the expense of the contractor.
- 6. Sampling and Testing
 - a. The purchaser (or their authorized representative) shall be afforded 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.
 - b. 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.

B. Revetment Cables and Fittings

- 1. Option 1. Polyester Revetment Cable and Fittings
 - a. Revetment cable shall be constructed of high tenacity, low elongating, and continuous filament polyester fibers. Cable shall consist of a core construction comprised of parallel fibers contained within an outer jacket or cover.
 - b. The size of the revetment cable shall be selected such that the minimum acceptable strength is at least five (5) times that required for lifting of the mats, in accordance with ASTM D-6684 paragraph 5.5.2. This design shall include a reduction factor for splicing of 60%, unless a larger factor can be substantiated by laboratory testing.
 - c. The revetment cable shall exhibit resistance to most concentrated acids, alkalis and solvents. Cable shall be impervious to rot, mildew and degradation associated with marine organisms. The materials used in the construction of the cable shall not be affected by continuous immersion in fresh or salt water.
 - d. Selection of cable and fittings shall be made in a manner that ensures a safe design factor for mats being lifted from both ends, thereby forming a catenary. Consideration shall be taken for the bending of the cables around hooks or pins during lifting. Fittings such as sleeves and stops shall be aluminum and washers shall be plastic unless otherwise shown on the Contract Drawings.
- 2. Option 2. Galvanized Steel Revetment Cable and Fittings
 - a. Revetment cable shall be constructed of preformed galvanized aircraft cable (GAC). 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.
 - b. Cable shall consist of a core construction comprised of seven (7) wires wrapped within seven (7) or nineteen (19) wire strands.
 - c. The size of the revetment cable shall be selected such that the minimum acceptable strength is at least five (5) times that required for lifting of the mats, in accordance with ASTM D-6684 paragraph 5.5.2. This design shall include a reduction factor for splicing of 75%, unless a larger factor can be substantiated by laboratory testing.
 - d. The revetment cable shall exhibit resistance to mild concentrations of acids, alkalis, and solvents. Fittings such as sleeves and stops shall be aluminum, and the washers shall be galvanized steel or plastic. Furthermore, depending on material availability, the cable type (7x7 or 7x19) can be interchanged while always ensuring the required factor of safety for the cable.
 - e. Selection of cable and fittings shall be made in a manner that insures a safe

design factor for mats being lifted from both ends, thereby forming a catenary. Consideration shall be taken for the bending of the cables around hooks or pins during lifting. Fittings such as sleeves and stops shall be aluminum and washers shall be plastic unless otherwise shown on the Contract Drawings.

C. Filter Fabric

1. The standard for sizing geotextile for these applications is AASHTO M-288, Permanent Erosion Control, Class 2. Either woven monofilament or non-woven geotextile are acceptable; woven slit-film geotextiles are not acceptable.
2. Geotextile shall be sized for the soil subgrade permeability per Section 31 35 19.16 – Geotextile Slope Protection.
3. Under no circumstances shall the filter fabric be permanently affixed or otherwise adhered to the blocks or mats; i.e., the filter fabric shall be independent of the block system.
4. 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. Geotextile exposure to sunlight or UV radiation shall be minimized to the greatest extent possible until the installation process begins.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

- A. All subgrade preparation shall be performed in accordance with the current version of ASTM D 6884, *Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems*.
- B. 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 individual ACBs. 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 0.5 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 EOR.
- C. Excavation and preparation for all termination trenches or aprons shall be done in accordance to the lines, grades and dimensions shown in the Contract Drawings. The termination 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 termination trench hinge-point shall also be graded uniformly to assure intimate contact between all ACBs and the underlying grade at the hinge-point.
- D. Immediately prior to placing the filter fabric and ACB mats, the prepared subgrade shall be inspected by the EOR 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.

3.2 PLACEMENT OF GEOTEXTILE FILTER FABRIC

- A. All placement and preparation should be performed in accordance with the current version of ASTM D 6884, *Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems*. Filter Fabric, or filtration geotextile, as specified elsewhere, will be placed within the limits of ACBs shown on the Contract Drawings.

- B. The filtration geotextile will be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile will not be walked on or disturbed when the result is a loss of intimate contact between the ACB and the geotextile or between the geotextile and the subgrade. The geotextile filter fabric will be placed so that the upstream strip of fabric overlaps the downstream strip. The longitudinal and transverse joints will be overlapped at least one and a half (1.5) feet for dry installations and at least three (3) feet for below-water installations. The geotextile will extend at least one (1) foot beyond the top and bottom revetment termination points, or as required by the EOR. If ACBs 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 ACB mats unless the space is concrete filled.

3.3 PLACEMENT OF THE ACBs/MATS

- A. ACB placement and preparation should be performed in accordance with the current version of ASTM D 6884, *Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems*. ACB block/mats, as specified in Part 2:A of these Specifications, will be constructed within the specified lines and grades shown on the Contract Drawings.
- B. Field installation shall be consistent with the way the system was installed in preparation for hydraulic testing pursuant to the current version of 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.
- C. The subgrade shall be prepared in such a manner as to produce a smooth plane surface prior to placement of the ACBs or mats. No individual block within the plane of placed ACBs will protrude more than 0.5 inches or as otherwise specified by the EOR. ACBs should be flush and develop intimate contact with the subgrade section, as approved by the EOR. Proposed hand placing is only to be used in limited areas, specifically identified by the EOR or manufacturers' mat layout drawings, as approved by the EOR.
- D. If assembled and placed as large mattresses, the ACB mats will 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 will be placed side-by-side, so that the mats abut each other, and/or end-to-end. Mat seams or openings between mats greater than two (2) inches will be backfilled with 4000 p.s.i. non-shrink grout, concrete or other material approved by the EOR. Whether placed by hand or in large mattresses, distinct changes in grade that results in a discontinuous revetment surface in the direction of flow will require backfill at the grade change location so as to produce a continuous surface.
- E. Termination trenches will be backfilled and compacted flush with the top of the blocks. The integrity of the trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the ACBs for its entire service life. Termination trenches will be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches will be completed in a timely fashion. No more than 500 linear feet of placed ACBs with non-completed termination trenches will be permitted at any time.
- F. The cells or openings in the ACBs will be backfilled and compacted with suitable material, as specified by the EOR. Backfilling and compaction will be completed in a timely manner so that no more than 500 feet of exposed mats exist at any time. Finishing requirements are

explicitly at the discretion of the EOR.

- G. The manufacturer of the ACBs/mats shall provide design and construction advice during the design and initial installation phases of the project when required or as necessary, at the discretion of the EOR. The ACB supplier shall provide, at a minimum, one full day or two half-days of on-site project support upon request.

END OF SECTION