PART 1   GENERAL

1.1   MEASUREMENT AND PAYMENT

Measurement of ACB revetment for payment will be made on the basis of the face area. The pay lines of ACB revetment will be neat lines taken off the approved shop drawings; and will include embedded blocks and anchor trenches. Work includes incidental grading and preparatory work, furnishing and installing the geotextile and ACB, filling the voids, securing cable fasteners, installing soil anchors, and seeding (where specified). Engineering services and product testing shall be incidental, if required. Placing cast-in-place concrete joints and cutting blocks shall be incidental, if required. Payment will be made at the respective unit price per square foot listed on the Bidding Schedule. Payment will be full compensation for all material, labor and equipment to complete the work.

1.2   REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)


1.3   DEFINITIONS

1.3.1   Articulating Concrete Block (ACB) Revetment System

A matrix of interconnected concrete block units for erosion protection. Units are connected by geometric interlock and/or cables, geotextiles, or geogrids, and typically include a geotextile underlayment for subsoil retention.

1.3.2   Blocks
Articulating concrete block revetment units will be referred to as blocks.

1.3.3 Interlocking Blocks

Each pair of abutting blocks shall have interlocking keys that limit lateral expansion. The key and keyhole shall have an interference fit such that the joint movement has a minimum aperture at closure, and a maximum aperture when pulled apart. The joint freeplay shall allow articulation of each individual block.

1.3.4 Freeplay

Freeplay shall be the maximum lateral joint movement for interlocking blocks (difference between maximum and minimum aperture).

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
   Articulated Concrete Block Matress with Anchors

SD-03 Product Data
   Articulating Concrete Block
   Geotextile
   Anchors

SD-04 Samples
   Articulating Concrete Block

SD-06 Test Reports
   Flume Test

1.5 DELIVERY, STORAGE, AND HANDLING

Check products upon delivery to assure that the proper material has been received and is undamaged. For geosynthetics, the guidelines presented in ASTM D4873/D4873M shall be followed.

1.5.1 Blocks

Provide blocks which are sound and free of defects that would interfere with proper placement or that would impair the strength or longevity of the installation. Discard blocks with the following defects:

a. Broken appendages.
b. Chips larger than 2 inches in any dimension.
c. Cracks wider than 0.02 inches and longer than 33 percent of the nominal height.

Minor cracks, incidental to the usual method of manufacture, or chipping
that results from customary methods of handling in shipping, delivery and placement will not be deemed grounds for rejection. Store blocks in a suitable location away from mud, paint, wet cement, and other contamination or disturbance.

1.5.2 Geotextiles

1.5.2.1 Labeling

Label each roll with the manufacturer's name, product identification, roll dimensions, lot number, and date manufactured.

1.5.2.2 Handling

Geosynthetic rolls shall be handled and unloaded by hand, or with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Geosynthetic rolls shall not be dragged, lifted by one end, lifted by cables or chains, or dropped to the ground.

1.5.2.3 Storage

Protect geotextiles from cement, paint, excessive mud, chemicals, sparks and flames, temperatures in excess of 160 degrees F, and any other environmental condition that may degrade the physical properties. If stored outdoors, the rolls shall be elevated from the ground surface and protected with an opaque waterproof cover. Geotextiles shall be delivered to the site in a dry and undamaged condition.

1.6 SCHEDULING

To limit ultraviolet light exposure of the geotextile, place the blocks within 7 days after placing the geotextile, and the void filler within 14 days after placing the geotextile.

PART 2 PRODUCTS

2.1 ARTICULATING CONCRETE BLOCK

Submit descriptive technical data on the blocks, cables, cable fittings, soil anchors, and geotextile. Include all material properties specified under paragraph PRODUCTS. Catalog cuts, technical data sheets, or test data shall be submitted showing that the products meet the specifications. The submittal shall also include a copy of any standard manufacturer's warranties for the products. See below under "geotextile" for more requirements. The ACB shall meet the following criteria:

<table>
<thead>
<tr>
<th>TABLE 1. ACB Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
</tr>
<tr>
<td>Matrix Assembly: [Cabled System]</td>
</tr>
<tr>
<td>Thickness, minimum</td>
</tr>
<tr>
<td>Net Weight/Area, minimum</td>
</tr>
</tbody>
</table>
**TABLE 1. ACB Requirements**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Required Value</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Shear Stress, minimum</td>
<td>[3.5 psf]</td>
<td>FHWA RD-89-199</td>
</tr>
<tr>
<td>Critical Velocity, minimum</td>
<td>15 ft/sec</td>
<td>FHWA RD-89-199</td>
</tr>
<tr>
<td>Curvature Radius, maximum</td>
<td>3 feet</td>
<td>Note b.</td>
</tr>
<tr>
<td>Surface Void Area Ratio</td>
<td>20 percent</td>
<td>Note c.</td>
</tr>
<tr>
<td>Drainage Correction Factor (DCF)</td>
<td>20 - 35 percent</td>
<td>Note d.</td>
</tr>
<tr>
<td>Block/Geotextile Interface Friction Angle</td>
<td>[35 degrees]</td>
<td>Note e.</td>
</tr>
</tbody>
</table>

a. Determine the weight of the mattress per unit area with the nominal joint spacing, in a non-submerged condition.

b. The curvature radius shall be indicative of the ability of the assembled mattress to conform to one dimensional subgrade curves without binding, such as for anchor trenches and swales. The curvature radius shall be demonstrated, if requested by the Contracting Officer.

c. The surface void area ratio shall be determined at the visible (with filled voids) surface of the blocks, with the joints spaced in a neutral position (50 percent), and shall be expressed as a percentage of the gross mat area. The void area shall include area between the blocks and open cells within the block.

d. The drainage correction factor shall be the minimum void area ratio (usually taken at the base of the blocks), with the joints spaced in a neutral position (50 percent freeplay in each direction), and shall be expressed as a percentage of the gross mat area.

e. The concrete surface shall be sufficiently rough to prevent sliding of the blocks on the geotextile. The interface friction must be matched with the selected block and geotextile combination, and shall be included with the ACB and Geotextile Data submittal. The block/geotextile interface friction angle shall be demonstrated, if requested by the Contracting Officer.

2.1.1 Hydraulic Stability

2.1.1.1 Flume Test

Submit a report of testing for the ACB in substantial conformance with FHWA RD-89-199, except that a drainage layer is not required, at the same time as the ACB and Geotextile Data submittal. The report shall clearly state if the critical shear stress associated with the stability threshold of the ACB system was derived from laboratory testing that included a sub-block drainage layer as a component of the tested system. The ACB product shall have been tested in a flume chamber in substantial conformance with FHWA RD-89-199. If the product was tested with a drainage layer, the installed product shall incorporate a similar drainage layer with adequate filtration design for the site soils. The flume test shall be based on conservative assumptions for field placement of the blocks (such as block orientation, and joint spacing within construction.
tolerances). The critical shear stress (and critical velocity) shall be indicated in the test report.

2.1.1.2 Extrapolation of Hydraulic Stability

Extrapolation of critical shear stress for untested blocks within a similar family of ACB shall be subject to limitations. Extrapolation shall only be used for blocks having a similar footprint area and interlock mechanism, but with variable thickness or net weight/area. Extrapolation shall only be accepted if the following conditions are met:

a. The extrapolation is in strict accordance with hydraulic similitude methods commonly accepted by the industry, and includes quantitative treatment for a block overturning failure mode.

b. The tested block is the smaller product size in both thickness and net weight/area, and extrapolation does not extend the critical velocity more than 10 feet per second from the tested product size.

2.1.2 Matrix Assembly - Cabled Systems

Cable tied concrete block shall be interconnected by flexible cables running through the blocks. Each block shall be penetrated by a cable that allows articulation of the blocks, but restrains removal of individual blocks. Void filler shall be placed to inhibit lateral movement, cover the geotextile, and increase hydraulic stability. Articulating concrete block, cables, and fittings shall be fabricated into mattresses at the manufacturer's plant.

2.1.3 Structural requirements

Articulating concrete block shall be wet cast using concrete as specified herein, or dry-cast by a vibratory block forming machine. The blocks shall be manufactured to the following requirements:

2.1.3.1 Compressive Strength

The minimum compressive strength shall be 4000 psi for an average of 3 units, and 3500 psi for an individual unit. Compressive strength shall be determined by ASTM C42/C42M for wet cast blocks, or by ASTM C140/C140M for dry cast blocks.

2.1.3.2 Water Absorption for Dry Cast Units

The maximum water absorption for dry cast units shall be 9 pcf for an average of 3 units, and 12 pcf for an individual unit. Water absorption shall be determined by ASTM C140/C140M.

2.1.3.3 Saturated Surface-Dry Density

The minimum saturated surface-dry density shall be 140 for average of 3 units, and 140 for an individual unit.

2.1.3.4 Air Entraining

Wet cast concrete shall be air entrained to contain between 4 and 7 percent total air.

2.2 CABLE
2.2.1 Installation Requirements for Cable

Cable used for preassembled mattresses shall be sufficiently sized and fastened for the size/weight of the assembled mattresses such that the assembled mattresses can be placed in compliance with OSHA standards. The manufacturer shall be responsible for determining the minimum cable strength compatible with the mattress size for safe handling. Cable strength shall be based on a minimum factor of safety of 5, and include appropriate reduction factors for mechanically crimped cable, and other fasteners. If applicable, loading conditions shall include the use of a spreader bar for placing the mattresses.

2.2.2 Anchors

Submit calculations for the anchor pullout capacity. Tabulated manufacturer's data is acceptable, if the embedment soil conditions are applicable to the project site. Anchors shall be selected with an ultimate vertical pullout resistance for the project site soil conditions of at least 400 pounds. Anchors shall be capable of being attached directly to the articulating concrete block mat in a manner which will achieve little or no slack in the cable system or gaps in the articulating concrete block mattress. Anchors shall be attached to the mat in such a manner that they will not be affected by tampering or vandalism. Anchors shall have the capability of being load-tested to the specified pull-out capacity.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

Place the ACB revetment on undisturbed native soils, or acceptably placed and compacted fill. Do not place the ACB on surfaces that contain mud, frost, organic soils, embankment that has not met compaction requirements, or where the Contracting Officer determines that unsatisfactory material remains in or under the subgrade.

3.1.1 Bank Grading

Grading shall be finished to a smooth surface, typical of that obtainable with a dozer and blade. A rough surface typically obtained with a backhoe or dragline will not be acceptable, except when ACB placement in water is shown on the drawings or approved by the Contracting Officer.

3.2 BLOCK INSTALLATION

All placement of blocks shall be in accordance with the manufacturer's recommendations and the Contractor's approved shop drawings. Submit drawings showing details of the ACB and Geotextile Installation, including the block layout patterns in relation to the feature alignment.

3.2.1 Placement of Pre-Assembled Mattresses

Placement of pre-assembled mattresses shall be done with mattresses attached to a spreader bar to aid in lifting, aligning and placing the mattresses. The mattresses shall be placed directly into position, with a maximum space or gap between mattresses of 1 inches in excess of the nominal joint spacing of blocks within the mattress. Mattresses out of alignment shall be lifted and reset. Mattresses shall not be pushed or pulled laterally after they are in contact with the geotextile. No overlapping of mats will be accepted and no blocks shall project vertically.
more than 1 inch beyond the adjacent blocks.

3.3 ANCHORS

Anchors shall be carefully positioned for attachment to the articulating concrete block. Rigid shafts shall align with the ACB cables. Flexible anchors (cables, etc.) shall be linear between the ACB fastener and the restraining device before tensioning. Penetrations in the geotextile to allow for penetration of the anchor shall be sealed.

3.4 QUALITY CONTROL TESTING

The following testing shall be performed independent of the manufacturing process, by an agency other than the manufacturer. The ACB blocks shall be sampled and tested for compressive strength, water absorption and unit weight. The sample frequency shall be 3 specimens for each 3000 SY. Test methods shall be consistent with those specified in PART 2 PRODUCTS.

-- End of Section --