

Special Specification 4153

Interlocking Articulating Concrete Blocks



1. DESCRIPTION

Furnish and install interlocking articulating concrete blocks and geotextile fabric underlayment, Woven Wire Mesh and percussion driven earth anchors to provide an erosion control matrix.

2. DEFINITION

Interlocking Articulating Concrete Blocks (IACB). Adjacent concrete blocks that fit together in such a manner that they cannot be laterally pulled apart in any horizontal direction. The blocks lift vertically to disengage them from the adjoining blocks. The blocks are held together as a result of the geometric shape of the blocks, parallel strands of cable must be inserted through two (2) cable ducts in each block allowing for longitudinal binding of the units within the Articulated Concrete block system, and include woven wire mesh to spread anchor loading and protect the geotextile underlayment. The geotextile underlayment provides for subsoil retention.

Percussion Driven Earth Anchors (PDEA). Lightweight corrosion resistant anchor system that does not disturb the soil during installation. The PDEA's are placed in a 4ft by 4ft grid pattern within the limits of the IACB's, driven perpendicular to the proposed slope, and connected to the IACB's cables. PDEAs are to be used as ballast against uplift or movement of the IACB's.

3. MATERIALS

Interlocking Articulating Concrete Blocks. Provide individual grid blocks consisting of a homogeneous mass of consolidated concrete. Ensure they are machine-made by a vibration and compression process and are composed of approved aggregates with a no-slump concrete mix produced by a dry cast method. Use mix water that is clean, fresh, and free from oil, acids, soluble salts, and organic impurities. Manufacture in accordance with ASTM D 6684.

Use cement conforming to ASTM C 150.

Use aggregates conforming to ASTM C 33.

When potentially reactive aggregates are used, replace 25% to 35% of the cement with a Class F fly ash meeting the requirements of the Departmental Material Specification DMS-8900, "Fly Ash" or replace 50% of the cement with Grade 100 or Grade 120 Ground Granular Blast Furnace (GGBF) slag meeting the requirements of ASTM C 989. Use Type II cement in sulfate or salt-water environments.

Provide the manufacturer's Hydraulic Stability Test Report that complies with the test procedures under the Federal Highway Guideline Report FHWA-RD-88-181 or FHWA-RD-89-199 to determine the system's critical shear stress value. Install the anchoring devices such as, duckbill anchors, cables, etc., used in the hydraulic stability test procedure in the field, in the same manner in which they were used during the hydraulic stability testing. Extrapolation of test data derived from testing smaller blocks or other methods is not allowed.

Provide IACB's that meet or exceed the type stated on the plans.

Provide IACB meeting the physical requirements in Table 1.

Table 1
Minimum Block Physical Requirements

Compressive Strength (min)	4000 lbs./sq. in. @ 28 days	ASTM C140
Water Absorption (ma)	7%	ASTM C140
Specific Weight (min)	130 lbs./cu. ft.	ASTM C140
Minimum Critical Shear Stress	4 lbs./ sq. ft. or as shown on the plans	
Percentage Open Area	As shown on the plans	

Before installation of the blocks, submit the following product information for review and approval of equivalent blocks:

- Block Dimensions (L,W,H),
- Block weight and submerged weight,
- Block moment arms (for use in calculation of block stability factor of safety by FHWA NHI 01-003, HEC 23, "Bridge Scour and Stream Instability Countermeasures," Latest Edition), and
- Block critical shear stress, πc

IACB's will only be accepted when accompanied by documented hydraulic performance characteristics that are derived from tests under controlled flow conditions. Testing must 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 will 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 must 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.

All units will 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, will not be deemed grounds for rejection. Cracks exceeding 0.25 in (.635 cm) in width and/or 1.0 inch (2.54 cm) in depth will be deemed grounds for rejection. Chipping resulting in a weight loss exceeding 10% of the average weight of a concrete unit will be deemed grounds for rejection.

- 3.1. **Revetment Cable.** Supply IACB with cables pre-manufactured as an assembly of concrete blocks when connected into mattresses by the use of revetment cables. Extend the revetment cable through 2 or more tunnels in each block in a manner that provides for binding of the mattresses in both the longitudinal and lateral directions. Use a cable conforming to ASTM D 4268-93. Fabricate the IACB mats at the manufacturer's plant or another approved location, into mattresses with a width of up to 8 ft. and a length of up to 20 ft.

Construct polyester revetment cable of high tenacity, low elongating continuous filament polyester fibers. Provide cable consisting of a core construction comprised of parallel fibers contained within an outer jacket or cover. Ensure the weight of the parallel core is within 65% to 70% of the total weight of the cable. Provide revetment cable with the following minimum characteristics: nominal 30 mm diameter cable, 10,000 lb. approximate average strength, 6.6 lb./100 ft. and the elongation requirements shown in Table 2.

Table 2
Elongation Requirement

Elongation Requirement (based upon stabilized new, dry cable)	% Breaking Strength		
	10%	20%	30%
Water Absorption (ma)	10%	20%	30%
Permanent Elongation (while working)	0.7	1.8	2.6
Elastic Elongation	0.6	1.4	2.2
Total Stretch	1.3	3.2	4.8

Use revetment cable exhibiting good to excellent resistance to most concentrated acids, alkalis, and solvents. Also, use cable impervious to rot, mildew, and degradation associated with marine organisms. Ensure the materials used in the construction of the cable are not affected by continuous immersion in fresh or salt water.

Select cables and fittings made in a manner that ensures a safe design factor for mattresses being lifted from both ends, thereby forming a catenary. Consider the bending of the cables around hooks or pins during lifting. Select revetment cable splicing fittings so that the resultant splice provides a minimum of 75% of the minimum rated cable strength. Provide fittings such as sleeves, stops, and washers in accordance with the manufacturer's recommendations unless otherwise shown.

- 3.2. **Filter Fabric Underlayment.** Use Type 2 filter fabric as defined by DMS-6200, "Filter Fabric," or of the type and properties as specified on the plans or approved equivalent.

The filter fabric should be inert to chemicals commonly encountered in natural water and soil conditions. When woven filter fabric is used, the side edges of the filter fabric panels should be salvaged or otherwise finished as to prevent filaments from pulling away from the edges.

During periods of shipment and storage, protect the filter fabric from direct sunlight, ultraviolet rays, and temperatures greater than 140°F. Keep the filter fabric in its protective covering. If the filter fabric protective covering is damaged or removed, immediately cover the filter fabric with an opaque tarp or move the filter fabric to an indoor storage facility.

Filter fabric will be rejected at the time of installation, as determined by the Engineer, if removed from its protective cover for over 72 hr., or has defects, tears, punctures or shows deterioration or damage incurred during manufacture, transportation or storage.

- 3.3. **Percussion Driven Earth Anchor.** Use materials that conform to ISO 9001 and the following criteria:

- Anchor: Galvanized Cast Iron Anchor (ultimate load capacity of 4,200 lbs)
- Lower Termination: stainless steel soft eye including copper ferrule
- Wire Tendon: 6-millimeter Grade 316 stainless steel round strand wire
- Top Accessory: 6" round 11 gauge Stainless Steel Load Plate
- Top Termination: 6-millimeter stainless steel cable clamp (aka "rope grips")

The installer must submit a record of at least one (1) previous successful PDEA installation in similar conditions by the same manufacturer or a certificate of completion of training of the installation crew by the PDEA manufacturer.

- 3.4. **Woven Wire Mesh.** Furnish double twisted wire mesh in accordance with ASTM A975 section 6.1.1 Style 1 or section 6.1.2 Style 2. Wire used for manufacturing of rolled mesh and lacing wire must have a maximum tensile strength of 70,000 psi (485 MPa) as per ASTM A856/A856M, soft temper steel. All tests on wire must be performed before manufacturing the mesh and must comply with ASTM A975 requirements.

- Nominal Mesh Opening: 2.5 in.
- Mesh Tensile Strength: 2.300 lb/ft.
- Mesh Connection to Selvedge: 700 lb/ft.
- Punch Test 4,000 lbs.
- Mesh Wire diameter: 0.087 in.

- Seldedge Wire: diameter 0.106 in.
- Lacing wire diameter: 0.087 in.

4. CONSTRUCTION

- 4.1. **Earthwork.** Construct the areas where placing the filter fabric, wire mesh and IACB's to the lines and grades as shown on the plans. Where such areas are below the allowable grade, place and compact these areas to grade in layers not exceeding 8 in. of the selected material. Use the depth of layers and amount of compaction necessary to obtain a density equal to the adjoining undisturbed soil. Remove obstructions, such as but not limited to, roots, lumps, and projecting stones larger than one inch. Remove soft or low-density pockets of material and fill the resulting void with select, compacted material. Use a compaction of 90% or greater of the optimum value as determined by Test Method Tex-114-E.

Construct the finished sub-grade to exhibit a raked, rolled, or otherwise smooth planer profile within 0 in. to 0.5 in. tolerance within a 10 ft. straightedge from established sub-grade elevation shown on the plans or as approved by the Engineer.

Immediately before placing the filter fabric, wire mesh and the IACB, Engineer will inspect the prepared area. Do not place filter fabric or blocks until the Engineer approves that area. Before placing blocks, perform any necessary repairs to the finished grade at no expense to the Department.

- 4.2. **Placing Filter Fabric.** Place the filter fabric directly on the prepared area. Overlap the longitudinal and transverse joints a minimum of 2 ft. Insert the securing staples, as needed, through both strips of overlapped fabric along one line through the midpoint of the overlap to temporarily hold the filter fabric panels in place until the IACB can be placed. Place only 200 sq. ft. or less of filter fabric before covering with the IACB. If the filter fabric is installed and not covered with the IACB for more than 2 days, lift the blocks and inspect the surface of the slope for slope defects. Lift uncovered filter fabric after a heavy rainfall and inspect the area for slope damage.

Place the filter fabric directly on the prepared area. Place the fabric smoothly on the subgrade minimizing tension, stress, folds, and wrinkles.

After placing, do not unnecessarily walk on or disturb the filter fabric unless required to preserve contact with the subgrade. Do not allow equipment on unprotected filter fabric. Protect the fabric from binding, clogging, tears, and other damage while installing.

Place the filter fabric strips from downstream to upstream. Overlap successive filter fabric sheets such that the upstream sheet is placed over the downstream sheet or the upslope sheet is placed over the downslope sheet. Overlap adjoining fabric sections a minimum of 2 ft.

Replace or repair, at no additional cost, fabric damaged while placing the blocks, as directed. Repair all torn, punctured, or otherwise damaged areas by placing a fabric patch of the same material over the area and extending it a minimum of 3 ft. beyond the perimeter of the tear or damage. Orient the patch material so that its fibers are aligned with the damaged filter fabric fibers.

- 4.3. **Placing Woven Wire Mesh.** Place woven wire mesh directly on filter fabric. Protect the filter fabric from binding, clogging, tears, and other damage while installing the wire mesh. Place the wire mesh in strips from upstream to downstream following the filter fabric. Lace adjoining strips using lacing wire or stainless-steel ring fasteners. Spacing of the rings must be in accordance with ASTM A975 Table 2, Panel to Panel connection, Pull-Apart Resistance. Ring fasteners spacing must not exceed 6 in. Ring diameter must be 0.118 in.

- 4.4. **Placing Interlocking Articulating Concrete Blocks (IACB).** Place the IACB individually on the filter fabric to produce a continually interlocking surface free from field seams and on non-interlocked connections

except as approved by the Engineer, or as shown on the plans. Construct the IACB to the specified lines and grades shown on the plans. The Engineer will make final acceptance and approval of the installation.

If shown on the plans, backfill the voids of the IACB with seeded and fertilized topsoil. Before placing the topsoil, inspect the concrete blocks for damage. Replace and grout individual concrete blocks which are cracked and which are reduced in individual block weight by 1/3, before placing the topsoil.

Excavate and prepare foundations for the IACB anchor trenches, toe trenches and aprons, top trenches, upstream termination trenches, and downstream termination trenches as shown on the plans.

- 4.5. **Placing Interlocking Articulating Concrete Blocks (IACB) with Cables.** Place the IACB with cables on the filter fabric in prefabricated mattresses or by individual concrete blocks.

Place individual concrete blocks subject to the spacing and level parameters as specified in prefabricated mattresses. Thread revetment cables into the blocks as the placement proceeds and fasten them with approved sleeves, fittings, or fasteners per the manufacturer's recommendations.

Place prefabricated mattresses with mats attached to a spreader bar or other approved device to aid in lifting and placing 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, or otherwise damaging the bedding layer. Place the mats side by side or end to end, so that the mats totally positive interlock with each other. The maximum allowable space or gap between mattresses is 2 in., except that local wider gaps may be accepted if approved by the Engineer. No overlapping of mats will be accepted, and no blocks may project more than 1 in. beyond the adjacent blocks. Place the mats in accordance with the manufacturer's recommendations and the plan details. As adjacent mats are placed, secure them to each other by connecting the protruding cables together with sleeves. Do not allow ties to protrude beyond the mat surface. Fasten with approved sleeves.

Construct IACB with cables to the specified lines and grades shown on the plans. The Engineer will make final acceptance and approval of the installation.

Excavate and prepare foundations for the IACB with cables anchor trenches, toe trenches, and aprons, top trenches, upstream termination trenches, and downstream termination trenches as shown on the plans.

- 4.6. **Install Percussion Driven Earth Anchors (PDEA).** Install the PDEAs in the pattern and length shown on the plans and to the manufacturer's recommendations.

Do not begin anchor installation until the earthwork in the area where PDEAs are to be installed has been completed and the IACBs has been installed. Do not install any anchors which are bent, cracked, of insufficient length, of reduced cross section due to any reason, or damaged in any way which would decrease the tension load carrying capacity of the anchor. All anchors must be continuous full length without splices.

Driving equipment must be adequate to obtain required embedment depth of the anchor in the subgrade encountered. Anchors must be driven using a percussive/demolition style hammer only.

The Contractor will use only specific hand tools provided by the anchor manufacturer that will not damage the anchor tendon or IACB revetment. These tools include hand held wire kleins for safely gripping the tendon to initially set the anchor, setting plate and/or bobbin (for properly setting the wedge grip, setting plate and bobbin does not apply to top loop assembly). Post tensioning of anchors to be accomplished by use of a tensioning device capable of applying the required tension loads and for load tested PDEAs, including appropriate gauges to indicate the load applied. Load testing must be performed by the Contractor by means of a hydraulic jack or appropriate tensioning device that includes an appropriate gauge that indicates a certified load in tension. The Contractor will keep a record of all anchors tested and provide a copy of the record to the Engineer.

If refusal is encountered before achieving specified depth, for < 3' depth, care should be taken to attempt to retrieve the anchor by pulling up on the tendon and drive rod at same time. If anchor is retrieved successfully, reposition anchor within 2ft (2ft) from the original location and attempt to drive and set anchor, record and report positioning and load to the Engineer. If anchor cannot be retrieved, record the depth and attempt to gain specified load and report the resulting load to the Engineer.

5. MEASUREMENT

- 5.1. **Interlocking Articulating Concrete Blocks (IACB).** Measurement will be measured by the square foot, complete in place.
- 5.2. **Interlocking Articulating Concrete Blocks (IACB) with Cables.** Measurement will be measured by the square foot, complete in place.

6. PAYMENT

The work performed, and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Interlocking Articulating Concrete Blocks" or "Interlocking Articulating Concrete Blocks with Cables," of the size specified. This price is full compensation for furnishing the materials, tools, equipment, labor, and incidentals (including filter fabric underlayment, woven wire mesh and percussion driven earth anchors) necessary to complete the work.

If required, furnishing and placing the topsoil, fertilizer, and seeding will be measured and paid for by the pertinent bid items.