HYDROTEX™

Specification Guideline

Fabric-formed Concrete Erosion Control Systems

HYDROCAST™ Armor Units

Product Description

HYDROCAST Armor Units are monolithic concrete structures which replace heavy rip rap and large precast concrete armor units, such as tetrapods. The rectangular fabric forms, when filled, assume a flattened cylindrical cross section and range in size from roughly 180 pounds to in excess of 70 tons per unit (80-64,000 kg). Available in custom sizes and shapes, the dimensions of the form control the concrete armor unit's length, width, height, and weight.

Armor Units have the mass and stability for the construction of gravity seawalls and revetments, groins, levees, dikes, dams, check dams, and other civil and marine structures subject to attack by waves or rapidly flowing water. Since they are filled in place, they adapt to variations in the subgrade and are ideal for preventing or repairing scour at bridge piers and abutments.

HYDROCAST installations do not require dewatering, a crucial advantage in emergency repair situations. Fabric forms can be positioned and filled from the surface in shallow water or by divers in deeper water.

HYDROCAST forms save time by simplifying many construction and repair jobs and save money by eliminating heavy equipment and forming and stripping of conventional concrete forms. Compared to rip rap, HYDROCAST forms are far easier and less expensive to deploy. This factor becomes especially critical when sensitive ecological zones, wetlands or poor soil conditions make moving heavy equipment to the site difficult or impossible.

1.0 GENERAL

1.1 Scope of Work: The Contractor shall furnish all labor, materials, equipment, and incidentals required to perform all operations in connection with the installation of the proposed HYDROCAST Armor Units in accordance with the lines, grades, design, and dimensions shown on the Contract Drawings and as specified herein.

1.2 Description: The work shall consist of installing a concrete armor unit structure by positioning specially woven, double-layer synthetic fabric forms on the surface to be protected and filling them with a pumpable, fine aggregate concrete (structural grout) in such a way as to form armor units of required thickness, weight and configuration.

2.0 MATERIALS REQUIREMENTS

2.1 Fine Aggregate Concrete: Fine aggregate concrete shall consist of a mixture of Portland cement, fine aggregate (sand) and water so proportioned and mixed as to provide a pumpable fine aggregate concrete. Pozzolan, fluidifier or pumping aid conforming to this Specification may be used at the option of the Contractor. The mix shall exhibit a compressive strength of 2,000 lb/in^2 (13.8 MPa) at 28 days, when made and tested in accordance with ASTM C 31 and C 39.

2.1.1 Portland cement shall conform to ASTM C 150, Type I or Type II.

2.1.2 Fine aggregate shall conform to ASTM C 33, except as to grading. Aggregate grading shall be reasonably consistent and shall not exceed the maximum size which can be conveniently handled with available pumping equipment.

2.1.3 Water for mixing shall be clean and free from injurious amounts of oil, acid, salt, alkali, organic matter or other deleterious substances.

PROPERTY REQUIREMENTS - HYDROCAST ARMOR UNIT FABRIC[1, 2]				
Property		**Test Method**	**Units**	**Values**
Physical:				
Composition of Yarns				Nylon or polyester
Mass Per Unit Area (double-layer)		ASTM D 5261	oz/yd^2 (g/m^2)	14 (470)
Thickness		ASTM D 5199	mils (mm)	28 (0.7)
Mill Width			in (m)	76 (1.92)
Mechanical:				
Wide-Width Strip Tensile Strength	- Machine	ASTM D 4595	lbf/in (kN/m)	190 (33.2)
	- Cross		lbf/in (kN/m)	140 (24.5)
Elongation at Break	- Machine	ASTM D 4595	%	20
	- Cross		%	30
Trapezoidal Tear Strength	- Machine	ASTM D 4533	lbf (N)	180 (800)
	- Cross		lbf (N)	115 (510)
Hydraulic:				
Apparent Opening Size (AOS)		ASTM D 4751	U.S. Standard Sieve (mm)	60 (0.250)
Flow Rate		ASTM D 4491	gal/min/ft^2 (l/min/m^2)	50 (2035)

Notes:

1. *Conformance of fabric to specification property requirements shall be based on ASTM D 4759, "Practice for Determining the Specification Conformance of Geotextiles."*
2. *All numerical values represent minimum average roll values (i.e., average of test results from any sample roll in a lot shall meet or exceed the minimum values). Lots shall be sampled according to ASTM D 4354, "Practice for Sampling of Geosynthetics for Testing."*

2.1.4 Pozzolan, if used, shall conform to ASTM C 618, Class C, F or N.

2.1.5 Plasticizing and air entraining admixtures, if used, shall conform to ASTM C 494 and ASTM C 260, respectively.

2.2 Fabric Forms: The fabric forms shall be as specified, HYDROCAST™ (see Note A) forms as manufactured by Geostar Corporation; 74 Perimeter Center East, Suite 7420; Atlanta, Georgia 30346-1803, Tel: 800.253.0561 (770.399.5051); or approved equal. The fabric forms shall be composed of synthetic yarns formed into a woven fabric. Yarns used in the manufacture of the fabric shall be composed of nylon and/or polyester. Forms shall be woven with a minimum of 50% textured yarns (by weight) to improve adhesion to fine aggregate concrete and to improve filtration. Partially-oriented (POY), draw-textured, and/or staple yarns shall not be used in the manufacture of the fabric. Each layer of fabric shall conform to the physical, mechanical and hydraulic requirements referenced herein. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

Note A: The engineer shall indicate the filled armor unit size required. Example: 240 inches x 58 inches x 24 inches (6100 mm x 1475 mm x 610 mm).

2.2.1 Fabric forms shall consist of two layers of woven fabric sewn together. When filled with fine aggregate concrete they shall form a concrete armor unit with finished average unit dimensions of _____ inches (mm) x _____ inches (mm) x _____ inches (mm) in thickness and a nominal unit volume of _____ lb/ft^3 (kg/m^3).

Note B: Tables 1.0 and 2.0 provide guidance on filled versus unfilled armor unit sizes and contained volumes.

2.2.2 Self-sealing filling valves, suitable for use with an injection pipe at the end of a pump hose for fine aggregate concrete, shall be installed at predetermined locations.

2.2.3 Mill widths of fabric shall be a minimum of 76 inches (1.92 m). Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 1.35 inches (35 mm) by adding a minimum of 6 warp yarns to each selvage construction. Mill width rolls shall be cut to the length required, and the two layers of fabric separately joined, bottom layer to bottom layer and top layer to top layer, by means of sewing thread, to form multiple mill width panels.

2.2.4 All seams sewn in the factory shall be not less than 90 lbf/in (15.7 kN/m) when tested in accordance with ASTM D 4884. All sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. All stitches shall be sewn simultaneously and be parallel to each other,

spaced between 0.25 inches (6 mm) to 0.75 inches (19 mm) apart. Each row of stitching shall consist of 4 to 7 stitches per inch (per 25.4 mm). Thread used for seaming shall be nylon and/or polyester.

2.2.5 Fabric Form Shipment and Storage: The fabric forms shall be kept dry and wrapped such that they are protected from the elements during shipping and storage. If stored outdoors, they shall be elevated and protected with a waterproof cover that is opaque to ultraviolet light. The fabric forms shall be labeled as per ASTM D 4873, "Guide for Identification, Storage and Handling of Geosynthetic Rolls."

2.2.6 The Contractor shall submit a manufacturer's certificate that the supplied fabric forms meet the criteria of these Specifications, as measured in full accordance with the test methods and standards referenced herein. The certificates shall include the following information about each fabric form delivered:

Manufacturer's name and current address;
full product name;
style and product code number;
form number(s);
composition of yarns; and
manufacturer's certification statement.

2.3 Filter Fabrics: The filter fabrics shall be composed of synthetic fibers or yarns formed into a nonwoven or woven fabric. Fibers and yarns used in the manufacture of filter fabrics shall be composed of at least 85% by weight of polypropylene, polyester or polyethylene. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages. These materials shall conform to the physical requirements shown below. The filter fabric shall be free of defects or flaws which significantly affect its mechanical or hydraulic properties.

PROPERTY REQUIREMENTS - FILTER FABRICS [1, 2]			
Property	**Test Method**	**Units**	**Values**
Grab Tensile Strength	ASTM D 4632	lbf (N)	90 (400)
Elongation at Break	ASTM D 4632	%	15
Trapezoidal Tear Strength	ASTM D 4533	lbf (N)	30 (130)
Permittivity	ASTM D 4491	sec^{-1}	0.5

Notes:

1. *Conformance of filter fabrics to specification property requirements shall be based on ASTM D 4759, "Practice for Determining the Specification Conformance of Geotextiles."*
2. *All numerical values represent minimum average roll values (i.e., average of test results from any sample roll in a lot shall meet or exceed the minimum values). Lots shall be sampled according to ASTM D 4354, "Practice for Sampling of Geosynthetics for Testing."*

3.0 DESIGN REQUIREMENTS

Note C: Select the appropriate pair of paragraphs for the final specification based upon the type of hydraulic application.

The average thickness, mass per unit area and hydraulic resistance of each concrete unit shall withstand the hydraulic loadings (velocity, depth, duration, shear stress, pressure, and frequency of immersion) for the design discharges along the structure(s). The stability analysis for each concrete unit shall be accomplished using a factor-of-safety methodology. A minimum factor of safety of 1.5 shall be required.

The Contractor shall provide to the Engineer calculations and design details, provided by the manufacturer or a professional engineer, attesting to the suitability of each fabric-formed concrete unit or structure for the purpose contemplated. Each concrete unit shall be accepted only when accompanied by hydraulic stability calculations derived from mathematical models developed specifically for this purpose.

or

The average thickness, mass per unit area and hydraulic resistance of each concrete unit shall withstand the hydraulic loadings (depth, duration, type of wave, wave height and period, and pressure distribution) for the design wave. The stability analysis for the concrete units shall be accomplished using the factor-of-safety methodology. A minimum factor of safety of 1.5 shall be required.

The Contractor shall provide to the Engineer calculations and design details, provided by the manufacturer or a professional engineer, attesting to the suitability of each fabric-formed concrete unit or structure for the purpose contemplated. Each concrete unit shall be accepted only when accompanied by hydraulic stability calculations derived from mathematical models developed specifically for this purpose.

4.0 CONSTRUCTION AND INSTALLATION REQUIREMENTS

4.1 Site Preparation

4.1.1 Areas on which fabric forms are to be placed shall be constructed to the lines, grades, contours, and dimensions shown on the Contract Drawings. All obstructions such as roots and projecting stones shall be removed. Where such areas are below the allowable grades, they shall be brought to grade by placing compacted layers of select material. The thickness of layers and the amount of compaction shall be as specified by the Engineer. Where required by the Contract Specifications, soft and otherwise unsuitable subgrade soils shall be

identified, excavated and replaced with select materials in accordance with the Contract Specifications.

4.1.2 Excavation and preparation of aprons as well as anchor, terminal or toe trenches shall be done in accordance with the lines, grades, contours, and dimensions shown on the Contract Drawings.

4.1.3 Immediately prior to placing the fabric forms, the prepared area shall be inspected by the Engineer, and no forms shall be placed thereon until the area has been approved.

4.2 Fabric Form Placement

4.2.1 Whenever specified, a filter fabric shall be placed on the graded surface approved by the Engineer. If a filter fabric is not required, fabric forms shall be placed directly on the prepared subgrade.

4.2.2 Fabric forms shall be placed within the limits shown on the Contract Drawings.

4.2.3 Immediately prior to filling with fine aggregate concrete, the assembled fabric forms shall be inspected by the Engineer, and no fine aggregate concrete shall be pumped therein until the fabric form placement has been approved. At no time shall the fabric forms be exposed to ultraviolet light (including direct sunlight) for a period exceeding five days.

4.3 Fine Aggregate Concrete Placement

4.3.1 Following the placement of the fabric form, the filling pipe at the end of the fine aggregate concrete pump hose shall be inserted through the self-sealing filling valve. Fine aggregate concrete shall be pumped between the top and bottom layers of fabric, filling the forms to the recommended thickness and configuration.

4.3.2 Fine aggregate concrete shall be pumped in such a way that excessive pressure on the fabric forms is avoided.

4.3.3 Foot traffic on the filled armor units shall be restricted to an absolute minimum for one hour after filling.

4.3.4 Abutting armor units, if placed laterally, may be installed immediately after placement of the preceding unit(s). If an armor unit is to bear on previously installed units, the lower units must be allotted a minimum of four hours of cure time before beginning installation of a succeeding, vertically adjacent course of armor units.

4.3.5 Adjacent armor units shall be joined by inserting reinforcement bar dowels or staples into the armor units, as shown on the Contract Drawings. Dowels or staples shall be inserted into the filled unit(s) not less than one half hour and not more than one hour after filling of the unit, unless directed otherwise by the Engineer. In the event that a unit will be vertically adjacent to another unit, reinforcing dowels shall be driven into the lower unit in the time frames specified in this paragraph. The vertically adjacent fabric form will then be placed over the reinforcing dowels. The dowels will be forced through the bottom layer of the vertically adjacent fabric form prior to filling that form.

4.3.6 After the fine aggregate concrete has set, all anchor, terminal and toe trenches shall be backfilled and compacted, as specified by the Engineer.

4.3.7 The HYDROCAST Armor Unit shall be measured by the number of cubic feet (cubic meters) computed from the payment lines shown on the Contract Drawings or from payment lines established in writing by the Engineer. This includes Armor Unit fabric forms, fine aggregate concrete, and filter fabric used in the aprons, overlaps, and anchor, terminal, or toe trenches. Site preparation, excavation and backfilling, and bedding are separate pay items.

Table 1.0 Unfilled Fabric Form Width/Length to Filled Thickness and Width/Length of Armor Unit

Filled Thick-ness	Width/Length of Unfilled Fabric Forms																
inches **meters**	24 0.61	30 0.76	36 0.91	42 1.07	48 1.22	54 1.37	60 1.52	66 1.68	72 1.83	78 1.96	84 2.13	90 2.29	96 2.44	102 2.59	108 2.74	114 2.90	120 3.05
	Width/Length of Filled Fabric Forms																
6 **0.15**	21 0.52	27 0.68	33 0.83	39 0.98	45 1.13	51 1.28	57 1.14	63 1.59	69 1.74	75 1.89	81 2.05	87 2.20	93 2.35	99 2.50	105 2.66	111 2.81	117 2.96
9 **0.23**	19 0.48	25 0.63	31 0.78	37 0.94	43 1.09	49 1.24	55 1.39	61 1.55	67 1.70	73 1.85	79 2.00	85 2.16	91 2.31	97 2.46	103 2.61	109 2.77	115 2.92
12 **0.30**	17 0.44	23 0.59	29 0.74	35 0.89	41 1.05	47 1.20	53 1.35	59 1.50	65 1.66	71 1.81	77 1.96	83 2.11	89 2.26	95 2.42	101 2.57	107 2.72	113 2.87
15 **0.38**		21 0.52	27 0.68	33 0.83	39 0.98	45 1.13	51 1.28	57 1.44	63 1.59	69 1.74	75 1.89	81 2.05	87 2.20	93 2.35	99 2.50	105 2.66	111 2.81
18 **0.46**			26 0.65	32 0.81	38 0.96	44 1.11	50 1.26	56 1.42	62 1.57	68 1.72	74 1.87	80 2.03	86 2.18	92 2.33	98 2.48	104 2.63	110 2.79
21 **0.53**				30 0.76	36 0.92	42 1.07	48 1.22	54 1.37	60 1.52	66 1.68	72 1.83	78 1.98	84 2.13	90 2.29	96 2.44	102 2.59	108 2.74
24 **0.61**					34 0.87	40 1.02	46 1.18	52 1.33	58 1.48	64 1.63	70 1.79	76 1.94	82 2.09	88 2.24	94 2.40	100 2.55	106 2.70
27 **0.69**						39 0.98	45 1.13	51 1.29	57 1.44	63 1.59	69 1.74	75 1.90	81 2.05	87 2.20	93 2.16	99 2.31	105 2.66
30 **0.76**							43 1.09	49 1.24	55 1.39	61 1.55	67 1.70	73 1.85	79 2.00	85 2.16	91 2.31	97 2.46	103 2.61
33 **0.84**								47 1.20	53 1.35	59 1.50	65 1.66	71 1.81	77 1.96	83 2.11	89 2.27	95 2.42	101 2.57
36 **0.91**									51 1.31	57 1.46	63 1.61	69 1.76	75 1.92	81 2.07	87 2.22	93 2.37	99 2.53
39 **0.99**										56 1.42	62 1.57	68 1.72	74 1.87	80 2.03	86 2.18	92 2.33	98 2.48
42 **1.07**											60 1.53	66 1.68	72 1.83	78 1.98	84 2.14	90 2.29	96 2.44
45 **1.14**												64 1.63	70 1.79	76 1.94	82 2.09	88 2.24	94 2.40
48 **1.22**													69 1.74	75 1.90	81 2.05	87 2.20	93 2.35

Note: Values shown are typical and will vary with weight of concrete and field conditions.

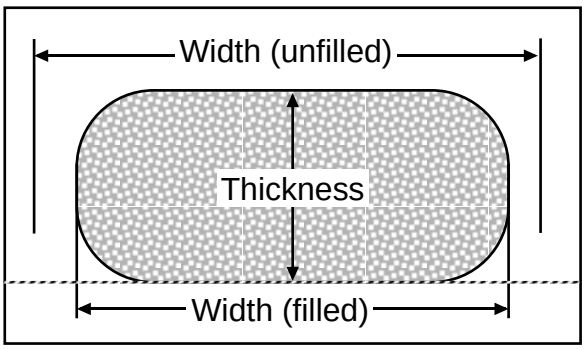

Table 2.0 Unfilled Fabric Form Width to Filled Volume of Armor Unit																	
Filled Thick-ness	**Width of Unfilled Fabric Forms**																
inches meters	24 0.61	30 0.76	36 0.91	42 1.07	48 1.22	54 1.37	60 1.52	66 1.68	72 1.83	78 1.96	84 2.13	90 2.29	96 2.44	102 2.59	108 2.74	114 2.90	120 3.05
	Volume of Concrete - Cubic Feet per Foot of Length (Cubic Meter per Meter of Length)																
6 0.15	0.8 0.07	1.1 0.10	1.3 0.12	1.6 0.15	1.8 0.17	2.1 0.20	2.3 0.21	2.6 0.24	2.8 0.26	3.1 0.29	3.3 0.31	3.6 0.34	3.8 0.35	4.1 0.38	4.3 0.40	4.4 0.41	4.7 0.44
9 0.23	1.1 0.10	1.4 0.13	1.8 0.17	2.2 0.20	2.6 0.24	2.9 0.27	3.3 0.31	3.7 0.34	4.1 0.38	4.4 0.41	4.8 0.45	5.2 0.48	5.6 0.52	5.9 0.55	6.3 0.59	6.7 0.62	7.1 0.66
12 0.30	1.2 0.11	1.7 0.16	2.2 0.20	2.7 0.25	3.2 0.30	3.7 0.34	4.2 0.39	4.7 0.44	5.2 0.48	5.7 0.53	6.5 0.60	6.7 0.62	7.2 0.67	7.7 0.72	8.2 0.76	8.7 0.81	9.2 0.86
15 0.38		1.9 0.18	2.5 0.23	3.1 0.29	3.8 0.35	4.4 0.41	5.0 0.47	5.6 0.52	6.3 0.59	6.9 0.64	7.5 0.70	8.1 0.75	8.8 0.82	9.4 0.87	10.0 0.93	10.6 0.99	11.3 1.05
18 0.46			2.7 0.25	3.5 0.33	4.2 0.39	5.0 0.47	5.7 0.53	6.5 0.60	7.2 0.67	8.0 0.74	8.7 0.81	9.5 0.88	10.2 0.95	11.0 1.02	11.7 1.09	12.5 1.16	13.2 1.23
21 0.53				3.7 0.34	4.6 0.43	5.5 0.51	6.3 0.59	7.2 0.67	8.1 0.75	9.0 0.84	9.8 0.91	10.7 0.99	11.6 1.08	12.5 1.16	13.3 1.24	14.2 1.32	15.1 1.40
24 0.61					4.9 0.46	5.9 0.55	6.9 0.64	7.9 0.73	8.9 0.83	9.9 0.92	10.9 1.01	11.9 1.11	12.9 1.20	13.9 1.29	14.9 1.39	15.9 1.47	16.9 1.57
27 0.69						6.2 0.58	7.3 0.68	8.4 0.78	9.5 0.88	10.7 0.99	11.8 1.10	12.9 1.20	14.0 1.30	15.2 1.41	16.3 1.52	17.4 1.62	18.5 1.72
30 0.76							7.6 0.71	8.8 0.82	10.1 0.94	11.3 1.05	12.6 1.17	13.8 1.28	15.1 1.40	16.3 1.52	17.6 1.64	18.8 1.75	20.1 1.87
33 0.84								9.2 0.86	10.6 0.99	11.9 1.11	13.3 1.24	14.7 1.37	16.1 1.50	17.4 1.62	18.8 1.75	20.2 1.88	21.6 2.00
36 0.91									10.9 1.02	12.4 1.15	13.9 1.29	15.4 1.43	16.9 1.57	18.4 1.71	19.9 1.85	21.4 1.99	22.9 2.13
39 0.99										12.8 1.19	14.5 1.35	16.1 1.50	17.7 1.65	19.3 1.79	21.0 1.95	22.6 2.10	24.2 2.25
42 1.07											14.9 1.39	16.6 1.54	18.4 1.71	20.1 1.87	21.9 2.04	23.6 2.20	25.4 2.36
45 1.14												17.1 1.59	19.0 1.77	20.8 1.93	22.7 2.11	24.6 2.28	26.5 2.46
48 1.22													19.4 1.80	21.4 1.99	23.4 2.18	25.4 2.36	27.4 2.55

Note: Values shown are typical and will vary with weight of concrete and field conditions.

Spec: CAST
Revised December 2001

Hydrotex products are manufactured by:

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