



HYDROTEX™

Specification Guideline

Fabric-formed Concrete Erosion Control Systems

Enviromat™ EB Lining

Table 1.0 Typical Dimensions and Weights

Enviromat	EB300	EB500
Average Thickness, mm	76	127
Mass Per Unit Area, kg/m ²	165	275
Open (vegetated) Area, %	20	20
Concrete Coverage, m ² /m ³	12.1	7.3
Shear Resistance, kg/m ²	59	98

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

Product Description

Enviromat EB Linings are installed to provide protection against periodic high flows. After installation, vegetation can be planted within the open structure of the lining. Enviromat Linings are used in drainage ditches and on the upper slopes of canals, channels, lakes, reservoirs, rivers, and other water courses as well as for embankments subject to heavy runoff. Once installed, they can articulate to compensate for uneven settlement of the underlying soil.

Enviromat EB Linings are comprised of concrete-filled elements and unfilled areas that allow for the establishment of vegetation. Once the concrete sets, the defined, unfilled and interwoven areas (approximately 20% of the total area of the lining) are opened by cutting the fabric and are planted or are filled with topsoil and seeded. Within a growing season a vegetated cover will normally extend over the lining, resulting in an erosion control system with the hydraulic, ecological and aesthetic features desired.

Enviromat EB is installed above the waterline to provide protection against periodic high flows. EB is woven from multifilament and textured yarns.

Enviromat EB concrete linings are formed with a woven double-layer fabric, joined together by large interwoven areas and perimeter bands to form a concrete lining with a matrix of "H" shaped compartments (blocks) in a stacked pattern. The permeable interwoven perimeter of each compartment serves as a hinge to permit articulation of the concrete-filled compartments (blocks) of EB lining, making them adaptive to changes in the underlying soil after installation.

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 Enviromat™ (EB) Lining 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 an unreinforced concrete lining by positioning specially woven, double-layer synthetic 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 a stable lining of required thickness, weight and configuration.

2.0 MATERIALS REQUIREMENTS

2.1 Fine Aggregate Concrete: Fine aggregate concrete shall consist of a proportioned mixture of Portland cement, fine aggregate (sand) and water. The consistency of the fine aggregate concrete delivered to the concrete pump shall be proportioned and mixed as to have an efflux time of 9-12 seconds when passed through the 19 mm orifice of the standard flow cone that is described in ASTM C 939. 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 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 - ENVIROMAT FABRIC^{1, 2}

Property	Test Method	Units	Values
Physical:			
Composition of Yarns			Nylon or polyester
Mass Per Unit Area (double-layer)	ASTM D 5261	g/m ²	403
Thickness	ASTM D 5199	mm	0.6
Mill Width		m	1.92
Mechanical:			
Wide-Width Strip Tensile Strength	- Machine	ASTM D 4595	kN/m
	- Cross		kN/m
Elongation at Break	- Machine	ASTM D 4595	%
	- Cross		%
Trapezoidal Tear Strength	- Machine	ASTM D 4533	N
	- Cross		N
Hydraulic:			
Apparent Opening Size (AOS)	ASTM D 4751	mm	0.425
Flow Rate	ASTM D 4491	l/min/m ²	3665

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, HYDROTEX™ Enviromat (EB) (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 Enviromat EB size required (see Table 1.0). Example: EB400.

2.2.1 Fabric forms shall consist of double-layer woven fabric joined together by spaced, interwoven, single-layer areas and narrow perimeters to form a concrete lining with a finished average thickness of (see Table 1.0) mm and a nominal mass per unit area of (see Table 1.0) kg/m². The "H" shaped compartments shall each be defined by the areas of interwoven, single-layer fabric. The rectangular, interwoven areas shall be ap-

proximately twenty percent of the area of the concrete lining. The interwoven areas within the "H" shape shall form a framework of structural elements with a stacked block pattern. Interwoven areas shall be removed, as specified elsewhere in this Specification, to create an open area for the establishment of vegetation.

2.2.2 Fabric form compartments shall each have six ducts, one on each end of the compartment's legs and one on each of the outer sides of each compartment, to allow passage of the fine aggregate concrete between adjacent compartments. The fine aggregate concrete filled cross sectional area of each duct shall be no more than 19.4 cm².

2.2.3 Mill widths of fabric shall be a minimum of 1.92 meters. Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 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 double-layer 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 with sewn seams on not less than 182 cm centers.

2.2.4 All factory-sewn seams shall be downward facing as shown on the Contract Drawings. All seams sewn in the factory shall be not less than 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 6 and 19 mm apart. Each row of stitching shall consist of 4 to 7 stitches per 25.4 mm. Thread used for seaming shall be nylon and/or polyester.

2.2.5 Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffle material shall be non-woven filter fabric. The grab tensile strength of the filter fabric shall be not less than 400 N when tested in accordance with ASTM D 4632.

2.2.6 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."

2.2.7 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 FABRIC ^{1, 2}			
Property	Test Method	Units	Values
Grab Tensile Strength	ASTM D 4632	N	400
Elongation at Break	ASTM D 4632	%	15
Trapezoidal Tear Strength	ASTM D 4533	N	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 B: 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 lining 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 lining 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 lining for the purpose contemplated. Each concrete lining shall be accepted only when accompanied by hydraulic stability calculations derived from mathematical models developed specifically for fabric formed concrete linings and for this purpose.

or

The average thickness, mass per unit area and hydraulic resistance of each concrete lining 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 lining 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 lining for the purpose contemplated. Each concrete lining shall be accepted only when accompanied by hydraulic stability calculations derived from mathematical models developed specifically for fabric formed concrete linings and 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 and grades 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 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 The 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. Anchoring of the fabric forms shall be accomplished through the use of anchor, terminal and toe trenches.

- 4.2.3 Adjacent fabric forms shall be joined before filling with fine aggregate concrete by field sewing or zippering the two bottom layers of fabric together and the two top layers of fabric together. All field seams shall be made using two lines of U.S. Federal Standard Type 101 stitches. All sewn seams shall be downward facing, and all zipper seams shall be fastened as shown on the Contract Drawings, except with the approval of the Engineer.
- 4.2.4 When conventional joining of fabric forms is impractical or where called for in the Contract Drawings, adjacent forms may be overlapped a minimum of one meter to form a lap joint, pending approval by the Engineer. Based on the predominant flow direction, the downstream edge of the form shall overlap the upstream edge of the next form. In no case shall simple butt joints between forms be permitted.
- 4.2.5 Expansion joints shall be provided as shown on the Contract Drawings, or as specified by the Engineer.
- 4.2.6 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 forms, small slits shall be cut in the top layer of the fabric form to allow the insertion of the filling pipe at the end of the fine aggregate concrete pump hose. These slits shall be of the minimum length to allow proper insertion of the filling pipe. 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 and cold joints are avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given form is discontinued or interrupted for an interval of forty-five or more minutes.
- 4.3.3 Holes in the fabric forms left by the removal of the filling pipe shall be temporarily closed by inserting a piece of nonwoven fabric or similar material. The nonwoven fabric shall be removed when the concrete is no longer fluid and the concrete surface at the hole shall be cleaned and smoothed by hand. Foot traffic on the filled form shall be restricted to an absolute minimum for one hour after filling.
- 4.3.4 After the fine aggregate concrete has set, all anchor, terminal and toe trenches shall be backfilled and compacted, as specified by the Engineer.
- 4.3.5 The interwoven, single-layer areas within the matrix of blocks and above the nominal waterline shall be removed to create an open area that permits the establishment of vegetation within the concrete-filled lining. The narrow perimeter of interwoven, single-layer fabric between abutting blocks shall not be removed. The open areas shall be filled with a topsoil, seed and fertilizer mixture, as specified elsewhere in these Specifications, to the top of the concrete lining. The nominal water line shall be taken as ___ mm above El. _____.
- 4.3.6 The Enviromat (EB) Lining shall be measured by the number of square meters computed from the payment lines shown on the Contract Drawings or from payment lines established in writing by the Engineer. This includes Enviromat (EB) fabric forms, fine aggregate concrete, and filter fabric used in the aprons, overlaps, and anchor, terminal, or toe trenches. Slope preparation, excavation and backfilling, and bedding are separate pay items.

**Spec: EB (siu)
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