EROSION CONTROL LINING SYSTEM SPECIFICATION
UNIFORM SECTION US300 - PET FABRIC FORMED CONCRETE

PART 1.0: GENERAL

1.1 Scope of Work

The work shall consist of furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of the fabric formed concrete erosion control lining systems in accordance with the lines, grades, design, and dimensions shown on the Contract Drawings and as specified herein. If the contractor is inexperienced, then the fabric formed concrete manufacturer's representative shall provide on-site technical assistance at the beginning of the installation for a length of time the contractor is sufficiently experienced to complete the remaining installation.

1.2.1 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 manner as to form a stable lining of required thickness, weight and configuration.

1.3 Referenced Documents

1.3.1 American Society for Testing and Materials (ASTM)

ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or [50-mm] Cardboard Cube Specimens)
ASTM C 150	Standard Specification for Portland Cement
ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete
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ASTM C 685	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM C 1603	Standard Test Method for Measurement of Solids in Water
ASTM D 2061	Standard Test Method of Strength of Zippers
ASTM D 2256	Standard Test Method for Tensile Properties of Yarns by the Single-Strand Method
ASTM D 4354	Practice for Sampling of Geotextiles for Testing
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D 4533	Standard Test Method for Trapezoidal Tearing Strength of Geotextiles
ASTM D 4595	Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method
ASTM D 4632	Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
ASTM D 4751	Test Method for Determining Apparent Opening Size for a Geotextile
ASTM D 4759	Practice for Determining the Specification Conformance of Geotextiles
ASTM D 4873	Standard Guide for Identification, Storage, and Handling of Geotextiles
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ASTM D 5199	Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
ASTM D 5261	Test Method for Measuring Mass per Unit Area of Geotextiles
ASTM D 6241	Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 2-inch [50-mm] Probe
ASTM D 6449	Standard Method for Flow of Fine Aggregate Concrete for Fabric Formed Concrete

1.4 Terminology

For the purpose of these specifications, the following definitions shall apply:

1.4.1 Compaction:

The densification of a soil by means of mechanical manipulation.

1.4.2 Subgrade:

The ground surface usually specially prepared against which lining shall be placed. In cases where lining is to be retained the same shall be considered as subgrade.

1.4.3 Hydrotex™ Fabric Form:

The fabric forms are constructed of woven, double-layer synthetic fabric. HYDROTEX linings are installed by positioning fabric forms over the areas to be protected and then pumping, high-strength, fine aggregate concrete into the forms. The fabric forms can be placed and filled either underwater or in-the-dry. The high-strength, fine aggregate concrete is used in place of conventional concrete because of its pumpability, high-strength, impermeability, and absorption resistance.

1.4.4 Hydrotex™ Uniform Section (US) Lining:

Hydrotex Uniform Section linings provide an erosion resistant, impermeable concrete lining having a brick pattern surface and a relatively low coefficient of hydraulic friction in order to maintain optimum water velocities. The thickness and weight of the lining is controlled by spacer cords.

1.4.5 Baffle:

Baffles are flow-directing vertical geotextile walls constructed between fabric form sections layers. Baffles are an integral part of the fabric form design. Baffles are designed to support the panel section, determine the concrete area of the section and direct the flow of fine aggregate concrete for maximum efficiency.

1.4.6 Slide Fastener (Zipper):

A zipper or zipper like devise having two grooved plastic edges joined by a sliding tab or pull.

1.5 Submittals

1.5.1 The Contractor shall furnish the fine aggregate concrete manufacturer's certificates of compliance, mix design, fine aggregate gradation and fineness modulus for the fine aggregate concrete.

1.5.2 The Contractor shall furnish the fabric form manufacturer's certificates of compliance for the fabric forms. The Contractor shall also furnish the manufacturer's specifications, literature, shop drawings for the layout of the concrete lining panels, and any recommendations, if applicable, that are specifically related to the project.

1.5.3 Alternative fabric formed concrete lining materials may be considered. Such materials must be pre-approved in writing by the Engineer prior to the bid date. Alternative material packages must be submitted to the Engineer a minimum of fourteen (14) days prior to the bid date. Submittal packages must include, as a minimum, the following:

Material testing reports prepared by a certified geotextile laboratory attesting to the alternative fabric form material's compliance with this Specification. Material laboratory testing shall have been performed within ninety (90) days of the bid date.

PART 2:.0 PRODUCT

2.1 General - Fabric Formed Concrete Lining

Fabric formed concrete lining shall be Uniform Section (US300) type and have a finished average thickness of 3 inches, a nominal mass per unit area of 34 lb/ft^2, and a comparatively uniform section with a brick pattern surface appearance. The shear resistance of the concrete lining shall be a minimum of 14 lb/ft^2, as demonstrated by full scale flume testing.

2.2 Fabric Forms

The fabric forms for casting the concrete lining(s) shall be as specified, HYDROTEX® Uniform Section (US300) fabric forms as manufactured by:

Synthetex, LLC; 5550 Triangle Parkway, Suite 220 Peachtree Corners, Georgia 30092
Tel: 800.253.0561 or 770.399.5051
E-Mail: info@synthetex.com

Distributed by: Quick Supply Co., 6620 NW Toni Drive Des Moines, IA 50313, Phone: (515)289-1271, www.quicksupplydm.com

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 polyester. Forms shall be woven with a minimum of 50% textured yarns (by weight). 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 Mean Average Roll Values listed in Table 1.0. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

Table 1.0 PROPERTY REQUIREMENTS – HYDROTEX FABRIC [1, 2]

	Test Method	**Units**	**MARV**
Physical Properties			
Composition of Yarns	-	-	Polyester
Mass Per Unit Area (double-layer)	ASTM D 5261	oz/yd^2	13
Thickness (single-layer)	ASTM D 5199	mils	15
Mill Width (Woven)		inch	84
Mechanical Properties			
Wide-Width Strip Tensile Strength - MD | TD	ASTM D 4595	lbs/inch	300 **|** 350
Elongation at Break - MD **|** TD - Max.		%	15 **|** 15
Trapezoidal Tear Strength - MD | TD	ASTM D 4533	lbs	150 **|** 175
CBR Puncture Strength	ASTM D 6241	lbs	1250
Mullen Burst Strength	ASTM D 3786 (Mod.)	psi	500
	Test Method	**Units**	**MARV Range**
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Standard Sieve	30 - 40

Flow Rate	ASTM D 4491	gal/min/ft^2	30 - 55

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

2.2.1 Fabric forms shall consist of double-layer woven fabric joined together by spaced, interwoven cords of uniform length to form a concrete lining of the specified average thickness. The cords shall be interwoven between the two layers of fabric, in parallel pairs, so that the two (2) cords together in the top layer and two (2) cords together in the bottom layer cross between layers at drop points. Each cord shall have a minimum breaking strength of 160 lbf when tested in accordance with ASTM D 2256.

2.2.2 Mill widths of fabric shall be a minimum of 84 inches. Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 1.35 inches 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 80-inch centers.

2.2.3 Fabric form panels shall be factory-sewn, by jointing together the layers of fabric, top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. Sewn seams shall be downward facing as shown on the Contract Drawings. All sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. All seams sewn shall be not less than 100 lbf/inch when tested in accordance with ASTM D 4884. Both lines of stitches shall be sewn simultaneously and be parallel to each other, spaced between 0.25 inches to 0.75 inches apart. Each row of stitching shall consist of 4 to 7 stitches per inch. Thread used for seaming shall be polyester.

2.2.4 Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffles shall be designed to maintain a full concrete lining thickness along the full length of the baffle. The baffle material shall be nonwoven filter fabric. The grab tensile strength of the filter fabric shall be not less than 180 lbf/inch when tested in accordance with ASTM D 4632.

2.2.5 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.

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 Fine Aggregate Concrete

Fine aggregate concrete consists of a mixture of Portland cement, fine aggregate (sand) and water, so proportioned and mixed as to provide a pumpable fine aggregate concrete.

The water/cement ratio of the fine aggregate concrete shall be determined by the ready-mix manufacturer, but generally should be on the order of 0.65 to 0.70. The pumping of fine aggregate concrete into the fabric forms

causes a reduction in the water content by filtering excess mixing water through the permeable fabric. The reduction of mixing water substantially improves the water/cement ratio of the in-place fine aggregate

concrete thereby increasing its strength and durability. The sand/cement ratio should be determined by the ready-mix manufacturer and should be on the order of 2.4:1.

The consistency of the fine aggregate concrete delivered to the concrete pump should be proportioned and mixed as to have a flow time of 9-15 seconds when passed through the ¾-inch [19 mm] orifice of the standard flow cone that is described in ASTM C6449-99. Additional Pozzolan and/or admixtures may be used with the approval of the Engineer-in-charge. The water/cement ratio varies with the exact granulometry of the fine aggregate (sand) and should be determined by the ready-mix manufacturer using the above referenced flow cone.

The Contractor should demonstrate the suitability by placing the proposed fine aggregate concrete mix into three (3) 2-inch concrete cubes. The mix should exhibit a minimum compressive strength of 3500 psi at 28 days, when made and tested in accordance ASTM C109/C109M-13.

With a typical loss of approximately 15% of the total mixing water, 27 ft^3 of pumpable fine aggregate concrete will reduce to approximately 25 ft^3 of hardened concrete. The mixing water reduction will also result in an increase of approximately 8% in the sand and cement per cubic foot of concrete. The range of fine aggregate concrete mix proportions provided in Table 2.0 has been developed under a variety of field conditions.

Table 2.0 Typical Range of Mix Proportions

Material	Mix Proportions lb/yd^3	After Placement Mix Proportions lb/yd^3
Cement	750-850	805-915
Sand	2120-2030	2290-2190
Water	540-555	460-470
Air	As Required	As Required

2.3.1 Components

2.3.1.1 Portland Cement

Portland cement should conform to ASTM C 150/150M, Type I, II or V. Pozzolan grade fly ash may be substituted for up to 35% of the cement as an aid to pumpability. (The pumpability of fine aggregate concrete mixes containing course sand is improved by the addition of fly ash.) Pozzolan, if used, should conform to ASTM C 618, Class C, F or N.

2.3.1.2 Fine Aggregate (sand)

Fine aggregate should consist of suitable clean, hard, strong and durable natural or manufactured sand. It should not contain dust, lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack any embedded steel, neoprene, rubber, plastic, etc. Motorized sand washing machines should be used to remove impurities from the fine aggregate. Fine aggregate having positive alkali-silica reaction should not be used. All fine aggregates should conform to ASTM C33/C33M-13. The fine aggregate should not have more than 45% passing any sieve and retained on the next consecutive sieve of those shown in Table 3.0. The fineness modulus of fine aggregate should neither be less than 2.3 nor greater than 3.1. Fine aggregate with grading near the minimum for passing the No. 50 and No. 100 sometimes have difficulties with workability or pumping. The additions of entrained air, additional cement, or the addition of an approved mineral admixture to supply the deficient fines, are methods used to alleviate such difficulties.

ASTM C33/C33M-13 defines the requirements for grading and quality of fine aggregate for use in fine aggregate concrete and is for use by a contractor as part of the purchase document describing the material to be furnished.

Table 3.0 Grading Requirement for Fine Aggregate

Sieve	Percent by Weight Passing the Sieve
9.5-mm (3/8-in.)	100
4.75-mm (No. 4)	95 to 100
2.36-mm (No. 8)	80 to 100
1.18-mm (No. 16)	50 to 85
600-µm (No. 30)	25 to 60
300-µm (No. 50)	5 to 30
150-µm (No. 100)	0 to 10
75-µm (No. 200)	0 to 3

Fine aggregate failing to meet these grading requirements can be utilized provided that the supplier can demonstrate to the specifier that fine aggregate concrete of the class specified, made with fine aggregate under consideration, will have relevant properties at least equal to those of fine aggregate concrete made with same ingredients, with the exception that the referenced fine aggregate will be selected from a source having an acceptable performance record in similar fine aggregate construction.

2.3.1.3 Water

Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.

Potable water is permitted to be used as mixing water in fine aggregate concrete without testing for conformance with the requirements of ASTM C1602/C1602M-12.

ASTM C1602/C1602M-12 covers the compositional and performance requirements for water used as mixing water in hydraulic cement fine aggregate concrete. It defines sources of water and provides requirements and testing frequencies for qualified individual or combined water sources.

2.3.2 Plasticizing and Air Entraining Admixtures

Grout fluidifier, water reducing or set time controlling agents may be used as recommended by their manufacturers to improve the pumpability and set time of the fine aggregate concrete.

Any air entraining agent or any other admixture may be used, as approved, by the Engineer-in-charge to increase workability, to make concrete impervious and more durable. Air entraining admixture should conform to ASTM C494/C494M and ASTM C260/C260M, respectively. Mixes designed with 5% to 8% air content will improve the pumpability of the fine aggregate concrete, freeze-thaw and sulfate resistance of the hardened concrete.

2.4 Geotextile Filter Fabrics

2.4.1 The geotextile 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. The geotextile shall be free of defects or flaws which significantly affect its mechanical or hydraulic properties.

2.4.2 The geotextile filter fabric must be permitted to function properly by allowing relief of hydrostatic pressure; therefore fine soil particles shall not be allowed to clog the geotextile. The geotextile filter fabric shall be as specified elsewhere in the Contract Specifications. Final acceptance of the geotextile filter fabric by the Engineer shall be based on project specific soil information, provided by the Contractor/Owner. The geotextile filter shall meet the minimum physical requirements listed in Table 5 or greater as required by the Engineer based on site soil conditions.

2.4.3 The geotextile filter fabric 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.

Table 5.0 MINIMUM PROPERTY REQUIREMENTS – FILTER FABRIC

	Test Method	Units	Minimum Value
Mechanical Properties			
Grab Tensile Strength	ASTM D 4632	lbf	180 (in any principal direction)
Elongation at Break	ASTM D 4632	%	50 max. (in any principal direction)
Trapezoidal Tear Strength	ASTM D 4533	lbf	75 (in any principal direction)
Puncture Strength	ASTM D 4833	lbs	105 (in any principal direction)
CBR Puncture Strength	ASTM D 6241	lbs	475 (in any principal direction)
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	US Sieve	As Specified Elsewhere in the Contract Specifications
Permittivity	ASTM D 4491	sec^{-1}	As Specified Elsewhere in the Contract Specifications
Flow Rate	ASTM D 4491	$gal/min/ft^2$	As Specified Elsewhere in the Contract Specifications

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

PART 3.0: DESIGN REQUIREMENTS

3.1 Certification (Open Channel Flow)

3.1.1 Fabric formed concrete lining will only be accepted when accompanied by documented full-scale hydraulic flume performance characteristics that are derived from tests under controlled flow conditions. Test guidelines shall conform to testing protocol as documented in “Hydraulic Stability of Fabric Formed Concrete Lining and Mat Systems During Overtopping Flow.”

3.1.2 The average thickness, mass per unit area and hydraulic resistance of each concrete lining shall withstand the hydraulic loadings 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 1.3 shall be required or higher as determined by lock conditions or critical structures.

3.2 Performance (Open Channel Flow)

3.2.1 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 the documented hydraulic performance characteristics derived from full-scale flume tests performed under controlled flow conditions.

PART 4.0: CONSTRUCTION AND INSTALLATION REQUIREMENTS

4.1 Site Preparation - Grading

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. The areas shall be graded and uniformly compacted to a smooth plane surface with an allowable tolerance of plus or minus 0.2 feet from bottom grade, as long as ponding does not occur, and plus or minus 0.2 foot from a side slope grade as long as humps or pockets are removed.

4.1.2 The areas shall be free of organic material and obstructions such as roots and projecting stones and grade stakes shall be removed. 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. Where 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.

4.1.3 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.

4.1.4 The terminal edges of the fabric form lining should be keyed into the subgrade to the lines, grades, and dimensions shown on the Contract Drawings.

4.2 Inspection

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.

4.3 Geotextile Filter Fabric Placement

4.3.1 The geotextile filter baric shall be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile filter fabric shall be placed so that the upstream roll of fabric overlaps the downstream roll. The longitudinal and transverse joints will be overlapped at least two (2) feet. The geotextile will extend at least one (1) foot beyond the top and bottom concrete lining termination points, or as required by the Engineer.

4.3.2 A geotextile filter fabric, as specified elsewhere, shall be placed on the graded surface approved by the Engineer.

4.4 Fabric Form Placement

4.4.1 Factory assembled fabric form panels shall be placed over the geotextile filter fabric and within the limits shown on the Contract Drawings. Perimeter termination of the fabric forms shall be accomplished through

the use of anchor, flank and toe trenches, as shown on the Contract Drawings. When placing panels an allowance for approximately 10% contraction of the form in each direction which will occur as a result of fine aggregate concrete filling. The contractor shall gather and fold the additional slope direction fabric form in the anchor trench to be secured in such a manners as to be gradually released as fabric forms contract during filling. The contractor shall gather the additional transverse direction fabric form at each baffle for self release during filling.

4.4.2 Adjacent fabric form panels shall be joined in the field by means of sewing or zippering closures. Adjacent panels shall be joined top layers to top layer and bottom layer to bottom. All field seams shall be made using two lines of U.S. Federal Standard Type 101 stitches. All sewn seams shall be downward facing.

4.4.3 When conventional joining of fabric forms is impractical or where called for on the Contract Drawings, adjacent forms may be overlapped a minimum of 3 ft to form a lap joint, pending approval by the Engineer. Based on the predominant flow direction, the upstream form shall overlap the downstream form. In no case shall simple butt joints between forms be permitted. Simple butt joints between panels shall not be allowed.

4.4.4 Expansion joints shall be provided as shown on the Contract Drawings, or as specified by the Engineer.

4.4.5 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 seams have been approved. At no time shall the unfilled fabric forms be exposed to ultraviolet light (including direct sunlight) for a period exceeding five (5) days.

4.5 **Fine Aggregate Concrete Placement**

4.5.1 Following the placement of the fabric forms over the geotextile filter fabric, fine aggregate concrete shall be pumped between the top and bottom layers of the fabric form through small slits to be cut in the top layer of the fabric form or manufacturer supplied valves. The slits shall be of the minimum length to allow proper insertion of a filling pipe inserted at the end of a 2-inch I.D. concrete pump hose. Fine aggregate concrete shall be pumped between the top and bottom layers of fabric, filling the forms to the recommended thickness and configuration.

Holes in the fabric forms left by the removal of the filling pipe shall be temporarily closed by inserting a piece of fabric. The 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.

4.5.2 Fine aggregate concrete coverage for US300 shall net 100 ft^2/yd^3 (see Section 2.3).

4.5.3 Fine aggregate concrete shall be pumped in such a manner that excessive pressure on the fabric forms is avoided. Consultation with the fabric form manufacturer with regard to the selection of grout/concrete pumps is recommended.

4.5.4 Cold joints shall be avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given section of form is discontinued or interrupted for an interval of forty-five (45) or more minutes.

4.5.5 The sequence of fine aggregate concrete shall be such as to ensure complete filling of the fabric formed concrete lining to the thickness specified by the Engineer. The flow of the fine aggregate concrete shall first be directed into the lower edge of the fabric form and working back up the slope, followed by redirecting the flow into the anchor trench.

4.5.6 Prior to removing the filling pipe from the current concrete lining section and proceeding to the fine aggregate concrete filling of the adjacent lining section, the thickness of the current lining section shall be measured by inserting a length of stiff wire through the lining at several locations from the crest to the toe of the slope. The average of all thickness measurements shall be not less than the specified average thickness

4.5.7 of the concrete lining. Should the measurements not meet the specified average thickness, pumping shall continue until the specified average thickness has been attained.

4.5.8 Excessive fine aggregate concrete that has inadvertently spilled on the concrete lining surface shall be removed. The use of a high-pressure water hose to remove spilled fine aggregate concrete from the surface of the freshly pumped concrete lining shall not be permitted.

4.5.9 Foot traffic will not be permitted on the freshly pumped concrete lining when such traffic will cause permanent indentations in the lining surface. Walk boards shall be used where necessary.

4.5.10 After the fine aggregate concrete has set, all anchor, flank and toe trenches shall be backfilled and compacted flush with the top of the concrete lining. The integrity of the trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the concrete lining for its entire service life. Toe trenches shall be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches shall be completed in a timely fashion to protect the completed concrete lining. No more than five hundred (500) linear feet of pumped concrete lining with non-completed anchor, anchor, flank, or toe trenches will be permitted at any time.

PART 5.0: Method of Measurement

The fabric formed concrete erosion control lining shall be measured by the number of square feet or yards computed from the lines and cross sections shown on the Contract Drawings or from payment lines established in writing by the Engineer. This includes fabric forms, fine aggregate concrete, and filter fabric used in the aprons, overlaps, anchor, terminal, or toe trenches. Slope preparation, excavation and backfilling, and bedding are separate pay items.

Hydrotex products are manufactured and sold by:

Synthetex, LLC
5550 Triangle Parkway, Suite 220
Peachtree Corners, GA 30092
Tel: 1.800.253.0561 or 770.399.5051
Fax: 770.394.5999
www.synthetex.com • e-mail: info@synthetex.com

Section _____

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The ground surface usually specially prepared against which lining shall be placed. In cases where lining is to be retained the same shall be considered as subgrade.

1.4.3 Hydrotex™ Fabric Form:

The fabric forms are constructed of woven, double-layer synthetic fabric. HYDROTEX linings are installed by positioning fabric forms over the areas to be protected and then pumping, high-strength, fine aggregate concrete into the forms. The fabric forms can be placed and filled either underwater or in-the-dry. The high-strength, fine aggregate concrete is used in place of conventional concrete because of its pumpability, high-strength, impermeability, and absorption resistance.

1.4.4 Hydrotex™ Uniform Section (US) Lining:

Hydrotex Uniform Section linings provide an erosion resistant, impermeable concrete lining having a brick pattern surface and a relatively low coefficient of hydraulic friction in order to maintain optimum water velocities. The thickness and weight of the lining is controlled by spacer cords.

1.4.5 Baffle:

Baffles are flow-directing vertical geotextile walls constructed between fabric form sections layers. Baffles are an integral part of the fabric form design. Baffles are designed to support the panel section, determine the concrete area of the section and direct the flow of fine aggregate concrete for maximum efficiency.

1.4.6 Slide Fastener (Zipper):

A zipper or zipper like devise having two grooved plastic edges joined by a sliding tab or pull.

1.5 Submittals

1.5.1 The Contractor shall furnish the fine aggregate concrete manufacturer's certificates of compliance, mix design, fine aggregate gradation and fineness modulus for the fine aggregate concrete.

1.5.2 The Contractor shall furnish the fabric form manufacturer's certificates of compliance for the fabric forms. The Contractor shall also furnish the manufacturer's specifications, literature, shop drawings for the layout of the concrete lining panels, and any recommendations, if applicable, that are specifically related to the project.

1.5.3 Alternative fabric formed concrete lining materials may be considered. Such materials must be pre-approved in writing by the Engineer prior to the bid date. Alternative material packages must be submitted to the Engineer a minimum of fourteen (14) days prior to the bid date. Submittal packages must include, as a minimum, the following:

Material testing reports prepared by a certified geotextile laboratory attesting to the alternative fabric form material's compliance with this Specification. Material laboratory testing shall have been performed within ninety (90) days of the bid date.

PART 2:.0 PRODUCT

2.1 General - Fabric Formed Concrete Lining

Fabric formed concrete lining shall be Uniform Section (US400) type and have a finished average thickness of 4 inches, a nominal mass per unit area of 45 lb/ft^2, and a comparatively uniform section with a brick pattern

surface appearance. The shear resistance of the concrete lining shall be a minimum of 14 lb/ft^2, as demonstrated by full scale flume testing.

2.2 Fabric Forms

The fabric forms for casting the concrete lining(s) shall be as specified, HYDROTEX® Uniform Section (US400) fabric forms as manufactured by:

Synthetex, LLC; 5550 Triangle Parkway, Suite 220 Peachtree Corners, Georgia 30092
Tel: 800.253.0561 or 770.399.5051
E-Mail: info@synthetex.com

Distributed by: Quick Supply Co., 6620 NW Toni Drive Des Moines, IA 50313, Phone: (515)289-1271, www.quicksupplydm.com

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 polyester. Forms shall be woven with a minimum of 50% textured yarns (by weight). 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 Mean Average Roll Values listed in Table 1.0. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

Table 1.0 PROPERTY REQUIREMENTS – HYDROTEX FABRIC [1, 2]

	Test Method	**Units**	**MARV**
Physical Properties			
Composition of Yarns	-	-	Polyester
Mass Per Unit Area (double-layer)	ASTM D 5261	oz/yd^2	13
Thickness (single-layer)	ASTM D 5199	mils	15
Mill Width (Woven)		inch	84
Mechanical Properties			
Wide-Width Strip Tensile Strength - MD | TD	ASTM D 4595	lbs/inch	300 **|** 350
Elongation at Break - MD **|** TD - Max.		%	15 **|** 15
Trapezoidal Tear Strength - MD | TD	ASTM D 4533	lbs	150 **|** 175
CBR Puncture Strength	ASTM D 6241	lbs	1250
Mullen Burst Strength	ASTM D 3786 (Mod.)	psi	500
	Test Method	**Units**	**MARV Range**
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Standard Sieve	30 - 40
Flow Rate	ASTM D 4491	gal/min/ft^2	30 - 55

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

2.2.1 Fabric forms shall consist of double-layer woven fabric joined together by spaced, interwoven cords of uniform length to form a concrete lining of the specified average thickness. The cords shall be interwoven between the two layers of fabric, in parallel pairs, so that the two (2) cords together in the top layer and two (2) cords together in the bottom layer cross between layers at drop points. Each cord shall have a minimum breaking strength of 160 lbf when tested in accordance with ASTM D 2256.

2.2.2 Mill widths of fabric shall be a minimum of 84 inches. Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 1.35 inches 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 80-inch centers.

2.2.3 Fabric form panels shall be factory-sewn, by jointing together the layers of fabric, top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. Sewn seams shall be downward facing as shown on the Contract Drawings. All sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. All seams sewn shall be not less than 100 lbf/inch when tested in accordance with ASTM D 4884. Both lines of stitches shall be sewn simultaneously and be parallel to each other, spaced between 0.25 inches to 0.75 inches apart. Each row of stitching shall consist of 4 to 7 stitches per inch. Thread used for seaming shall be polyester.

2.2.4 Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffles shall be designed to maintain a full concrete lining thickness along the full length of the baffle. The baffle material shall be nonwoven filter fabric. The grab tensile strength of the filter fabric shall be not less than 180 lbf/inch when tested in accordance with ASTM D 4632.

2.2.5 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.

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 Fine Aggregate Concrete

Fine aggregate concrete consists of a mixture of Portland cement, fine aggregate (sand) and water, so proportioned and mixed as to provide a pumpable fine aggregate concrete.

The water/cement ratio of the fine aggregate concrete shall be determined by the ready-mix manufacturer, but generally should be on the order of 0.65 to 0.70. The pumping of fine aggregate concrete into the fabric forms causes a reduction in the water content by filtering excess mixing water through the permeable fabric. The reduction of mixing water substantially improves the water/cement ratio of the in-place fine aggregate concrete thereby increasing its strength and durability. The sand/cement ratio should be determined by the ready-mix manufacturer and should be on the order of 2.4:1.

The consistency of the fine aggregate concrete delivered to the concrete pump should be proportioned and mixed as to have a flow time of 9-15 seconds when passed through the 19 mm orifice of the standard flow cone that is described in ASTM C6449-99. Additional Pozzolan and/or admixtures may be used with the approval of the Engineer-in-charge. The water/cement ratio varies with the exact granulometry of the fine aggregate (sand) and should be determined by the ready-mix manufacturer using the above referenced flow cone.

The Contractor should demonstrate the suitability by placing the proposed fine aggregate concrete mix into three (3) 2-inch concrete cubes or grout prisms. The mix should exhibit a minimum compressive strength of 3500 psi at 28 days, when made and tested in accordance ASTM C109/C109M-13 and ASTM C 1019.

With a typical loss of approximately 15% of the total mixing water, 27 ft^3 of pumpable fine aggregate concrete will reduce to approximately 25 ft^3 of hardened concrete. The mixing water reduction will also result in an increase of approximately 8% in the sand and cement per cubic foot of concrete. The range of fine aggregate concrete mix proportions provided in Table 2.0 has been developed under a variety of field conditions.

Table 2.0 Typical Range of Mix Proportions

Material	Mix Proportions lb/yd^3	After Placement Mix Proportions lb/yd^3
Cement	750-850	805-915
Sand	2120-2030	2290-2190
Water	540-555	460-470
Air	As Required	As Required

2.3.1 Components

2.3.1.1 Portland Cement

Portland cement should conform to ASTM C 150/150M, Type I, II or V. Pozzolan grade fly ash may be substituted for up to 35% of the cement as an aid to pumpability. (The pumpability of fine aggregate concrete mixes containing course sand is improved by the addition of fly ash.) Pozzolan, if used, should conform to ASTM C 618, Class C, F or N.

2.3.1.2 Fine Aggregate (sand)

Fine aggregate should consist of suitable clean, hard, strong and durable natural or manufactured sand. It should not contain dust, lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack any embedded steel, neoprene, rubber, plastic, etc. Motorized sand washing machines should be used to remove impurities from the fine aggregate. Fine aggregate having positive alkali-silica reaction should not be used. All fine aggregates should conform to ASTM C33/C33M-13. The fine aggregate should not have more than 45% passing any sieve and retained on the next consecutive sieve of those shown in Table 3.0. The fineness modulus of fine aggregate should neither be less than 2.3 nor greater than 3.1. Fine aggregate with grading near the minimum for passing the No. 50 and No. 100 sometimes have difficulties with workability or pumping. The additions of entrained air, additional cement, or the addition of an approved mineral admixture to supply the deficient fines, are methods used to alleviate such difficulties.

ASTM C33/C33M-13 defines the requirements for grading and quality of fine aggregate for use in fine aggregate concrete and is for use by a contractor as part of the purchase document describing the material to be furnished.

Table 3.0 Grading Requirement for Fine Aggregate

Sieve	Percent by Weight Passing the Sieve
9.5-mm (3/8-in.)	100
4.75-mm (No. 4)	95 to 100
2.36-mm (No. 8)	80 to 100
1.18-mm (No. 16)	50 to 85
600-µm (No. 30)	25 to 60
300-µm (No. 50)	5 to 30
150-µm (No. 100)	0 to 10
75-µm (No. 200)	0 to 3

Fine aggregate failing to meet these grading requirements can be utilized provided that the supplier can demonstrate to the specifier that fine aggregate concrete of the class specified, made with fine aggregate under consideration, will have relevant properties at least equal to those of fine aggregate concrete made with same ingredients, with the exception that the referenced fine aggregate will be selected from a source having an acceptable performance record in similar fine aggregate construction.

2.3.1.3 Water

Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.

Potable water is permitted to be used as mixing water in fine aggregate concrete without testing for conformance with the requirements of ASTM C1602/C1602M-12.

ASTM C1602/C1602M-12 covers the compositional and performance requirements for water used as mixing water in hydraulic cement fine aggregate concrete. It defines sources of water and provides requirements and testing frequencies for qualified individual or combined water sources.

2.3.2 Plasticizing and Air Entraining Admixtures

Grout fluidifier, water reducing or set time controlling agents may be used as recommended by their manufacturers to improve the pumpability and set time of the fine aggregate concrete.

Any air entraining agent or any other admixture may be used, as approved, by the Engineer-in-charge to increase workability, to make concrete impervious and more durable. Air entraining admixture should conform to ASTM C494/C494M and ASTM C260/C260M, respectively. Mixes designed with 5% to 8% air content will improve the pumpability of the fine aggregate concrete, freeze-thaw and sulfate resistance of the hardened concrete.

2.4 Ready-Mixed Concrete

The basis of standard specifications for ready-mixed concrete should be ASTM C94/C94M-13a.

2.4.1 Ordering

The contractor should require the manufacturer to assume full responsibility for the selection of the proportions for the concrete mixture, the contractor should also specify the following:

1. Requirements for compressive strength as determined on samples taken from the transportation unit at the point of discharge. Unless otherwise specified the age at test should be 28 days.

2. That the manufacturer, prior to the actual delivery of the fine aggregate concrete, furnish a statement to the contractor, giving the dry mass of cement and saturated surface-dry-mass of fine aggregate and quantities, type, and name of admixtures (if any) and the water per cubic yard or cubic metre of fine aggregate concrete that will be used in the manufacture. The manufacturer should also furnish evidence satisfactory to the contractor that the materials to be used and proportions selected will produce fine aggregate concrete of the quality specified.

2.4.2 Mixing and Delivery

Ready-mixed fine aggregate concrete should be mixed and delivered to the point of discharge by means of one of the following combinations of operation:

Central-Mixed Concrete is mixed completely in a stationary mixer and transported to the point of delivery in a truck agitator, or a truck mixer operating at agitating speed, or in non-agitating equipment meeting the requirements of Section 13 of ASTM C94/C94M-13a. The acceptable mixing time for mixers having capacity of 1 yd^3 or less is one (1) minuet. For mixers of greater capacity, this minimum should be increased 15 seconds for each cubic yard [cubic metre] of fraction thereof of additional capacity.

Shrink-Mixed Concrete—Concrete that is first partially mixed in a stationary mixer, and then completely in a truck mixer, should conform to the following: The time for the partial mixing should be the minimum required to intermingle the ingredients. After transfer to a truck mixer the amount of mixing at the designated mixing

speed will be that necessary to meet the requirements for uniformity of concrete.

Truck-Mixed Concrete—Concrete that is completely mixed in a truck mixer, 70 to 100 revolutions at the mixing speed designated by the manufacturer to produce the uniformity of concrete.

No water from the truck water system should or elsewhere should be added after the initial introduction of mixing water for the batch except when on arrival to the project site the flow rate of the fine aggregate concrete is less than 9 seconds. If the flow rate is less than 9 seconds obtain the desired flow rate within 9 to 15 seconds with a one-time addition of water. A one-time addition of water is not prohibited from being several distinct additions of water provided that no fine aggregate concrete has been discharged except for flow testing. All water additions should be completed within 15 minutes from the start of the first water addition. Such addition should be injected into the mixer under such pressure and direction of flow to allow for proper distribution within the mixer. The drum should be turned an additional 30 revolutions, or more if necessary, at mixing speed to ensure that a homogenous mixture is attained. Water should not be added to the batch at any later time.

Discharge of fine aggregate concrete should be completed within 1 1/2 hours after the introduction of mixing water to the cement and fine aggregate. This limitation may be waived by the contractor if concrete is of such flow after 1 1/2 hours time has been reached that it can be placed, without the addition of water to the batch. In hot weather, or under conditions contributing to rapid stiffening of the fine aggregate concrete, a time less than 1 1/2 hours is permitted to be specified by the contractor. *Depending on the project requirements the technology is available to the manufacture to alter fresh fine aggregate properties (such as setting time or flow.) On some projects the manufacturer may request changes to certain fresh fine aggregate concrete properties due to the distance or projected transportation time between the batch plant and the point of delivery.*

Fine aggregate concrete delivered in cold weather should have the minimum temperature indicated in Table 4.0. The maximum temperature of fine aggregate concrete produced with heated aggregate, heated water, or both, should at no time during its production or transportation exceed 90 °F.

Table 4.0 Minimum Fine Aggregate Temperature as Placed

Section Size, inch	Temperature, min, °F
< 12	55
12—36	50

2.4.3 Sampling for Uniformity

The fine aggregate concrete should be discharged at the normal operating rate for the mixer being tested, with care being exercised not to obstruct or retard the discharge by an incompletely opened gate or seal. As the mixer is being emptied, individual samples should be taken after discharge of approximately 15% and 85% of the load. *No samples should be taken before 10% or after 90% of the batch has been discharged. Due to the difficulties of determining the actual quantity of fine aggregate discharged, the intent is to provide samples that are representative of widely separated portions, but not the beginning and end of the load.*

2.4.4 Batch Ticket Information

The manufacturer of the concrete should furnish to the contractor with each batch of fine aggregate concrete before unloading at the site, a delivery ticket with the following information:

- Name of ready-mix company and batch plant, or batch plant number.
- Serial number of ticket,
- Date,
- Truck number,
- Specific designation of job (name and location),
- Specific call or designation of the concrete in conformance with that employed in project specifications,
- Amount of fine aggregate concrete in cubic yards,
- Time loaded or of first mixing of cement and fine aggregate, and

- Amount of water added to the fine aggregate concrete by the contractor, at site, or the contractor's designated representative and their initials.

The following information, for certification purposes, required by the project specifications should be furnished:

- Type, brand, and amount of cement,
- Class, brand, and amount of coal fly ash, or raw or calcined natural pozzolans,
- Type, brand, and amount of admixtures.
- Source and amount of each metered or weighted water,
- Information necessary to calculate the total mixing water. Total mixing water includes water on fine aggregates, batch water (metered or weighted) including ice batched at the plant, wash water retained in the mixing drum, and water added by the truck operator from the mixer tank,
- Amount of fine aggregate,
- Ingredients certified as being previously approved, and
- Signature or initials of manufacturer's' representative.

2.3 **Geotextile Filter Fabrics**

2.4.1 The geotextile 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. The geotextile shall be free of defects or flaws which significantly affect its mechanical or hydraulic properties.

2.4.2 The geotextile filter fabric must be permitted to function properly by allowing relief of hydrostatic pressure; therefore fine soil particles shall not be allowed to clog the geotextile. The geotextile filter fabric shall be as specified elsewhere in the Contract Specifications. Final acceptance of the geotextile filter fabric by the Engineer shall be based on project specific soil information, provided by the Contractor/Owner. The geotextile filter shall meet the minimum physical requirements listed in Table 5 or greater as required by the Engineer based on site soil conditions.

2.4.3 The geotextile filter fabric 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.

Table 5.0 MINIMUM PROPERTY REQUIREMENTS – FILTER FABRIC

	Test Method	**Units**	**Minimum Value**
Mechanical Properties			
Grab Tensile Strength	ASTM D 4632	lbf	180 (in any principal direction)
Elongation at Break	ASTM D 4632	%	50 max. (in any principal direction)
Trapezoidal Tear Strength	ASTM D 4533	lbf	75 (in any principal direction)
Puncture Strength	ASTM D 4833	lbs	105 (in any principal direction)
CBR Puncture Strength	ASTM D 6241	lbs	475 (in any principal direction)
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	US Sieve	As Specified Elsewhere in the Contract Specifications
Permittivity	ASTM D 4491	sec^{-1}	As Specified Elsewhere in the Contract Specifications
Flow Rate	ASTM D 4491	$gal/min/ft^2$	As Specified Elsewhere in the Contract Specifications

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

PART 3.0: DESIGN REQUIREMENTS

3.1 Certification (Open Channel Flow)

3.1.1 Fabric formed concrete lining will only be accepted when accompanied by documented full-scale hydraulic flume performance characteristics that are derived from tests under controlled flow conditions. Test guidelines shall conform to testing protocol as documented in "Hydraulic Stability of Fabric Formed Concrete Lining and Mat Systems During Overtopping Flow."

3.1.2 The average thickness, mass per unit area and hydraulic resistance of each concrete lining shall withstand the hydraulic loadings 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 1.3 shall be required or higher as determined by lock conditions or critical structures.

3.2 Performance (Open Channel Flow)

3.2.1 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 the documented hydraulic performance characteristics derived from full-scale flume tests performed under controlled flow conditions.

PART 4.0: CONSTRUCTION AND INSTALLATION REQUIREMENTS

4.1 Site Preparation - Grading

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. The areas shall be graded and uniformly compacted to a smooth plane surface with an allowable tolerance of plus or minus 0.2 feet from bottom grade, as long as ponding does not occur, and plus or minus 0.2 foot from a side slope grade as long as humps or pockets are removed.

4.1.2 The areas shall be free of organic material and obstructions such as roots and projecting stones and grade stakes shall be removed. 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. Where 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.

4.1.3 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.

4.1.4 The terminal edges of the fabric form lining should be keyed into the subgrade to the lines, grades, and dimensions shown on the Contract Drawings.

4.2 Inspection

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.

4.3 Geotextile Filter Fabric Placement

4.3.1 The geotextile filter baric shall be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile filter fabric shall be placed so that the upstream roll of fabric overlaps the downstream roll. The longitudinal and transverse joints will be overlapped at least two (2) feet. The geotextile will extend at least one (1) foot beyond the top and bottom concrete lining termination points, or as required by the Engineer.

4.3.2 A geotextile filter fabric, as specified elsewhere, shall be placed on the graded surface approved by the Engineer.

4.4 Fabric Form Placement

4.4.1 Factory assembled fabric form panels shall be placed over the geotextile filter fabric and within the limits shown on the Contract Drawings. Perimeter termination of the fabric forms shall be accomplished through the use of anchor, flank and toe trenches, as shown on the Contract Drawings. When placing panels an allowance for approximately 10% contraction of the form in each direction which will occur as a result of fine aggregate concrete filling. The contractor shall gather and fold the additional slope direction fabric form in the anchor trench to be secured in such a manners as to be gradually released as fabric forms contract during filling. The contractor shall gather the additional transverse direction fabric form at each baffle for self release during filling.

4.4.2 Adjacent fabric form panels shall be joined in the field by means of sewing or zippering closures. Adjacent panels shall be joined top layers to top layer and bottom layer to bottom. All field seams shall be made using two lines of U.S. Federal Standard Type 101 stitches. All sewn seams shall be downward facing.

4.4.3 When conventional joining of fabric forms is impractical or where called for on the Contract Drawings, adjacent forms may be overlapped a minimum of 3 ft to form a lap joint, pending approval by the Engineer. Based on the predominant flow direction, the upstream form shall overlap the downstream form. In no case shall simple butt joints between forms be permitted. Simple butt joints between panels shall not be allowed.

4.4.4 Expansion joints shall be provided as shown on the Contract Drawings, or as specified by the Engineer.

4.4.5 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 seams have been approved. At no time shall the unfilled fabric forms be exposed to ultraviolet light (including direct sunlight) for a period exceeding five (5) days.

4.5 **Fine Aggregate Concrete Placement**

4.5.1 Following the placement of the fabric forms over the geotextile filter fabric, fine aggregate concrete shall be pumped between the top and bottom layers of the fabric form through small slits to be cut in the top layer of the fabric form or manufacturer supplied valves. The slits shall be of the minimum length to allow proper insertion of a filling pipe inserted at the end of a 2-inch I.D. concrete pump hose. Fine aggregate concrete shall be pumped between the top and bottom layers of fabric, filling the forms to the recommended thickness and configuration.

Holes in the fabric forms left by the removal of the filling pipe shall be temporarily closed by inserting a piece of fabric. The 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.

4.5.2 Fine aggregate concrete coverage for US400 shall net 75 ft^2/yd^3 (see Section 2.3).

4.5.3 Fine aggregate concrete shall be pumped in such a manner that excessive pressure on the fabric forms is avoided. Consultation with the fabric form manufacturer with regard to the selection of grout/concrete pumps is recommended.

4.5.4 Cold joints shall be avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given section of form is discontinued or interrupted for an interval of forty-five (45) or more minutes.

4.5.5 The sequence of fine aggregate concrete shall be such as to ensure complete filling of the fabric formed concrete lining to the thickness specified by the Engineer. The flow of the fine aggregate concrete shall first be directed into the lower edge of the fabric form and working back up the slope, followed by redirecting the flow into the anchor trench.

4.5.6 Prior to removing the filling pipe from the current concrete lining section and proceeding to the fine aggregate concrete filling of the adjacent lining section, the thickness of the current lining section shall be measured by inserting a length of stiff wire through the lining at several locations from the crest to the toe of the slope. The average of all thickness measurements shall be not less than the specified average thickness of the concrete

lining. Should the measurements not meet the specified average thickness, pumping shall continue until the specified average thickness has been attained.

4.5.7 Excessive fine aggregate concrete that has inadvertently spilled on the concrete lining surface shall be removed. The use of a high-pressure water hose to remove spilled fine aggregate concrete from the surface of the freshly pumped concrete lining shall not be permitted.

4.5.8 Foot traffic will not be permitted on the freshly pumped concrete lining when such traffic will cause permanent indentations in the lining surface. Walk boards shall be used where necessary.

4.5.9 After the fine aggregate concrete has set, all anchor, flank and toe trenches shall be backfilled and compacted flush with the top of the concrete lining. The integrity of the trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the concrete lining for its entire service life. Toe trenches shall be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches shall be completed in a timely fashion to protect the completed concrete lining. No more than five hundred (500) linear feet of pumped concrete lining with non-completed anchor, anchor, flank, or toe trenches will be permitted at any time.

PART 5.0: Method of Measurement

The fabric formed concrete erosion control lining shall be measured by the number of square feet or yards computed from the lines and cross sections shown on the Contract Drawings or from payment lines established in writing by the Engineer. This includes fabric forms, fine aggregate concrete, and filter fabric used in the aprons, overlaps, anchor, terminal, or toe trenches. Slope preparation, excavation and backfilling, and bedding are separate pay items.

Hydrotex products are manufactured and sold by:

SYNTHETEX
Synthetex, LLC
5550 Triangle Parkway, Suite 220
Peachtree Corners, GA 30092
Tel: 1.800.253.0561 or 770.399.5051
Fax: 770.394.5999
www.synthetex.com • e-mail: info@synthetex.com

Section _____

EROSION CONTROL LINING SYSTEM SPECIFICATION
UNIFORM SECTION US600 – PET FABRIC FORMED CONCRETE

PART 1.0: GENERAL

1.1 Scope of Work

The work shall consist of furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of the fabric formed concrete erosion control lining systems in accordance with the lines, grades, design, and dimensions shown on the Contract Drawings and as specified herein. If the contractor is inexperienced, then the fabric formed concrete manufacturer's representative shall provide on-site technical assistance at the beginning of the installation for a length of time the contractor is sufficiently experienced to complete the remaining installation.

1.2.1 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 manner as to form a stable lining of required thickness, weight and configuration.

1.3 Referenced Documents

1.3.1 American Society for Testing and Materials (ASTM)

ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or [50-mm] Cardboard Prism/Cube Specimens)
ASTM C 150	Standard Specification for Portland Cement
ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 494	Standard Specification for Chemical Admixtures for Concrete
ASTM C 618	Standard Specification for Coal Fly Ash and Calcined Natural Pozzolan for Use in Concrete
ASTM C 685	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
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ASTM D 6449	Standard Method for Flow of Fine Aggregate Concrete for Fabric Formed Concrete

1.4 Terminology

For the purpose of these specifications, the following definitions shall apply:

1.4.1 Compaction:

The densification of a soil by means of mechanical manipulation.

1.4.2 Subgrade:

The ground surface usually specially prepared against which lining shall be placed. In cases where lining is to be retained the same shall be considered as subgrade.

1.4.3 Hydrotex™ Fabric Form:

The fabric forms are constructed of woven, double-layer synthetic fabric. HYDROTEX linings are installed by positioning fabric forms over the areas to be protected and then pumping, high-strength, fine aggregate concrete into the forms. The fabric forms can be placed and filled either underwater or in-the-dry. The high-strength, fine aggregate concrete is used in place of conventional concrete because of its pumpability, high-strength, impermeability, and absorption resistance.

1.4.4 Hydrotex™ Uniform Section (US) Lining:

Hydrotex Uniform Section linings provide an erosion resistant, impermeable concrete lining having a brick pattern surface and a relatively low coefficient of hydraulic friction in order to maintain optimum water velocities. The thickness and weight of the lining is controlled by spacer cords.

1.4.5 Baffle:

Baffles are flow-directing vertical geotextile walls constructed between fabric form sections layers. Baffles are an integral part of the fabric form design. Baffles are designed to support the panel section, determine the concrete area of the section and direct the flow of fine aggregate concrete for maximum efficiency.

1.4.6 Slide Fastener (Zipper):

A zipper or zipper like devise having two grooved plastic edges joined by a sliding tab or pull.

1.5 Submittals

1.5.1 The Contractor shall furnish the fine aggregate concrete manufacturer's certificates of compliance, mix design, fine aggregate gradation and fineness modulus for the fine aggregate concrete.

1.5.2 The Contractor shall furnish the fabric form manufacturer's certificates of compliance for the fabric forms. The Contractor shall also furnish the manufacturer's specifications, literature, shop drawings for the layout of the concrete lining panels, and any recommendations, if applicable, that are specifically related to the project.

1.5.3 Alternative fabric formed concrete lining materials may be considered. Such materials must be pre-approved in writing by the Engineer prior to the bid date. Alternative material packages must be submitted to the Engineer a minimum of fourteen (14) days prior to the bid date. Submittal packages must include, as a minimum, the following:

Material testing reports prepared by a certified geotextile laboratory attesting to the alternative fabric form material's compliance with this Specification. Material laboratory testing shall have been performed within ninety (90) days of the bid date.

PART 2:.0 PRODUCT

2.1 General - Fabric Formed Concrete Lining

Fabric formed concrete lining shall be Uniform Section (US600) type and have a finished average thickness of 6.0 inches, a nominal mass per unit area of 68 lb/ft^2, and a comparatively uniform section with a brick pattern surface appearance. The shear resistance of the concrete lining shall be a minimum of 14 lb/ft^2, as demonstrated by full scale flume testing.

2.2 Fabric Forms

The fabric forms for casting the concrete lining(s) shall be as specified, HYDROTEX® Uniform Section (US600) fabric forms as manufactured by:

Synthetex, LLC; 5550 Triangle Parkway, Suite 220 Peachtree Corners, Georgia 30092
Tel: 800.253.0561 or 770.399.5051
E-Mail: info@synthetex.com

Distributed by: Quick Supply Co., 6620 NW Toni Drive Des Moines, IA 50313, Phone: (515)289-1271, www.quicksupplydm.com

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 polyester. Forms shall be woven with a minimum of 50% textured yarns (by weight). 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 Mean Average Roll Values listed in Table 1.0. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

Table 1.0 PROPERTY REQUIREMENTS – HYDROTEX FABRIC [1, 2]

	Test Method	**Units**	**MARV**
Physical Properties			
Composition of Yarns	-	-	Polyester
Mass Per Unit Area (double-layer)	ASTM D 5261	oz/yd^2	13
Thickness (single-layer)	ASTM D 5199	mils	15
Mill Width (Woven)		inch	84
Mechanical Properties			
Wide-Width Strip Tensile Strength - MD | TD	ASTM D 4595	lbs/inch	300 **|** 350
Elongation at Break - MD **|** TD - Max.		%	15 **|** 15
Trapezoidal Tear Strength - MD | TD	ASTM D 4533	lbs	150 **|** 175
CBR Puncture Strength	ASTM D 6241	lbs	1250
Mullen Burst Strength	ASTM D 3786 (Mod.)	psi	500
	Test Method	**Units**	**MARV Range**
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Standard Sieve	30 - 40
Flow Rate	ASTM D 4491	gal/min/ft^2	30 - 55

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

2.2.1 Fabric forms shall consist of double-layer woven fabric joined together by spaced, interwoven cords of uniform length to form a concrete lining of the specified average thickness. The cords shall be interwoven between the two layers of fabric, in parallel pairs, so that the two (2) cords together in the top layer and two (2) cords

together in the bottom layer cross between layers at drop points. Each cord shall have a minimum breaking strength of 160 lbf when tested in accordance with ASTM D 2256.

2.2.2 Mill widths of fabric shall be a minimum of 84 inches. Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 1.35 inches 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 80-inch centers.

2.2.3 Fabric form panels shall be factory-sewn, by jointing together the layers of fabric, top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. Sewn seams shall be downward facing as shown on the Contract Drawings. All sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. All seams sewn shall be not less than 100 lbf/inch when tested in accordance with ASTM D 4884. Both lines of stitches shall be sewn simultaneously and be parallel to each other, spaced between 0.25 inches to 0.75 inches apart. Each row of stitching shall consist of 4 to 7 stitches per inch. Thread used for seaming shall be polyester.

2.2.4 Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffles shall be designed to maintain a full concrete lining thickness along the full length of the baffle. The baffle material shall be nonwoven filter fabric. The grab tensile strength of the filter fabric shall be not less than 180 lbf/inch when tested in accordance with ASTM D 4632.

2.2.5 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.

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 Fine Aggregate Concrete

Fine aggregate concrete consists of a mixture of Portland cement, fine aggregate (sand) and water, so proportioned and mixed as to provide a pumpable fine aggregate concrete.

The water/cement ratio of the fine aggregate concrete shall be determined by the ready-mix manufacturer, but generally should be on the order of 0.65 to 0.70. The pumping of fine aggregate concrete into the fabric forms causes a reduction in the water content by filtering excess mixing water through the permeable fabric. The reduction of mixing water substantially improves the water/cement ratio of the in-place fine aggregate concrete thereby increasing its strength and durability. The sand/cement ratio should be determined by the ready-mix manufacturer and should be on the order of 2.4:1.

The consistency of the fine aggregate concrete delivered to the concrete pump should be proportioned and mixed as to have a flow time of 9-12 seconds when passed through the ¾-inch [19 mm] orifice of the standard flow cone that is described in ASTM C6449-99. Additional Pozzolan and/or admixtures may be used with the approval of the Engineer-in-charge. The water/cement ratio varies with the exact granulometry of the fine aggregate (sand) and should be determined by the ready-mix manufacturer using the above referenced flow cone.

The Contractor should demonstrate the suitability by placing the proposed fine aggregate concrete mix into three (3) 2-inch concrete cardboard prisms / cubes. The mix should exhibit a minimum compressive strength of 3500 psi at 28 days, when made and tested in accordance ASTM C109/C109M-13.

With a typical loss of approximately 15% of the total mixing water, 27 ft^3 of pumpable fine aggregate concrete will reduce to approximately 25 ft^3 of hardened concrete. The mixing water reduction will also result in an

increase of approximately 8% in the sand and cement per cubic foot of concrete. The range of fine aggregate concrete mix proportions provided in Table 2.0 has been developed under a variety of field conditions.

Table 2.0 Typical Range of Mix Proportions

Material	Mix Proportions lb/yd^3	After Placement Mix Proportions lb/yd^3
Cement	750-850	805-915
Sand	2120-2030	2290-2190
Water	540-555	460-470
Air	As Required	As Required

2.3.1 Components

2.3.1.1 Portland Cement

Portland cement should conform to ASTM C 150/150M, Type I, II or V. Pozzolan grade fly ash may be substituted for up to 35% of the cement as an aid to pumpability. (The pumpability of fine aggregate concrete mixes containing course sand is improved by the addition of fly ash.) Pozzolan, if used, should conform to ASTM C 618, Class C, F or N.

2.3.1.2 Fine Aggregate (sand)

Fine aggregate should consist of suitable clean, hard, strong and durable natural or manufactured sand. It should not contain dust, lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack any embedded steel, neoprene, rubber, plastic, etc. Motorized sand washing machines should be used to remove impurities from the fine aggregate. Fine aggregate having positive alkali-silica reaction should not be used. All fine aggregates should conform to ASTM C33/C33M-13. The fine aggregate should not have more than 45% passing any sieve and retained on the next consecutive sieve of those shown in Table 3.0. The fineness modulus of fine aggregate should neither be less than 2.3 nor greater than 3.1. Fine aggregate with grading near the minimum for passing the No. 50 and No. 100 sometimes have difficulties with workability or pumping. The additions of entrained air, additional cement, or the addition of an approved mineral admixture to supply the deficient fines, are methods used to alleviate such difficulties.

ASTM C33/C33M-13 defines the requirements for grading and quality of fine aggregate for use in fine aggregate concrete and is for use by a contractor as part of the purchase document describing the material to be furnished.

Table 3.0 Grading Requirement for Fine Aggregate

Sieve	Percent by Weight Passing the Sieve
9.5-mm (3/8-in.)	100
4.75-mm (No. 4)	95 to 100
2.36-mm (No. 8)	80 to 100
1.18-mm (No. 16)	50 to 85
600-µm (No. 30)	25 to 60
300-µm (No. 50)	5 to 30
150-µm (No. 100)	0 to 10
75-µm (No. 200)	0 to 3

Fine aggregate failing to meet these grading requirements can be utilized provided that the supplier can demonstrate to the specifier that fine aggregate concrete of the class specified, made with fine aggregate under consideration, will have relevant properties at least equal to those of fine aggregate concrete made with

same ingredients, with the exception that the referenced fine aggregate will be selected from a source having an acceptable performance record in similar fine aggregate construction.

2.3.1.3 Water

Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.

Potable water is permitted to be used as mixing water in fine aggregate concrete without testing for conformance with the requirements of ASTM C1602/C1602M-12.

ASTM C1602/C1602M-12 covers the compositional and performance requirements for water used as mixing water in hydraulic cement fine aggregate concrete. It defines sources of water and provides requirements and testing frequencies for qualified individual or combined water sources.

2.3.2 Plasticizing and Air Entraining Admixtures

Grout fluidifier, water reducing or set time controlling agents may be used as recommended by their manufacturers to improve the pumpability and set time of the fine aggregate concrete.

Any air entraining agent or any other admixture may be used, as approved, by the Engineer-in-charge to increase workability, to make concrete impervious and more durable. Air entraining admixture should conform to ASTM C494/C494M and ASTM C260/C260M, respectively. Mixes designed with 5% to 8% air content will improve the pumpability of the fine aggregate concrete, freeze-thaw and sulfate resistance of the hardened concrete.

2.4 Geotextile Filter Fabrics

2.4.1 The geotextile 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. The geotextile shall be free of defects or flaws which significantly affect its mechanical or hydraulic properties.

2.4.2 The geotextile filter fabric must be permitted to function properly by allowing relief of hydrostatic pressure; therefore fine soil particles shall not be allowed to clog the geotextile. The geotextile filter fabric shall be as specified elsewhere in the Contract Specifications. Final acceptance of the geotextile filter fabric by the Engineer shall be based on project specific soil information, provided by the Contractor/Owner. The geotextile filter shall meet the minimum physical requirements listed in Table 5 or greater as required by the Engineer based on site soil conditions.

2.4.3 The geotextile filter fabric 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.

Table 5.0 MINIMUM PROPERTY REQUIREMENTS – FILTER FABRIC

	Test Method	**Units**	**Minimum Value**
Mechanical Properties			
Grab Tensile Strength	ASTM D 4632	lbf	180 (in any principal direction)
Elongation at Break	ASTM D 4632	%	50 max. (in any principal direction)
Trapezoidal Tear Strength	ASTM D 4533	lbf	75 (in any principal direction)
Puncture Strength	ASTM D 4833	lbs	105 (in any principal direction)
CBR Puncture Strength	ASTM D 6241	lbs	475 (in any principal direction)
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	US Sieve	As Specified Elsewhere in the Contract Specifications

Permittivity	ASTM D 4491	sec^{-1}	As Specified Elsewhere in the Contract Specifications
Flow Rate	ASTM D 4491	$gal/min/ft^2$	As Specified Elsewhere in the Contract Specifications

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

PART 3.0: DESIGN REQUIREMENTS

3.1 Certification (Open Channel Flow)

3.1.1 Fabric formed concrete lining will only be accepted when accompanied by documented full-scale hydraulic flume performance characteristics that are derived from tests under controlled flow conditions. Test guidelines shall conform to testing protocol as documented in "Hydraulic Stability of Fabric Formed Concrete Lining and Mat Systems During Overtopping Flow."

3.1.2 The average thickness, mass per unit area and hydraulic resistance of each concrete lining shall withstand the hydraulic loadings 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 1.3 shall be required or higher as determined by lock conditions or critical structures.

3.2 Performance (Open Channel Flow)

3.2.1 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 the documented hydraulic performance characteristics derived from full-scale flume tests performed under controlled flow conditions.

PART 4.0: CONSTRUCTION AND INSTALLATION REQUIREMENTS

4.1 Site Preparation - Grading

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. The areas shall be graded and uniformly compacted to a smooth plane surface with an allowable tolerance of plus or minus 0.2 feet from bottom grade, as long as ponding does not occur, and plus or minus 0.2 foot from a side slope grade as long as humps or pockets are removed.

4.1.2 The areas shall be free of organic material and obstructions such as roots and projecting stones and grade stakes shall be removed. 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. Where 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.

4.1.3 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.

4.1.4 The terminal edges of the fabric form lining should be keyed into the subgrade to the lines, grades, and dimensions shown on the Contract Drawings.

4.2 Inspection

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.

4.3 Geotextile Filter Fabric Placement

4.3.1 The geotextile filter baric shall be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile filter fabric shall be placed so that the upstream roll of fabric overlaps the downstream roll. The longitudinal and transverse joints will be overlapped at least two (2) feet. The geotextile will extend at least one (1) foot beyond the top and bottom concrete lining termination points, or as required by the Engineer.

4.3.2 A geotextile filter fabric, as specified elsewhere, shall be placed on the graded surface approved by the Engineer.

4.4 Fabric Form Placement

4.4.1 Factory assembled fabric form panels shall be placed over the geotextile filter fabric and within the limits shown on the Contract Drawings. Perimeter termination of the fabric forms shall be accomplished through the use of anchor, flank and toe trenches, as shown on the Contract Drawings. When placing panels an allowance for approximately 10% contraction of the form in each direction which will occur as a result of fine aggregate concrete filling. The contractor shall gather and fold the additional slope direction fabric form in the anchor trench to be secured in such a manners as to be gradually released as fabric forms contract during filling. The contractor shall gather the additional transverse direction fabric form at each baffle for self release during filling.

4.4.2 Adjacent fabric form panels shall be joined in the field by means of sewing or zippering closures. Adjacent panels shall be joined top layers to top layer and bottom layer to bottom. All field seams shall be made using two lines of U.S. Federal Standard Type 101 stitches. All sewn seams shall be downward facing.

4.4.3 When conventional joining of fabric forms is impractical or where called for on the Contract Drawings, adjacent forms may be overlapped a minimum of 3 ft to form a lap joint, pending approval by the Engineer. Based on the predominant flow direction, the upstream form shall overlap the downstream form. In no case shall simple butt joints between forms be permitted. Simple butt joints between panels shall not be allowed.

4.4.4 Expansion joints shall be provided as shown on the Contract Drawings, or as specified by the Engineer.

4.4.5 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 seams have been approved. At no time shall the unfilled fabric forms be exposed to ultraviolet light (including direct sunlight) for a period exceeding five (5) days.

4.5 **Fine Aggregate Concrete Placement**

4.5.1 Following the placement of the fabric forms over the geotextile filter fabric, fine aggregate concrete shall be pumped between the top and bottom layers of the fabric form through small slits to be cut in the top layer of the fabric form or manufacturer supplied valves. The slits shall be of the minimum length to allow proper insertion of a filling pipe inserted at the end of a 2-inch I.D. concrete pump hose. Fine aggregate concrete shall be pumped between the top and bottom layers of fabric, filling the forms to the recommended thickness and configuration.

Holes in the fabric forms left by the removal of the filling pipe shall be temporarily closed by inserting a piece of fabric. The 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.

4.5.2 Fine aggregate concrete coverage for US600 shall net 50 ft^2/yd^3 (see Section 2.3).

4.5.3 Fine aggregate concrete shall be pumped in such a manner that excessive pressure on the fabric forms is avoided. Consultation with the fabric form manufacturer with regard to the selection of grout/concrete pumps is recommended.

4.5.4 Cold joints shall be avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given section of form is discontinued or interrupted for an interval of forty-five (45) or more minutes.

4.5.5 The sequence of fine aggregate concrete shall be such as to ensure complete filling of the fabric formed concrete lining to the thickness specified by the Engineer. The flow of the fine aggregate concrete shall first be directed into the lower edge of the fabric form and working back up the slope, followed by redirecting the flow into the anchor trench.

4.5.6 Prior to removing the filling pipe from the current concrete lining section and proceeding to the fine aggregate concrete filling of the adjacent lining section, the thickness of the current lining section shall be measured by inserting a length of stiff wire through the lining at several locations from the crest to the toe of the slope. The average of all thickness measurements shall be not less than the specified average thickness of the concrete lining. Should the measurements not meet the specified average thickness, pumping shall continue until the specified average thickness has been attained.

4.5.7 Excessive fine aggregate concrete that has inadvertently spilled on the concrete lining surface shall be removed. The use of a high-pressure water hose to remove spilled fine aggregate concrete from the surface of the freshly pumped concrete lining shall not be permitted.

4.5.8 Foot traffic will not be permitted on the freshly pumped concrete lining when such traffic will cause permanent indentations in the lining surface. Walk boards shall be used where necessary.

4.5.9 After the fine aggregate concrete has set, all anchor, flank and toe trenches shall be backfilled and compacted flush with the top of the concrete lining. The integrity of the trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the concrete lining for its entire service life. Toe trenches shall be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches shall be completed in a timely fashion to protect the completed concrete lining. No more than five hundred (500) linear feet of pumped concrete lining with non-completed anchor, anchor, flank, or toe trenches will be permitted at any time.

PART 5.0: Method of Measurement

The fabric formed concrete erosion control lining shall be measured by the number of square feet or yards computed from the lines and cross sections shown on the Contract Drawings or from payment lines established in writing by the Engineer. This includes fabric forms, fine aggregate concrete, and filter fabric used in the aprons, overlaps, anchor, terminal, or toe trenches. Slope preparation, excavation and backfilling, and bedding are separate pay items.

Hydrotex products are manufactured and sold by:

SYNTHETEX
Synthetex, LLC
5550 Triangle Parkway, Suite 220
Peachtree Corners, GA 30092
Tel: 1.800.253.0561 or 770.399.5051
Fax: 770.394.5999
www.synthetex.com • e-mail: info@synthetex.com

Section _____

EROSION CONTROL LINING SYSTEM SPECIFICATION
UNIFORM SECTION US800 – PET FABRIC FORMED CONCRETE

PART 1.0: GENERAL

1.1 Scope of Work

The work shall consist of furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of the fabric formed concrete erosion control lining systems in accordance with the lines, grades, design, and dimensions shown on the Contract Drawings and as specified herein. If the contractor is inexperienced, then the fabric formed concrete manufacturer's representative shall provide on-site technical assistance at the beginning of the installation for a length of time the contractor is sufficiently experienced to complete the remaining installation.

1.2.1 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 manner as to form a stable lining of required thickness, weight and configuration.

1.3 Referenced Documents

1.3.1 American Society for Testing and Materials (ASTM)

ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or [50-mm] Cube Specimens)
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A zipper or zipper like devise having two grooved plastic edges joined by a sliding tab or pull.

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1.5.1 The Contractor shall furnish the fine aggregate concrete manufacturer's certificates of compliance, mix design, fine aggregate gradation and fineness modulus for the fine aggregate concrete.

1.5.2 The Contractor shall furnish the fabric form manufacturer's certificates of compliance for the fabric forms. The Contractor shall also furnish the manufacturer's specifications, literature, shop drawings for the layout of the concrete lining panels, and any recommendations, if applicable, that are specifically related to the project.

1.5.3 Alternative fabric formed concrete lining materials may be considered. Such materials must be pre-approved in writing by the Engineer prior to the bid date. Alternative material packages must be submitted to the Engineer a minimum of fourteen (14) days prior to the bid date. Submittal packages must include, as a minimum, the following:

Material testing reports prepared by a certified geotextile laboratory attesting to the alternative fabric form material's compliance with this Specification. Material laboratory testing shall have been performed within ninety (90) days of the bid date.

PART 2:.0 PRODUCT

2.1 General - Fabric Formed Concrete Lining

Fabric formed concrete lining shall be Uniform Section (US800) type and have a finished average thickness of 8.0 inches, a nominal mass per unit area of 90 lb/ft^2, and a comparatively uniform section with a brick pattern surface appearance. The shear resistance of the concrete lining shall be a minimum of 14 lb/ft^2, as demonstrated by full scale flume testing.

2.2 Fabric Forms

The fabric forms for casting the concrete lining(s) shall be as specified, HYDROTEX® Uniform Section (US800) fabric forms as manufactured by:

Synthetex, LLC; 5550 Triangle Parkway, Suite 220 Peachtree Corners, Georgia 30092
Tel: 800.253.0561 or 770.399.5051
E-Mail: info@synthetex.com

Distributed by: Quick Supply Co., 6620 NW Toni Drive Des Moines, IA 50313, Phone: (515)289-1271, www.quicksupplydm.com

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 polyester. Forms shall be woven with a minimum of 50% textured yarns (by weight). 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 Mean Average Roll Values listed in Table 1.0. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

Table 1.0 PROPERTY REQUIREMENTS – HYDROTEX FABRIC [1, 2]

	Test Method	**Units**	**MARV**
Physical Properties			
Composition of Yarns	-	-	Polyester
Mass Per Unit Area (double-layer)	ASTM D 5261	oz/yd^2	13
Thickness (single-layer)	ASTM D 5199	mils	15
Mill Width (Woven)		inch	84
Mechanical Properties			
Wide-Width Strip Tensile Strength - MD | TD	ASTM D 4595	lbs/inch	300 **|** 350
Elongation at Break - MD **|** TD - Max.		%	15 **|** 15
Trapezoidal Tear Strength - MD | TD	ASTM D 4533	lbs	150 **|** 175
CBR Puncture Strength	ASTM D 6241	lbs	1250
Mullen Burst Strength	ASTM D 3786 (Mod.)	psi	500
	Test Method	**Units**	**MARV Range**
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Standard Sieve	30 - 40
Flow Rate	ASTM D 4491	gal/min/ft^2	30 - 55

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

2.2.1 Fabric forms shall consist of double-layer woven fabric joined together by spaced, interwoven cords of uniform length to form a concrete lining of the specified average thickness. The cords shall be interwoven between the two layers of fabric, in parallel pairs, so that the two (2) cords together in the top layer and two (2) cords

together in the bottom layer cross between layers at drop points. Each cord shall have a minimum breaking strength of 160 lbf when tested in accordance with ASTM D 2256.

2.2.2 Mill widths of fabric shall be a minimum of 84 inches. Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 1.35 inches 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 80-inch centers.

2.2.3 Fabric form panels shall be factory-sewn, by jointing together the layers of fabric, top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. Sewn seams shall be downward facing as shown on the Contract Drawings. All sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. All seams sewn shall be not less than 100 lbf/inch when tested in accordance with ASTM D 4884. Both lines of stitches shall be sewn simultaneously and be parallel to each other, spaced between 0.25 inches to 0.75 inches apart. Each row of stitching shall consist of 4 to 7 stitches per inch. Thread used for seaming shall be polyester.

2.2.4 Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffles shall be designed to maintain a full concrete lining thickness along the full length of the baffle. The baffle material shall be nonwoven filter fabric. The grab tensile strength of the filter fabric shall be not less than 180 lbf/inch when tested in accordance with ASTM D 4632.

2.2.5 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.

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 Fine Aggregate Concrete

Fine aggregate concrete consists of a mixture of Portland cement, fine aggregate (sand) and water, so proportioned and mixed as to provide a pumpable fine aggregate concrete.

The water/cement ratio of the fine aggregate concrete shall be determined by the ready-mix manufacturer, but generally should be on the order of 0.65 to 0.70. The pumping of fine aggregate concrete into the fabric forms causes a reduction in the water content by filtering excess mixing water through the permeable fabric. The reduction of mixing water substantially improves the water/cement ratio of the in-place fine aggregate concrete thereby increasing its strength and durability. The sand/cement ratio should be determined by the ready-mix manufacturer and should be on the order of 2.4:1.

The consistency of the fine aggregate concrete delivered to the concrete pump should be proportioned and mixed as to have a flow time of 9-15 seconds when passed through the ¾-inch [19 mm] orifice of the standard flow cone that is described in ASTM C6449-99. Additional Pozzolan and/or admixtures may be used with the approval of the Engineer-in-charge. The water/cement ratio varies with the exact granulometry of the fine aggregate (sand) and should be determined by the ready-mix manufacturer using the above referenced flow cone.

The Contractor should demonstrate the suitability by placing the proposed fine aggregate concrete mix into three (3) 2-inch concrete cubes. The mix should exhibit a minimum compressive strength of 3500 psi at 28 days, when made and tested in accordance ASTM C109/C109M-13.

With a typical loss of approximately 15% of the total mixing water, 27 ft^3 of pumpable fine aggregate concrete will reduce to approximately 25 ft^3 of hardened concrete. The mixing water reduction will also result in an

increase of approximately 8% in the sand and cement per cubic foot of concrete. The range of fine aggregate concrete mix proportions provided in Table 2.0 has been developed under a variety of field conditions.

Table 2.0 Typical Range of Mix Proportions

Material	Mix Proportions lb/yd^3	After Placement Mix Proportions lb/yd^3
Cement	750-850	805-915
Sand	2120-2030	2290-2190
Water	540-555	460-470
Air	As Required	As Required

2.3.1 Components

2.3.1.1 Portland Cement

Portland cement should conform to ASTM C 150/150M, Type I, II or V. Pozzolan grade fly ash may be substituted for up to 35% of the cement as an aid to pumpability. (The pumpability of fine aggregate concrete mixes containing course sand is improved by the addition of fly ash.) Pozzolan, if used, should conform to ASTM C 618, Class C, F or N.

2.3.1.2 Fine Aggregate (sand)

Fine aggregate should consist of suitable clean, hard, strong and durable natural or manufactured sand. It should not contain dust, lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack any embedded steel, neoprene, rubber, plastic, etc. Motorized sand washing machines should be used to remove impurities from the fine aggregate. Fine aggregate having positive alkali-silica reaction should not be used. All fine aggregates should conform to ASTM C33/C33M-13. The fine aggregate should not have more than 45% passing any sieve and retained on the next consecutive sieve of those shown in Table 3.0. The fineness modulus of fine aggregate should neither be less than 2.3 nor greater than 3.1. Fine aggregate with grading near the minimum for passing the No. 50 and No. 100 sometimes have difficulties with workability or pumping. The additions of entrained air, additional cement, or the addition of an approved mineral admixture to supply the deficient fines, are methods used to alleviate such difficulties.

ASTM C33/C33M-13 defines the requirements for grading and quality of fine aggregate for use in fine aggregate concrete and is for use by a contractor as part of the purchase document describing the material to be furnished.

Table 3.0 Grading Requirement for Fine Aggregate

Sieve	Percent by Weight Passing the Sieve
9.5-mm (3/8-in.)	100
4.75-mm (No. 4)	95 to 100
2.36-mm (No. 8)	80 to 100
1.18-mm (No. 16)	50 to 85
600-µm (No. 30)	25 to 60
300-µm (No. 50)	5 to 30
150-µm (No. 100)	0 to 10
75-µm (No. 200)	0 to 3

Fine aggregate failing to meet these grading requirements can be utilized provided that the supplier can demonstrate to the specifier that fine aggregate concrete of the class specified, made with fine aggregate under consideration, will have relevant properties at least equal to those of fine aggregate concrete made with

same ingredients, with the exception that the referenced fine aggregate will be selected from a source having an acceptable performance record in similar fine aggregate construction.

2.3.1.3 Water

Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.

Potable water is permitted to be used as mixing water in fine aggregate concrete without testing for conformance with the requirements of ASTM C1602/C1602M-12.

ASTM C1602/C1602M-12 covers the compositional and performance requirements for water used as mixing water in hydraulic cement fine aggregate concrete. It defines sources of water and provides requirements and testing frequencies for qualified individual or combined water sources.

2.3.2 Plasticizing and Air Entraining Admixtures

Grout fluidifier, water reducing or set time controlling agents may be used as recommended by their manufacturers to improve the pumpability and set time of the fine aggregate concrete.

Any air entraining agent or any other admixture may be used, as approved, by the Engineer-in-charge to increase workability, to make concrete impervious and more durable. Air entraining admixture should conform to ASTM C494/C494M and ASTM C260/C260M, respectively. Mixes designed with 5% to 8% air content will improve the pumpability of the fine aggregate concrete, freeze-thaw and sulfate resistance of the hardened concrete.

2.4 Ready-Mixed Concrete

The basis of standard specifications for ready-mixed concrete should be ASTM C94/C94M-13a.

2.4.1 Ordering

The contractor should require the manufacturer to assume full responsibility for the selection of the proportions for the concrete mixture, the contractor should also specify the following:

1. Requirements for compressive strength as determined on samples taken from the transportation unit at the point of discharge. Unless otherwise specified the age at test should be 28 days.

2. That the manufacturer, prior to the actual delivery of the fine aggregate concrete, furnish a statement to the contractor, giving the dry mass of cement and saturated surface-dry-mass of fine aggregate and quantities, type, and name of admixtures (if any) and the water per cubic yard or cubic metre of fine aggregate concrete that will be used in the manufacture. The manufacturer should also furnish evidence satisfactory to the contractor that the materials to be used and proportions selected will produce fine aggregate concrete of the quality specified.

2.4.2 Mixing and Delivery

Ready-mixed fine aggregate concrete should be mixed and delivered to the point of discharge by means of one of the following combinations of operation:

Central-Mixed Concrete is mixed completely in a stationary mixer and transported to the point of delivery in a truck agitator, or a truck mixer operating at agitating speed, or in non-agitating equipment meeting the requirements of Section 13 of ASTM C94/C94M-13a. The acceptable mixing time for mixers having capacity of 1 yd^3 or less is one (1) minuet. For mixers of greater capacity, this minimum should be increased 15 seconds for each cubic yard [cubic metre] of fraction thereof of additional capacity.

Shrink-Mixed Concrete—Concrete that is first partially mixed in a stationary mixer, and then completely in a truck mixer, should conform to the following: The time for the partial mixing should be the minimum required to intermingle the ingredients. After transfer to a truck mixer the amount of mixing at the designated mixing speed will be that necessary to meet the requirements for uniformity of concrete.

Truck-Mixed Concrete—Concrete that is completely mixed in a truck mixer, 70 to 100 revolutions at the mixing

speed designated by the manufacturer to produce the uniformity of concrete.

No water from the truck water system should or elsewhere should be added after the initial introduction of mixing water for the batch except when on arrival to the project site the flow rate of the fine aggregate concrete is less than 9 seconds. If the flow rate is less than 9 seconds obtain the desired flow rate within 9 to 15 seconds with a one-time addition of water. A one-time addition of water is not prohibited from being several distinct additions of water provided that no fine aggregate concrete has been discharged except for flow testing. All water additions should be completed within 15 minutes from the start of the first water addition. Such addition should be injected into the mixer under such pressure and direction of flow to allow for proper distribution within the mixer. The drum should be turned an additional 30 revolutions, or more if necessary, at mixing speed to ensure that a homogenous mixture is attained. Water should not be added to the batch at any later time.

Discharge of fine aggregate concrete should be completed within 1 1/2 hours after the introduction of mixing water to the cement and fine aggregate. This limitation may be waived by the contractor if concrete is of such flow after 1 1/2 hours time has been reached that it can be placed, without the addition of water to the batch. In hot weather, or under conditions contributing to rapid stiffening of the fine aggregate concrete, a time less than 1 1/2 hours is permitted to be specified by the contractor. *Depending on the project requirements the technology is available to the manufacture to alter fresh fine aggregate properties (such as setting time or flow.) On some projects the manufacturer may request changes to certain fresh fine aggregate concrete properties due to the distance or projected transportation time between the batch plant and the point of delivery.*

Fine aggregate concrete delivered in cold weather should have the minimum temperature indicated in Table 4.0. The maximum temperature of fine aggregate concrete produced with heated aggregate, heated water, or both, should at no time during its production or transportation exceed 90 °F.

Table 4.0 Minimum Fine Aggregate Temperature as Placed

Section Size, inch	Temperature, min, °F
< 12	55
12—36	50

2.4.3 Sampling for Uniformity

The fine aggregate concrete should be discharged at the normal operating rate for the mixer being tested, with care being exercised not to obstruct or retard the discharge by an incompletely opened gate or seal. As the mixer is being emptied, individual samples should be taken after discharge of approximately 15% and 85% of the load. *No samples should be taken before 10% or after 90% of the batch has been discharged. Due to the difficulties of determining the actual quantity of fine aggregate discharged, the intent is to provide samples that are representative of widely separated portions, but not the beginning and end of the load.*

2.4.4 Batch Ticket Information

The manufacturer of the concrete should furnish to the contractor with each batch of fine aggregate concrete before unloading at the site, a delivery ticket with the following information:

- Name of ready-mix company and batch plant, or batch plant number.
- Serial number of ticket,
- Date,
- Truck number,
- Specific designation of job (name and location),
- Specific call or designation of the concrete in conformance with that employed in project specifications,
- Amount of fine aggregate concrete in cubic yards,
- Time loaded or of first mixing of cement and fine aggregate, and
- Amount of water added to the fine aggregate concrete by the contractor, at site, or the contractor's designated representative and their initials.

The following information, for certification purposes, required by the project specifications should be furnished:

- Type, brand, and amount of cement,
- Class, brand, and amount of coal fly ash, or raw or calcined natural pozzolans,
- Type, brand, and amount of admixtures.
- Source and amount of each metered or weighted water,
- Information necessary to calculate the total mixing water. Total mixing water includes water on fine aggregates, batch water (metered or weighted) including ice batched at the plant, wash water retained in the mixing drum, and water added by the truck operator from the mixer tank,
- Amount of fine aggregate,
- Ingredients certified as being previously approved, and
- Signature or initials of manufacturer's' representative.

2.3 **Geotextile Filter Fabrics**

2.4.1 The geotextile 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. The geotextile shall be free of defects or flaws which significantly affect its mechanical or hydraulic properties.

2.4.2 The geotextile filter fabric must be permitted to function properly by allowing relief of hydrostatic pressure; therefore fine soil particles shall not be allowed to clog the geotextile. The geotextile filter fabric shall be as specified elsewhere in the Contract Specifications. Final acceptance of the geotextile filter fabric by the Engineer shall be based on project specific soil information, provided by the Contractor/Owner. The geotextile filter shall meet the minimum physical requirements listed in Table 5 or greater as required by the Engineer based on site soil conditions.

2.4.3 The geotextile filter fabric 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.

Table 5.0 MINIMUM PROPERTY REQUIREMENTS – FILTER FABRIC

	Test Method	**Units**	**Minimum Value**
Mechanical Properties			
Grab Tensile Strength	ASTM D 4632	lbf	180 (in any principal direction)
Elongation at Break	ASTM D 4632	%	50 max. (in any principal direction)
Trapezoidal Tear Strength	ASTM D 4533	lbf	75 (in any principal direction)
Puncture Strength	ASTM D 4833	lbs	105 (in any principal direction)
CBR Puncture Strength	ASTM D 6241	lbs	475 (in any principal direction)
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	US Sieve	As Specified Elsewhere in the Contract Specifications
Permittivity	ASTM D 4491	sec^{-1}	As Specified Elsewhere in the Contract Specifications
Flow Rate	ASTM D 4491	$gal/min/ft^2$	As Specified Elsewhere in the Contract Specifications

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

PART 3.0: DESIGN REQUIREMENTS

3.1 Certification (Open Channel Flow)

3.1.1 Fabric formed concrete lining will only be accepted when accompanied by documented full-scale hydraulic flume performance characteristics that are derived from tests under controlled flow conditions. Test guidelines shall conform to testing protocol as documented in “Hydraulic Stability of Fabric Formed Concrete Lining and Mat Systems During Overtopping Flow.”

3.1.2 The average thickness, mass per unit area and hydraulic resistance of each concrete lining shall withstand the hydraulic loadings 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 1.3 shall be required or higher as determined by lock conditions or critical structures.

3.2 Performance (Open Channel Flow)

3.2.1 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 the documented hydraulic performance characteristics derived from full-scale flume tests performed under controlled flow conditions.

PART 4.0: CONSTRUCTION AND INSTALLATION REQUIREMENTS

4.1 Site Preparation - Grading

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. The areas shall be graded and uniformly compacted to a smooth plane surface with an allowable tolerance of plus or minus 0.2 feet from bottom grade, as long as ponding does not occur, and plus or minus 0.2 foot from a side slope grade as long as humps or pockets are removed.

4.1.2 The areas shall be free of organic material and obstructions such as roots and projecting stones and grade stakes shall be removed. 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. Where 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.

4.1.3 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.

4.1.4 The terminal edges of the fabric form lining should be keyed into the subgrade to the lines, grades, and dimensions shown on the Contract Drawings.

4.2 Inspection

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.

4.3 Geotextile Filter Fabric Placement

4.3.1 The geotextile filter baric shall be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile filter fabric shall be placed so that the upstream roll of fabric overlaps the downstream roll. The longitudinal and transverse joints will be overlapped at least two (2) feet. The geotextile will extend at least one (1) foot beyond the top and bottom concrete lining termination points, or as required by the Engineer.

4.3.2 A geotextile filter fabric, as specified elsewhere, shall be placed on the graded surface approved by the Engineer.

4.4 Fabric Form Placement

4.4.1 Factory assembled fabric form panels shall be placed over the geotextile filter fabric and within the limits shown on the Contract Drawings. Perimeter termination of the fabric forms shall be accomplished through the use of anchor, flank and toe trenches, as shown on the Contract Drawings. When placing panels an allowance for approximately 10% contraction of the form in each direction which will occur as a result of fine aggregate concrete filling. The contractor shall gather and fold the additional slope direction fabric form in the anchor trench to be secured in such a manners as to be gradually released as fabric forms contract during filling. The contractor shall gather the additional transverse direction fabric form at each baffle for self release during filling.

4.4.2 Adjacent fabric form panels shall be joined in the field by means of sewing or zippering closures. Adjacent panels shall be joined top layers to top layer and bottom layer to bottom. All field seams shall be made using two lines of U.S. Federal Standard Type 101 stitches. All sewn seams shall be downward facing.

4.4.3 When conventional joining of fabric forms is impractical or where called for on the Contract Drawings, adjacent forms may be overlapped a minimum of 3 ft to form a lap joint, pending approval by the Engineer. Based on the predominant flow direction, the upstream form shall overlap the downstream form. In no case shall simple butt joints between forms be permitted. Simple butt joints between panels shall not be allowed.

4.4.4 Expansion joints shall be provided as shown on the Contract Drawings, or as specified by the Engineer.

4.4.5 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 seams have been approved. At no time shall the unfilled fabric forms be exposed to ultraviolet light (including direct sunlight) for a period exceeding five (5) days.

4.5 Fine Aggregate Concrete Placement

4.5.1 Following the placement of the fabric forms over the geotextile filter fabric, fine aggregate concrete shall be pumped between the top and bottom layers of the fabric form through small slits to be cut in the top layer of the fabric form or manufacturer supplied valves. The slits shall be of the minimum length to allow proper insertion of a filling pipe inserted at the end of a 2-inch I.D. concrete pump hose. Fine aggregate concrete shall be pumped between the top and bottom layers of fabric, filling the forms to the recommended thickness and configuration.

Holes in the fabric forms left by the removal of the filling pipe shall be temporarily closed by inserting a piece of fabric. The 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.

4.5.2 Fine aggregate concrete coverage for US800 shall net 37.5 ft^2/yd^3 (see Section 2.3).

4.5.3 Fine aggregate concrete shall be pumped in such a manner that excessive pressure on the fabric forms is avoided. Consultation with the fabric form manufacturer with regard to the selection of grout/concrete pumps is recommended.

4.5.4 Cold joints shall be avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given section of form is discontinued or interrupted for an interval of forty-five (45) or more minutes.

4.5.5 The sequence of fine aggregate concrete shall be such as to ensure complete filling of the fabric formed concrete lining to the thickness specified by the Engineer. The flow of the fine aggregate concrete shall first be directed into the lower edge of the fabric form and working back up the slope, followed by redirecting the flow into the anchor trench.

4.5.6 Prior to removing the filling pipe from the current concrete lining section and proceeding to the fine aggregate concrete filling of the adjacent lining section, the thickness of the current lining section shall be measured by inserting a length of stiff wire through the lining at several locations from the crest to the toe of the slope. The average of all thickness measurements shall be not less than the specified average thickness of the concrete lining. Should the measurements not meet the specified average thickness, pumping shall continue until the specified average thickness has been attained.

4.5.7 Excessive fine aggregate concrete that has inadvertently spilled on the concrete lining surface shall be removed. The use of a high-pressure water hose to remove spilled fine aggregate concrete from the surface of the freshly pumped concrete lining shall not be permitted.

4.5.8 Foot traffic will not be permitted on the freshly pumped concrete lining when such traffic will cause permanent indentations in the lining surface. Walk boards shall be used where necessary.

4.5.9 After the fine aggregate concrete has set, all anchor, flank and toe trenches shall be backfilled and compacted flush with the top of the concrete lining. The integrity of the trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the concrete lining for its entire service life. Toe trenches shall be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches shall be completed in a timely fashion to protect the completed concrete lining. No more than five hundred (500) linear feet of pumped concrete lining with non-completed anchor, anchor, flank, or toe trenches will be permitted at any time.

PART 5.0: Method of Measurement

The fabric formed concrete erosion control lining shall be measured by the number of square feet or yards computed from the lines and cross sections shown on the Contract Drawings or from payment lines established in writing by the Engineer. This includes fabric forms, fine aggregate concrete, and filter fabric used in the aprons, overlaps, anchor, terminal, or toe trenches. Slope preparation, excavation and backfilling, and bedding are separate pay items.

Hydrotex products are manufactured and sold by:

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Section _____

EROSION CONTROL LINING SYSTEM SPECIFICATION
UNIFORM SECTION US1000 – PET FABRIC FORMED CONCRETE

PART 1.0: GENERAL

1.1 Scope of Work

The work shall consist of furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of the fabric formed concrete erosion control lining systems in accordance with the lines, grades, design, and dimensions shown on the Contract Drawings and as specified herein. If the contractor is inexperienced, then the fabric formed concrete manufacturer's representative shall provide on-site technical assistance at the beginning of the installation for a length of time the contractor is sufficiently experienced to complete the remaining installation.

1.2.1 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 manner as to form a stable lining of required thickness, weight and configuration.

1.3 Referenced Documents

1.3.1 American Society for Testing and Materials (ASTM)

ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or [50-mm] Cube Specimens)
ASTM C 150	Standard Specification for Portland Cement
ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 494	Standard Specification for Chemical Admixtures for Concrete
ASTM C 618	Standard Specification for Coal Fly Ash and Calcined Natural Pozzolan for Use in Concrete
ASTM C 685	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM C 1603	Standard Test Method for Measurement of Solids in Water
ASTM D 2061	Standard Test Method of Strength of Zippers
ASTM D 2256	Standard Test Method for Tensile Properties of Yarns by the Single-Strand Method
ASTM D 4354	Practice for Sampling of Geotextiles for Testing
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D 4533	Standard Test Method for Trapezoidal Tearing Strength of Geotextiles
ASTM D 4595	Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method
ASTM D 4632	Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
ASTM D 4751	Test Method for Determining Apparent Opening Size for a Geotextile
ASTM D 4759	Practice for Determining the Specification Conformance of Geotextiles
ASTM D 4873	Standard Guide for Identification, Storage, and Handling of Geotextiles
ASTM D 4884	Test Method for Seam Strength of Sewn Geotextiles
ASTM D 5199	Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
ASTM D 5261	Test Method for Measuring Mass per Unit Area of Geotextiles
ASTM D 6241	Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 2-inch [50-mm] Probe
ASTM D 6449	Standard Method for Flow of Fine Aggregate Concrete for Fabric Formed Concrete

1.4 Terminology

For the purpose of these specifications, the following definitions shall apply:

1.4.1 Compaction:

The densification of a soil by means of mechanical manipulation.

1.4.2 Subgrade:

The ground surface usually specially prepared against which lining shall be placed. In cases where lining is to be retained the same shall be considered as subgrade.

1.4.3 Hydrotex™ Fabric Form:

The fabric forms are constructed of woven, double-layer synthetic fabric. HYDROTEX linings are installed by positioning fabric forms over the areas to be protected and then pumping, high-strength, fine aggregate concrete into the forms. The fabric forms can be placed and filled either underwater or in-the-dry. The high-strength, fine aggregate concrete is used in place of conventional concrete because of its pumpability, high-strength, impermeability, and absorption resistance.

1.4.4 Hydrotex™ Uniform Section (US) Lining:

Hydrotex Uniform Section linings provide an erosion resistant, impermeable concrete lining having a brick pattern surface and a relatively low coefficient of hydraulic friction in order to maintain optimum water velocities. The thickness and weight of the lining is controlled by spacer cords.

1.4.5 Baffle:

Baffles are flow-directing vertical geotextile walls constructed between fabric form sections layers. Baffles are an integral part of the fabric form design. Baffles are designed to support the panel section, determine the concrete area of the section and direct the flow of fine aggregate concrete for maximum efficiency.

1.4.6 Slide Fastener (Zipper):

A zipper or zipper like devise having two grooved plastic edges joined by a sliding tab or pull.

1.5 Submittals

1.5.1 The Contractor shall furnish the fine aggregate concrete manufacturer's certificates of compliance, mix design, fine aggregate gradation and fineness modulus for the fine aggregate concrete.

1.5.2 The Contractor shall furnish the fabric form manufacturer's certificates of compliance for the fabric forms. The Contractor shall also furnish the manufacturer's specifications, literature, shop drawings for the layout of the concrete lining panels, and any recommendations, if applicable, that are specifically related to the project.

1.5.3 Alternative fabric formed concrete lining materials may be considered. Such materials must be pre-approved in writing by the Engineer prior to the bid date. Alternative material packages must be submitted to the Engineer a minimum of fourteen (14) days prior to the bid date. Submittal packages must include, as a minimum, the following:

Material testing reports prepared by a certified geotextile laboratory attesting to the alternative fabric form material's compliance with this Specification. Material laboratory testing shall have been performed within ninety (90) days of the bid date.

PART 2:.0 PRODUCT

2.1 General - Fabric Formed Concrete Lining

Fabric formed concrete lining shall be Uniform Section (US1000) type and have a finished average thickness of 10.0 inches, a nominal mass per unit area of 113 lb/ft^2, and a comparatively uniform section with a brick pattern surface appearance. The shear resistance of the concrete lining shall be a minimum of 14 lb/ft^2, as demonstrated by full scale flume testing.

2.2 Fabric Forms

The fabric forms for casting the concrete lining(s) shall be as specified, HYDROTEX® Uniform Section (US1000) fabric forms as manufactured by:

Synthetex, LLC; 5550 Triangle Parkway, Suite 220 Peachtree Corners, Georgia 30092
Tel: 800.253.0561 or 770.399.5051
E-Mail: info@synthetex.com

Distributed by: Quick Supply Co., 6620 NW Toni Drive Des Moines, IA 50313, Phone: (515)289-1271, www.quicksupplydm.com

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 polyester. Forms shall be woven with a minimum of 50% textured yarns (by weight). 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 Mean Average Roll Values listed in Table 1.0. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

Table 1.0 PROPERTY REQUIREMENTS – HYDROTEX FABRIC [1, 2]

	Test Method	**Units**	**MARV**
Physical Properties			
Composition of Yarns	-	-	Polyester
Mass Per Unit Area (double-layer)	ASTM D 5261	oz/yd^2	13
Thickness (single-layer)	ASTM D 5199	mils	15
Mill Width (Woven)		inch	84
Mechanical Properties			
Wide-Width Strip Tensile Strength - MD | TD	ASTM D 4595	lbs/inch	300 **|** 350
Elongation at Break - MD **|** TD - Max.		%	15 **|** 15
Trapezoidal Tear Strength - MD | TD	ASTM D 4533	lbs	150 **|** 175
CBR Puncture Strength	ASTM D 6241	lbs	1250
Mullen Burst Strength	ASTM D 3786 (Mod.)	psi	500
	Test Method	**Units**	**MARV Range**
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Standard Sieve	30 - 40
Flow Rate	ASTM D 4491	gal/min/ft^2	30 - 55

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

2.2.1 Fabric forms shall consist of double-layer woven fabric joined together by spaced, interwoven cords of uniform length to form a concrete lining of the specified average thickness. The cords shall be interwoven between the two layers of fabric, in parallel pairs, so that the two (2) cords together in the top layer and two (2) cords

together in the bottom layer cross between layers at drop points. Each cord shall have a minimum breaking strength of 160 lbf when tested in accordance with ASTM D 2256.

2.2.2 Mill widths of fabric shall be a minimum of 84 inches. Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 1.35 inches 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 80-inch centers.

2.2.3 Fabric form panels shall be factory-sewn, by jointing together the layers of fabric, top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. Sewn seams shall be downward facing as shown on the Contract Drawings. All sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. All seams sewn shall be not less than 100 lbf/inch when tested in accordance with ASTM D 4884. Both lines of stitches shall be sewn simultaneously and be parallel to each other, spaced between 0.25 inches to 0.75 inches apart. Each row of stitching shall consist of 4 to 7 stitches per inch. Thread used for seaming shall be polyester.

2.2.4 Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffles shall be designed to maintain a full concrete lining thickness along the full length of the baffle. The baffle material shall be nonwoven filter fabric. The grab tensile strength of the filter fabric shall be not less than 180 lbf/inch when tested in accordance with ASTM D 4632.

2.2.5 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.

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 Fine Aggregate Concrete

Fine aggregate concrete consists of a mixture of Portland cement, fine aggregate (sand) and water, so proportioned and mixed as to provide a pumpable fine aggregate concrete.

The water/cement ratio of the fine aggregate concrete shall be determined by the ready-mix manufacturer, but generally should be on the order of 0.65 to 0.70. The pumping of fine aggregate concrete into the fabric forms causes a reduction in the water content by filtering excess mixing water through the permeable fabric. The reduction of mixing water substantially improves the water/cement ratio of the in-place fine aggregate concrete thereby increasing its strength and durability. The sand/cement ratio should be determined by the ready-mix manufacturer and should be on the order of 2.4:1.

The consistency of the fine aggregate concrete delivered to the concrete pump should be proportioned and mixed as to have a flow time of 9-15 seconds when passed through the ¾-inch [19 mm] orifice of the standard flow cone that is described in ASTM C6449-99. Additional Pozzolan and/or admixtures may be used with the approval of the Engineer-in-charge. The water/cement ratio varies with the exact granulometry of the fine aggregate (sand) and should be determined by the ready-mix manufacturer using the above referenced flow cone.

The Contractor should demonstrate the suitability by placing the proposed fine aggregate concrete mix into three (3) 2-inch concrete cubes. The mix should exhibit a minimum compressive strength of 3500 psi at 28 days, when made and tested in accordance ASTM C109/C109M-13.

With a typical loss of approximately 15% of the total mixing water, 27 ft^3 of pumpable fine aggregate concrete will reduce to approximately 25 ft^3 of hardened concrete. The mixing water reduction will also result in an

increase of approximately 8% in the sand and cement per cubic foot of concrete. The range of fine aggregate concrete mix proportions provided in Table 2.0 has been developed under a variety of field conditions.

Table 2.0 Typical Range of Mix Proportions

Material	Mix Proportions lb/yd^3	After Placement Mix Proportions lb/yd^3
Cement	750-850	805-915
Sand	2120-2030	2290-2190
Water	540-555	460-470
Air	As Required	As Required

2.3.1 Components

2.3.1.1 Portland Cement

Portland cement should conform to ASTM C 150/150M, Type I, II or V. Pozzolan grade fly ash may be substituted for up to 35% of the cement as an aid to pumpability. (The pumpability of fine aggregate concrete mixes containing course sand is improved by the addition of fly ash.) Pozzolan, if used, should conform to ASTM C 618, Class C, F or N.

2.3.1.2 Fine Aggregate (sand)

Fine aggregate should consist of suitable clean, hard, strong and durable natural or manufactured sand. It should not contain dust, lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack any embedded steel, neoprene, rubber, plastic, etc. Motorized sand washing machines should be used to remove impurities from the fine aggregate. Fine aggregate having positive alkali-silica reaction should not be used. All fine aggregates should conform to ASTM C33/C33M-13. The fine aggregate should not have more than 45% passing any sieve and retained on the next consecutive sieve of those shown in Table 3.0. The fineness modulus of fine aggregate should neither be less than 2.3 nor greater than 3.1. Fine aggregate with grading near the minimum for passing the No. 50 and No. 100 sometimes have difficulties with workability or pumping. The additions of entrained air, additional cement, or the addition of an approved mineral admixture to supply the deficient fines, are methods used to alleviate such difficulties.

ASTM C33/C33M-13 defines the requirements for grading and quality of fine aggregate for use in fine aggregate concrete and is for use by a contractor as part of the purchase document describing the material to be furnished.

Table 3.0 Grading Requirement for Fine Aggregate

Sieve	Percent by Weight Passing the Sieve
9.5-mm (3/8-in.)	100
4.75-mm (No. 4)	95 to 100
2.36-mm (No. 8)	80 to 100
1.18-mm (No. 16)	50 to 85
600-µm (No. 30)	25 to 60
300-µm (No. 50)	5 to 30
150-µm (No. 100)	0 to 10
75-µm (No. 200)	0 to 3

Fine aggregate failing to meet these grading requirements can be utilized provided that the supplier can demonstrate to the specifier that fine aggregate concrete of the class specified, made with fine aggregate under consideration, will have relevant properties at least equal to those of fine aggregate concrete made with

same ingredients, with the exception that the referenced fine aggregate will be selected from a source having an acceptable performance record in similar fine aggregate construction.

2.3.1.3 Water

Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.

Potable water is permitted to be used as mixing water in fine aggregate concrete without testing for conformance with the requirements of ASTM C1602/C1602M-12.

ASTM C1602/C1602M-12 covers the compositional and performance requirements for water used as mixing water in hydraulic cement fine aggregate concrete. It defines sources of water and provides requirements and testing frequencies for qualified individual or combined water sources.

2.3.2 Plasticizing and Air Entraining Admixtures

Grout fluidifier, water reducing or set time controlling agents may be used as recommended by their manufacturers to improve the pumpability and set time of the fine aggregate concrete.

Any air entraining agent or any other admixture may be used, as approved, by the Engineer-in-charge to increase workability, to make concrete impervious and more durable. Air entraining admixture should conform to ASTM C494/C494M and ASTM C260/C260M, respectively. Mixes designed with 5% to 8% air content will improve the pumpability of the fine aggregate concrete, freeze-thaw and sulfate resistance of the hardened concrete.

2.4 Ready-Mixed Concrete

The basis of standard specifications for ready-mixed concrete should be ASTM C94/C94M-13a.

2.4.1 Ordering

The contractor should require the manufacturer to assume full responsibility for the selection of the proportions for the concrete mixture, the contractor should also specify the following:

1. Requirements for compressive strength as determined on samples taken from the transportation unit at the point of discharge. Unless otherwise specified the age at test should be 28 days.

2. That the manufacturer, prior to the actual delivery of the fine aggregate concrete, furnish a statement to the contractor, giving the dry mass of cement and saturated surface-dry-mass of fine aggregate and quantities, type, and name of admixtures (if any) and the water per cubic yard or cubic metre of fine aggregate concrete that will be used in the manufacture. The manufacturer should also furnish evidence satisfactory to the contractor that the materials to be used and proportions selected will produce fine aggregate concrete of the quality specified.

2.4.2 Mixing and Delivery

Ready-mixed fine aggregate concrete should be mixed and delivered to the point of discharge by means of one of the following combinations of operation:

Central-Mixed Concrete is mixed completely in a stationary mixer and transported to the point of delivery in a truck agitator, or a truck mixer operating at agitating speed, or in non-agitating equipment meeting the requirements of Section 13 of ASTM C94/C94M-13a. The acceptable mixing time for mixers having capacity of 1 yd^3 or less is one (1) minuet. For mixers of greater capacity, this minimum should be increased 15 seconds for each cubic yard [cubic metre] of fraction thereof of additional capacity.

Shrink-Mixed Concrete—Concrete that is first partially mixed in a stationary mixer, and then completely in a truck mixer, should conform to the following: The time for the partial mixing should be the minimum required to intermingle the ingredients. After transfer to a truck mixer the amount of mixing at the designated mixing speed will be that necessary to meet the requirements for uniformity of concrete.

Truck-Mixed Concrete—Concrete that is completely mixed in a truck mixer, 70 to 100 revolutions at the mixing

speed designated by the manufacturer to produce the uniformity of concrete.

No water from the truck water system should or elsewhere should be added after the initial introduction of mixing water for the batch except when on arrival to the project site the flow rate of the fine aggregate concrete is less than 9 seconds. If the flow rate is less than 9 seconds obtain the desired flow rate within 9 to 15 seconds with a one-time addition of water. A one-time addition of water is not prohibited from being several distinct additions of water provided that no fine aggregate concrete has been discharged except for flow testing. All water additions should be completed within 15 minutes from the start of the first water addition. Such addition should be injected into the mixer under such pressure and direction of flow to allow for proper distribution within the mixer. The drum should be turned an additional 30 revolutions, or more if necessary, at mixing speed to ensure that a homogenous mixture is attained. Water should not be added to the batch at any later time.

Discharge of fine aggregate concrete should be completed within 1 1/2 hours after the introduction of mixing water to the cement and fine aggregate. This limitation may be waived by the contractor if concrete is of such flow after 1 1/2 hours time has been reached that it can be placed, without the addition of water to the batch. In hot weather, or under conditions contributing to rapid stiffening of the fine aggregate concrete, a time less than 1 1/2 hours is permitted to be specified by the contractor. *Depending on the project requirements the technology is available to the manufacture to alter fresh fine aggregate properties (such as setting time or flow.) On some projects the manufacturer may request changes to certain fresh fine aggregate concrete properties due to the distance or projected transportation time between the batch plant and the point of delivery.*

Fine aggregate concrete delivered in cold weather should have the minimum temperature indicated in Table 4.0. The maximum temperature of fine aggregate concrete produced with heated aggregate, heated water, or both, should at no time during its production or transportation exceed 90 °F.

Table 4.0 Minimum Fine Aggregate Temperature as Placed

Section Size, inch	Temperature, min, °F
< 12	55
12—36	50

2.4.3 Sampling for Uniformity

The fine aggregate concrete should be discharged at the normal operating rate for the mixer being tested, with care being exercised not to obstruct or retard the discharge by an incompletely opened gate or seal. As the mixer is being emptied, individual samples should be taken after discharge of approximately 15% and 85% of the load. *No samples should be taken before 10% or after 90% of the batch has been discharged. Due to the difficulties of determining the actual quantity of fine aggregate discharged, the intent is to provide samples that are representative of widely separated portions, but not the beginning and end of the load.*

2.4.4 Batch Ticket Information

The manufacturer of the concrete should furnish to the contractor with each batch of fine aggregate concrete before unloading at the site, a delivery ticket with the following information:

- Name of ready-mix company and batch plant, or batch plant number.
- Serial number of ticket,
- Date,
- Truck number,
- Specific designation of job (name and location),
- Specific call or designation of the concrete in conformance with that employed in project specifications,
- Amount of fine aggregate concrete in cubic yards,
- Time loaded or of first mixing of cement and fine aggregate, and
- Amount of water added to the fine aggregate concrete by the contractor, at site, or the contractor's designated representative and their initials.

The following information, for certification purposes, required by the project specifications should be furnished:

- Type, brand, and amount of cement,
- Class, brand, and amount of coal fly ash, or raw or calcined natural pozzolans,
- Type, brand, and amount of admixtures.
- Source and amount of each metered or weighted water,
- Information necessary to calculate the total mixing water. Total mixing water includes water on fine aggregates, batch water (metered or weighted) including ice batched at the plant, wash water retained in the mixing drum, and water added by the truck operator from the mixer tank,
- Amount of fine aggregate,
- Ingredients certified as being previously approved, and
- Signature or initials of manufacturer's' representative.

2.3 **Geotextile Filter Fabrics**

2.4.1 The geotextile 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. The geotextile shall be free of defects or flaws which significantly affect its mechanical or hydraulic properties.

2.4.2 The geotextile filter fabric must be permitted to function properly by allowing relief of hydrostatic pressure; therefore fine soil particles shall not be allowed to clog the geotextile. The geotextile filter fabric shall be as specified elsewhere in the Contract Specifications. Final acceptance of the geotextile filter fabric by the Engineer shall be based on project specific soil information, provided by the Contractor/Owner. The geotextile filter shall meet the minimum physical requirements listed in Table 5 or greater as required by the Engineer based on site soil conditions.

2.4.3 The geotextile filter fabric 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.

Table 5.0 MINIMUM PROPERTY REQUIREMENTS – FILTER FABRIC

	Test Method	**Units**	**Minimum Value**
Mechanical Properties			
Grab Tensile Strength	ASTM D 4632	lbf	180 (in any principal direction)
Elongation at Break	ASTM D 4632	%	50 max. (in any principal direction)
Trapezoidal Tear Strength	ASTM D 4533	lbf	75 (in any principal direction)
Puncture Strength	ASTM D 4833	lbs	105 (in any principal direction)
CBR Puncture Strength	ASTM D 6241	lbs	475 (in any principal direction)
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	US Sieve	As Specified Elsewhere in the Contract Specifications
Permittivity	ASTM D 4491	sec^{-1}	As Specified Elsewhere in the Contract Specifications
Flow Rate	ASTM D 4491	$gal/min/ft^2$	As Specified Elsewhere in the Contract Specifications

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

PART 3.0: DESIGN REQUIREMENTS

3.1 Certification (Open Channel Flow)

3.1.1 Fabric formed concrete lining will only be accepted when accompanied by documented full-scale hydraulic flume performance characteristics that are derived from tests under controlled flow conditions. Test guidelines shall conform to testing protocol as documented in “Hydraulic Stability of Fabric Formed Concrete Lining and Mat Systems During Overtopping Flow.”

3.1.2 The average thickness, mass per unit area and hydraulic resistance of each concrete lining shall withstand the hydraulic loadings 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 1.3 shall be required or higher as determined by lock conditions or critical structures.

3.2 Performance (Open Channel Flow)

3.2.1 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 the documented hydraulic performance characteristics derived from full-scale flume tests performed under controlled flow conditions.

PART 4.0: CONSTRUCTION AND INSTALLATION REQUIREMENTS

4.1 Site Preparation - Grading

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. The areas shall be graded and uniformly compacted to a smooth plane surface with an allowable tolerance of plus or minus 0.2 feet from bottom grade, as long as ponding does not occur, and plus or minus 0.2 foot from a side slope grade as long as humps or pockets are removed.

4.1.2 The areas shall be free of organic material and obstructions such as roots and projecting stones and grade stakes shall be removed. 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. Where 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.

4.1.3 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.

4.1.4 The terminal edges of the fabric form lining should be keyed into the subgrade to the lines, grades, and dimensions shown on the Contract Drawings.

4.2 Inspection

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.

4.3 Geotextile Filter Fabric Placement

4.3.1 The geotextile filter baric shall be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile filter fabric shall be placed so that the upstream roll of fabric overlaps the downstream roll. The longitudinal and transverse joints will be overlapped at least two (2) feet. The geotextile will extend at least one (1) foot beyond the top and bottom concrete lining termination points, or as required by the Engineer.

4.3.2 A geotextile filter fabric, as specified elsewhere, shall be placed on the graded surface approved by the Engineer.

4.4 Fabric Form Placement

4.4.1 Factory assembled fabric form panels shall be placed over the geotextile filter fabric and within the limits shown on the Contract Drawings. Perimeter termination of the fabric forms shall be accomplished through the use of anchor, flank and toe trenches, as shown on the Contract Drawings. When placing panels an allowance for approximately 10% contraction of the form in each direction which will occur as a result of fine aggregate concrete filling. The contractor shall gather and fold the additional slope direction fabric form in the anchor trench to be secured in such a manners as to be gradually released as fabric forms contract during filling. The contractor shall gather the additional transverse direction fabric form at each baffle for self release during filling.

4.4.2 Adjacent fabric form panels shall be joined in the field by means of sewing or zippering closures. Adjacent panels shall be joined top layers to top layer and bottom layer to bottom. All field seams shall be made using two lines of U.S. Federal Standard Type 101 stitches. All sewn seams shall be downward facing.

4.4.3 When conventional joining of fabric forms is impractical or where called for on the Contract Drawings, adjacent forms may be overlapped a minimum of 3 ft to form a lap joint, pending approval by the Engineer. Based on the predominant flow direction, the upstream form shall overlap the downstream form. In no case shall simple butt joints between forms be permitted. Simple butt joints between panels shall not be allowed.

4.4.4 Expansion joints shall be provided as shown on the Contract Drawings, or as specified by the Engineer.

4.4.5 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 seams have been approved. At no time shall the unfilled fabric forms be exposed to ultraviolet light (including direct sunlight) for a period exceeding five (5) days.

4.5 Fine Aggregate Concrete Placement

4.5.1 Following the placement of the fabric forms over the geotextile filter fabric, fine aggregate concrete shall be pumped between the top and bottom layers of the fabric form through small slits to be cut in the top layer of the fabric form or manufacturer supplied valves. The slits shall be of the minimum length to allow proper insertion of a filling pipe inserted at the end of a 2-inch I.D. concrete pump hose. Fine aggregate concrete shall be pumped between the top and bottom layers of fabric, filling the forms to the recommended thickness and configuration.

Holes in the fabric forms left by the removal of the filling pipe shall be temporarily closed by inserting a piece of fabric. The 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.

4.5.2 Fine aggregate concrete coverage for US1000 shall net 30 ft^2/yd^3 (see Section 2.3).

4.5.3 Fine aggregate concrete shall be pumped in such a manner that excessive pressure on the fabric forms is avoided. Consultation with the fabric form manufacturer with regard to the selection of grout/concrete pumps is recommended.

4.5.4 Cold joints shall be avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given section of form is discontinued or interrupted for an interval of forty-five (45) or more minutes.

4.5.5 The sequence of fine aggregate concrete shall be such as to ensure complete filling of the fabric formed concrete lining to the thickness specified by the Engineer. The flow of the fine aggregate concrete shall first be directed into the lower edge of the fabric form and working back up the slope, followed by redirecting the flow into the anchor trench.

4.5.6 Prior to removing the filling pipe from the current concrete lining section and proceeding to the fine aggregate concrete filling of the adjacent lining section, the thickness of the current lining section shall be measured by inserting a length of stiff wire through the lining at several locations from the crest to the toe of the slope. The average of all thickness measurements shall be not less than the specified average thickness of the concrete lining. Should the measurements not meet the specified average thickness, pumping shall continue until the specified average thickness has been attained.

4.5.7 Excessive fine aggregate concrete that has inadvertently spilled on the concrete lining surface shall be removed. The use of a high-pressure water hose to remove spilled fine aggregate concrete from the surface of the freshly pumped concrete lining shall not be permitted.

4.5.8 Foot traffic will not be permitted on the freshly pumped concrete lining when such traffic will cause permanent indentations in the lining surface. Walk boards shall be used where necessary.

4.5.9 After the fine aggregate concrete has set, all anchor, flank and toe trenches shall be backfilled and compacted flush with the top of the concrete lining. The integrity of the trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the concrete lining for its entire service life. Toe trenches shall be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches shall be completed in a timely fashion to protect the completed concrete lining. No more than five hundred (500) linear feet of pumped concrete lining with non-completed anchor, anchor, flank, or toe trenches will be permitted at any time.

PART 5.0: Method of Measurement

The fabric formed concrete erosion control lining shall be measured by the number of square feet or yards computed from the lines and cross sections shown on the Contract Drawings or from payment lines established in writing by the Engineer. This includes fabric forms, fine aggregate concrete, and filter fabric used in the aprons, overlaps, anchor, terminal, or toe trenches. Slope preparation, excavation and backfilling, and bedding are separate pay items.

Hydrotex products are manufactured and sold by:

SYNTHETEX
Synthetex, LLC
5550 Triangle Parkway, Suite 220
Peachtree Corners, GA 30092
Tel: 1.800.253.0561 or 770.399.5051
Fax: 770.394.5999
www.synthetex.com • e-mail: info@synthetex.com

Section _____

EROSION CONTROL LINING SYSTEM SPECIFICATION
UNIFORM SECTION US1200 - PET FABRIC FORMED CONCRETE

PART 1.0: GENERAL

1.1 Scope of Work

The work shall consist of furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of the fabric formed concrete erosion control lining systems in accordance with the lines, grades, design, and dimensions shown on the Contract Drawings and as specified herein. If the contractor is inexperienced, then the fabric formed concrete manufacturer's representative shall provide on-site technical assistance at the beginning of the installation for a length of time the contractor is sufficiently experienced to complete the remaining installation.

1.2.1 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 manner as to form a stable lining of required thickness, weight and configuration.

1.3 Referenced Documents

1.3.1 American Society for Testing and Materials (ASTM)

ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or [50-mm] Cube Specimens)
ASTM C 150	Standard Specification for Portland Cement
ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 494	Standard Specification for Chemical Admixtures for Concrete
ASTM C 618	Standard Specification for Coal Fly Ash and Calcined Natural Pozzolan for Use in Concrete
ASTM C 685	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM C 1603	Standard Test Method for Measurement of Solids in Water
ASTM D 2061	Standard Test Method of Strength of Zippers
ASTM D 2256	Standard Test Method for Tensile Properties of Yarns by the Single-Strand Method
ASTM D 4354	Practice for Sampling of Geotextiles for Testing
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D 4533	Standard Test Method for Trapezoidal Tearing Strength of Geotextiles
ASTM D 4595	Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method
ASTM D 4632	Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
ASTM D 4751	Test Method for Determining Apparent Opening Size for a Geotextile
ASTM D 4759	Practice for Determining the Specification Conformance of Geotextiles
ASTM D 4873	Standard Guide for Identification, Storage, and Handling of Geotextiles
ASTM D 4884	Test Method for Seam Strength of Sewn Geotextiles
ASTM D 5199	Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
ASTM D 5261	Test Method for Measuring Mass per Unit Area of Geotextiles
ASTM D 6241	Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 2-inch [50-mm] Probe
ASTM D 6449	Standard Method for Flow of Fine Aggregate Concrete for Fabric Formed Concrete

1.4 Terminology

For the purpose of these specifications, the following definitions shall apply:

1.4.1 Compaction:

The densification of a soil by means of mechanical manipulation.

1.4.2 Subgrade:

The ground surface usually specially prepared against which lining shall be placed. In cases where lining is to be retained the same shall be considered as subgrade.

1.4.3 Hydrotex® Fabric Form:

The fabric forms are constructed of woven, double-layer synthetic fabric. HYDROTEX linings are installed by positioning fabric forms over the areas to be protected and then pumping, high-strength, fine aggregate concrete into the forms. The fabric forms can be placed and filled either underwater or in-the-dry. The high-strength, fine aggregate concrete is used in place of conventional concrete because of its pumpability, high-strength, impermeability, and absorption resistance.

1.4.4 Hydrotex® Uniform Section (US) Lining:

Hydrotex Uniform Section linings provide an erosion resistant, impermeable concrete lining having a brick pattern surface and a relatively low coefficient of hydraulic friction in order to maintain optimum water velocities. The thickness and weight of the lining is controlled by spacer cords.

1.4.5 Baffle:

Baffles are flow-directing vertical geotextile walls constructed between fabric form sections layers. Baffles are an integral part of the fabric form design. Baffles are designed to support the panel section, determine the concrete area of the section and direct the flow of fine aggregate concrete for maximum efficiency.

1.4.6 Slide Fastener (Zipper):

A zipper or zipper like devise having two grooved plastic edges joined by a sliding tab or pull.

1.5 Submittals

1.5.1 The Contractor shall furnish the fine aggregate concrete manufacturer's certificates of compliance, mix design, fine aggregate gradation and fineness modulus for the fine aggregate concrete.

1.5.2 The Contractor shall furnish the fabric form manufacturer's certificates of compliance for the fabric forms. The Contractor shall also furnish the manufacturer's specifications, literature, shop drawings for the layout of the concrete lining panels, and any recommendations, if applicable, that are specifically related to the project.

1.5.3 Alternative fabric formed concrete lining materials may be considered. Such materials must be pre-approved in writing by the Engineer prior to the bid date. Alternative material packages must be submitted to the Engineer a minimum of fourteen (14) days prior to the bid date. Submittal packages must include, as a minimum, the following:

Material testing reports prepared by a certified geotextile laboratory attesting to the alternative fabric form material's compliance with this Specification. Material laboratory testing shall have been performed within ninety (90) days of the bid date.

PART 2:.0 PRODUCT

2.1 General - Fabric Formed Concrete Lining

Fabric formed concrete lining shall be Uniform Section (US1200) type and have a finished average thickness of 12 inches, a nominal mass per unit area of 135 lb/ft^2, and a comparatively uniform section with a brick pattern surface appearance. The shear resistance of the concrete lining shall be a minimum of 42 lb/ft^2, as demonstrated by full scale flume testing.

2.2 Fabric Forms

The fabric forms for casting the concrete lining(s) shall be as specified, HYDROTEX® Uniform Section (US1200) fabric forms as manufactured by:

Synthetex, LLC; 5550 Triangle Parkway, Suite 220 Peachtree Corners, Georgia 30092
Tel: 800.253.0561 or 770.399.5051
E-Mail: info@synthetex.com

Distributed by: Quick Supply Co., 6620 NW Toni Drive Des Moines, IA 50313, Phone: (515)289-1271, www.quicksupplydm.com

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 polyester. Forms shall be woven with a minimum of 50% textured yarns (by weight). 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 Mean Average Roll Values listed in Table 1.0. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

Table 1.0 PROPERTY REQUIREMENTS – HYDROTEX FABRIC [1, 2]			
	Test Method	**Units**	**MARV**
Physical Properties			
Composition of Yarns	-	-	Polyester
Mass Per Unit Area (double-layer)	ASTM D 5261	oz/yd^2	13
Thickness (single-layer)	ASTM D 5199	mils	15
Mill Width (Woven)		inch	84
Mechanical Properties			
Wide-Width Strip Tensile Strength - MD | TD	ASTM D 4595	lbs/inch	300 **|** 350
Elongation at Break - MD **|** TD - Max.		%	15 **|** 15
Trapezoidal Tear Strength - MD | TD	ASTM D 4533	lbs	150 **|** 175
CBR Puncture Strength	ASTM D 6241	lbs	1250
Mullen Burst Strength	ASTM D 3786 (Mod.)	psi	500
	Test Method	**Units**	**MARV Range**
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Standard Sieve	30 - 40
Flow Rate	ASTM D 4491	gal/min/ft^2	30 - 55

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

2.2.1 Fabric forms shall consist of double-layer woven fabric joined together by spaced, interwoven cords of uniform length to form a concrete lining of the specified average thickness. The cords shall be interwoven between the two layers of fabric, in parallel pairs, so that the two (2) cords together in the top layer and two (2) cords

together in the bottom layer cross between layers at drop points. Each cord shall be a No. 30 bonded cord and shall have a minimum breaking strength of 280 lbf when tested in accordance with ASTM D 2256.

2.2.2 Mill widths of fabric shall be a minimum of 84 inches. Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 1.35 inches 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 80-inch centers.

2.2.3 Fabric form panels shall be factory-sewn, by jointing together the layers of fabric, top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. Sewn seams shall be downward facing as shown on the Contract Drawings. All sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. All seams sewn shall be not less than 100 lbf/inch when tested in accordance with ASTM D 4884. Both lines of stitches shall be sewn simultaneously and be parallel to each other, spaced between 0.25 inches to 0.75 inches apart. Each row of stitching shall consist of 4 to 7 stitches per inch. Thread used for seaming shall be polyester.

2.2.4 Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffles shall be designed to maintain a full concrete lining thickness along the full length of the baffle. The baffle material shall be nonwoven filter fabric. The grab tensile strength of the filter fabric shall be not less than 180 lbf/inch when tested in accordance with ASTM D 4632.

2.2.5 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.

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 Fine Aggregate Concrete

Fine aggregate concrete consists of a mixture of Portland cement, fine aggregate (sand) and water, so proportioned and mixed as to provide a pumpable fine aggregate concrete.

The water/cement ratio of the fine aggregate concrete shall be determined by the ready-mix manufacturer, but generally should be on the order of 0.65 to 0.70. The pumping of fine aggregate concrete into the fabric forms causes a reduction in the water content by filtering excess mixing water through the permeable fabric. The reduction of mixing water substantially improves the water/cement ratio of the in-place fine aggregate concrete thereby increasing its strength and durability. The sand/cement ratio should be determined by the ready-mix manufacturer and should be on the order of 2.4:1.

The consistency of the fine aggregate concrete delivered to the concrete pump should be proportioned and mixed as to have a flow time of 9-15 seconds when passed through the ¾-inch [19 mm] orifice of the standard flow cone that is described in ASTM C6449-99. Additional Pozzolan and/or admixtures may be used with the approval of the Engineer-in-charge. The water/cement ratio varies with the exact granulometry of the fine aggregate (sand) and should be determined by the ready-mix manufacturer using the above referenced flow cone.

The Contractor should demonstrate the suitability by placing the proposed fine aggregate concrete mix into three (3) 2-inch concrete cubes. The mix should exhibit a minimum compressive strength of 3500 psi at 28 days, when made and tested in accordance ASTM C109/C109M-13.

With a typical loss of approximately 15% of the total mixing water, 27 ft^3 of pumpable fine aggregate concrete will reduce to approximately 25 ft^3 of hardened concrete. The mixing water reduction will also result in an

increase of approximately 8% in the sand and cement per cubic foot of concrete. The range of fine aggregate concrete mix proportions provided in Table 2.0 has been developed under a variety of field conditions.

Table 2.0 Typical Range of Mix Proportions

Material	Mix Proportions lb/yd^3	After Placement Mix Proportions lb/yd^3
Cement	750-850	805-915
Sand	2100-2000	2290-2190
Water	540-555	460-470
Air	As Required	As Required

2.3.1 Components

2.3.1.1 Portland Cement

Portland cement should conform to ASTM C 150/150M, Type I, II or V. Pozzolan grade fly ash may be substituted for up to 35% of the cement as an aid to pumpability. (The pumpability of fine aggregate concrete mixes containing course sand is improved by the addition of fly ash.) Pozzolan, if used, should conform to ASTM C 618, Class C, F or N.

2.3.1.2 Fine Aggregate (sand)

Fine aggregate should consist of suitable clean, hard, strong and durable natural or manufactured sand. It should not contain dust, lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack any embedded steel, neoprene, rubber, plastic, etc. Motorized sand washing machines should be used to remove impurities from the fine aggregate. Fine aggregate having positive alkali-silica reaction should not be used. All fine aggregates should conform to ASTM C33/C33M-13. The fine aggregate should not have more than 45% passing any sieve and retained on the next consecutive sieve of those shown in Table 3.0. The fineness modulus of fine aggregate should neither be less than 2.3 nor greater than 3.1. Fine aggregate with grading near the minimum for passing the No. 50 and No. 100 sometimes have difficulties with workability or pumping. The additions of entrained air, additional cement, or the addition of an approved mineral admixture to supply the deficient fines, are methods used to alleviate such difficulties.

ASTM C33/C33M-13 defines the requirements for grading and quality of fine aggregate for use in fine aggregate concrete and is for use by a contractor as part of the purchase document describing the material to be furnished.

Table 3.0 Grading Requirement for Fine Aggregate

Sieve	Percent by Weight Passing the Sieve
9.5-mm (3/8-in.)	100
4.75-mm (No. 4)	95 to 100
2.36-mm (No. 8)	80 to 100
1.18-mm (No. 16)	50 to 85
600-µm (No. 30)	25 to 60
300-µm (No. 50)	5 to 30
150-µm (No. 100)	0 to 10
75-µm (No. 200)	0 to 3

Fine aggregate failing to meet these grading requirements can be utilized provided that the supplier can demonstrate to the specifier that fine aggregate concrete of the class specified, made with fine aggregate under consideration, will have relevant properties at least equal to those of fine aggregate concrete made with

same ingredients, with the exception that the referenced fine aggregate will be selected from a source having an acceptable performance record in similar fine aggregate construction.

2.3.1.3 Water

Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.

Potable water is permitted to be used as mixing water in fine aggregate concrete without testing for conformance with the requirements of ASTM C1602/C1602M-12.

ASTM C1602/C1602M-12 covers the compositional and performance requirements for water used as mixing water in hydraulic cement fine aggregate concrete. It defines sources of water and provides requirements and testing frequencies for qualified individual or combined water sources.

2.3.2 Plasticizing and Air Entraining Admixtures

Grout fluidifier, water reducing or set time controlling agents may be used as recommended by their manufacturers to improve the pumpability and set time of the fine aggregate concrete.

Any air entraining agent or any other admixture may be used, as approved, by the Engineer-in-charge to increase workability, to make concrete impervious and more durable. Air entraining admixture should conform to ASTM C494/C494M and ASTM C260/C260M, respectively. Mixes designed with 5% to 8% air content will improve the pumpability of the fine aggregate concrete, freeze-thaw and sulfate resistance of the hardened concrete.

2.4 Ready-Mixed Concrete

The basis of standard specifications for ready-mixed concrete should be ASTM C94/C94M-13a.

2.4.1 Ordering

The contractor should require the manufacturer to assume full responsibility for the selection of the proportions for the concrete mixture, the contractor should also specify the following:

1. Requirements for compressive strength as determined on samples taken from the transportation unit at the point of discharge. Unless otherwise specified the age at test should be 28 days.

2. That the manufacturer, prior to the actual delivery of the fine aggregate concrete, furnish a statement to the contractor, giving the dry mass of cement and saturated surface-dry-mass of fine aggregate and quantities, type, and name of admixtures (if any) and the water per cubic yard or cubic metre of fine aggregate concrete that will be used in the manufacture. The manufacturer should also furnish evidence satisfactory to the contractor that the materials to be used and proportions selected will produce fine aggregate concrete of the quality specified.

2.4.2 Mixing and Delivery

Ready-mixed fine aggregate concrete should be mixed and delivered to the point of discharge by means of one of the following combinations of operation:

Central-Mixed Concrete is mixed completely in a stationary mixer and transported to the point of delivery in a truck agitator, or a truck mixer operating at agitating speed, or in non-agitating equipment meeting the requirements of Section 13 of ASTM C94/C94M-13a. The acceptable mixing time for mixers having capacity of 1 yd^3 or less is one (1) minuet. For mixers of greater capacity, this minimum should be increased 15 seconds for each cubic yard [cubic metre] of fraction thereof of additional capacity.

Shrink-Mixed Concrete—Concrete that is first partially mixed in a stationary mixer, and then completely in a truck mixer, should conform to the following: The time for the partial mixing should be the minimum required to intermingle the ingredients. After transfer to a truck mixer the amount of mixing at the designated mixing speed will be that necessary to meet the requirements for uniformity of concrete.

Truck-Mixed Concrete—Concrete that is completely mixed in a truck mixer, 70 to 100 revolutions at the mixing

speed designated by the manufacturer to produce the uniformity of concrete.

No water from the truck water system should or elsewhere should be added after the initial introduction of mixing water for the batch except when on arrival to the project site the flow rate of the fine aggregate concrete is less than 9 seconds. If the flow rate is less than 9 seconds obtain the desired flow rate within 9 to 15 seconds with a one-time addition of water. A one-time addition of water is not prohibited from being several distinct additions of water provided that no fine aggregate concrete has been discharged except for flow testing. All water additions should be completed within 15 minutes from the start of the first water addition. Such addition should be injected into the mixer under such pressure and direction of flow to allow for proper distribution within the mixer. The drum should be turned an additional 30 revolutions, or more if necessary, at mixing speed to ensure that a homogenous mixture is attained. Water should not be added to the batch at any later time.

Discharge of fine aggregate concrete should be completed within 1 1/2 hours after the introduction of mixing water to the cement and fine aggregate. This limitation may be waived by the contractor if concrete is of such flow after 1 1/2 hours time has been reached that it can be placed, without the addition of water to the batch. In hot weather, or under conditions contributing to rapid stiffening of the fine aggregate concrete, a time less than 1 1/2 hours is permitted to be specified by the contractor. *Depending on the project requirements the technology is available to the manufacture to alter fresh fine aggregate properties (such as setting time or flow.) On some projects the manufacturer may request changes to certain fresh fine aggregate concrete properties due to the distance or projected transportation time between the batch plant and the point of delivery.*

Fine aggregate concrete delivered in cold weather should have the minimum temperature indicated in Table 4.0. The maximum temperature of fine aggregate concrete produced with heated aggregate, heated water, or both, should at no time during its production or transportation exceed 90 °F.

Table 4.0 Minimum Fine Aggregate Temperature as Placed

Section Size, inch	Temperature, min, °F
< 12	55
12—36	50

2.4.3 Sampling for Uniformity

The fine aggregate concrete should be discharged at the normal operating rate for the mixer being tested, with care being exercised not to obstruct or retard the discharge by an incompletely opened gate or seal. As the mixer is being emptied, individual samples should be taken after discharge of approximately 15% and 85% of the load. *No samples should be taken before 10% or after 90% of the batch has been discharged. Due to the difficulties of determining the actual quantity of fine aggregate discharged, the intent is to provide samples that are representative of widely separated portions, but not the beginning and end of the load.*

2.4.4 Batch Ticket Information

The manufacturer of the concrete should furnish to the contractor with each batch of fine aggregate concrete before unloading at the site, a delivery ticket with the following information:

- Name of ready-mix company and batch plant, or batch plant number.
- Serial number of ticket,
- Date,
- Truck number,
- Specific designation of job (name and location),
- Specific call or designation of the concrete in conformance with that employed in project specifications,
- Amount of fine aggregate concrete in cubic yards,
- Time loaded or of first mixing of cement and fine aggregate, and
- Amount of water added to the fine aggregate concrete by the contractor, at site, or the contractor's designated representative and their initials.

The following information, for certification purposes, required by the project specifications should be furnished:

- Type, brand, and amount of cement,
- Class, brand, and amount of coal fly ash, or raw or calcined natural pozzolans,
- Type, brand, and amount of admixtures.
- Source and amount of each metered or weighted water,
- Information necessary to calculate the total mixing water. Total mixing water includes water on fine aggregates, batch water (metered or weighted) including ice batched at the plant, wash water retained in the mixing drum, and water added by the truck operator from the mixer tank,
- Amount of fine aggregate,
- Ingredients certified as being previously approved, and
- Signature or initials of manufacturer's' representative.

2.3 **Geotextile Filter Fabrics**

2.4.1 The geotextile 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. The geotextile shall be free of defects or flaws which significantly affect its mechanical or hydraulic properties.

2.4.2 The geotextile filter fabric must be permitted to function properly by allowing relief of hydrostatic pressure; therefore fine soil particles shall not be allowed to clog the geotextile. The geotextile filter fabric shall be as specified elsewhere in the Contract Specifications. Final acceptance of the geotextile filter fabric by the Engineer shall be based on project specific soil information, provided by the Contractor/Owner. The geotextile filter shall meet the minimum physical requirements listed in Table 5 or greater as required by the Engineer based on site soil conditions.

2.4.3 The geotextile filter fabric 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.

Table 5.0 MINIMUM PROPERTY REQUIREMENTS – FILTER FABRIC

	Test Method	**Units**	**Minimum Value**
Mechanical Properties			
Grab Tensile Strength	ASTM D 4632	lbf	180 (in any principal direction)
Elongation at Break	ASTM D 4632	%	50 max. (in any principal direction)
Trapezoidal Tear Strength	ASTM D 4533	lbf	75 (in any principal direction)
Puncture Strength	ASTM D 4833	lbs	105 (in any principal direction)
CBR Puncture Strength	ASTM D 6241	lbs	475 (in any principal direction)
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	US Sieve	As Specified Elsewhere in the Contract Specifications
Permittivity	ASTM D 4491	sec^{-1}	As Specified Elsewhere in the Contract Specifications
Flow Rate	ASTM D 4491	$gal/min/ft^2$	As Specified Elsewhere in the Contract Specifications

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

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.

PART 3.0: DESIGN REQUIREMENTS

3.1 Certification (Open Channel Flow)

3.1.1 Fabric formed concrete lining will only be accepted when accompanied by documented full-scale hydraulic flume performance characteristics that are derived from tests under controlled flow conditions. Test guidelines shall conform to testing protocol as documented in “Hydraulic Stability of Fabric Formed Concrete Lining and Mat Systems During Overtopping Flow.”

3.1.2 The average thickness, mass per unit area and hydraulic resistance of each concrete lining shall withstand the hydraulic loadings 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 1.3 shall be required or higher as determined by lock conditions or critical structures.

3.2 Performance (Open Channel Flow)

3.2.1 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 the documented hydraulic performance characteristics derived from full-scale flume tests performed under controlled flow conditions.

PART 4.0: CONSTRUCTION AND INSTALLATION REQUIREMENTS

4.1 Site Preparation - Grading

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. The areas shall be graded and uniformly compacted to a smooth plane surface with an allowable tolerance of plus or minus 0.2 feet from bottom grade, as long as ponding does not occur, and plus or minus 0.2 foot from a side slope grade as long as humps or pockets are removed.

4.1.2 The areas shall be free of organic material and obstructions such as roots and projecting stones and grade stakes shall be removed. 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. Where 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.

4.1.3 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.

4.1.4 The terminal edges of the fabric form lining should be keyed into the subgrade to the lines, grades, and dimensions shown on the Contract Drawings.

4.2 Inspection

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.

4.3 Geotextile Filter Fabric Placement

4.3.1 The geotextile filter fabric shall be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile filter fabric shall be placed so that the upstream roll of fabric overlaps the downstream roll. The longitudinal and transverse joints will be overlapped at least two (2) feet. The geotextile will extend at least one (1) foot beyond the top and bottom concrete lining termination points, or as required by the Engineer.

4.3.2 A geotextile filter fabric, as specified elsewhere, shall be placed on the graded surface approved by the Engineer.

4.4 Fabric Form Placement

4.4.1 Factory assembled fabric form panels shall be placed over the geotextile filter fabric and within the limits shown on the Contract Drawings. Perimeter termination of the fabric forms shall be accomplished through the use of anchor, flank and toe trenches, as shown on the Contract Drawings. When placing panels an allowance for approximately 10% contraction of the form in each direction which will occur as a result of fine aggregate concrete filling. The contractor shall gather and fold the additional slope direction fabric form in the anchor trench to be secured in such a manners as to be gradually released as fabric forms contract during filling. The contractor shall gather the additional transverse direction fabric form at each baffle for self release during filling.

4.4.2 Adjacent fabric form panels shall be joined in the field by means of sewing or zippering closures. Adjacent panels shall be joined top layers to top layer and bottom layer to bottom. All field seams shall be made using two lines of U.S. Federal Standard Type 101 stitches. All sewn seams shall be downward facing.

4.4.3 When conventional joining of fabric forms is impractical or where called for on the Contract Drawings, adjacent forms may be overlapped a minimum of 3 ft to form a lap joint, pending approval by the Engineer. Based on the predominant flow direction, the upstream form shall overlap the downstream form. In no case shall simple butt joints between forms be permitted. Simple butt joints between panels shall not be allowed.

4.4.4 Expansion joints shall be provided as shown on the Contract Drawings, or as specified by the Engineer.

4.4.5 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 seams have been approved. At no time shall the unfilled fabric forms be exposed to ultraviolet light (including direct sunlight) for a period exceeding five (5) days.

4.5 Fine Aggregate Concrete Placement

4.5.1 Following the placement of the fabric forms over the geotextile filter fabric, fine aggregate concrete shall be pumped between the top and bottom layers of the fabric form through small slits to be cut in the top layer of the fabric form or manufacturer supplied valves. The slits shall be of the minimum length to allow proper insertion of a filling pipe inserted at the end of a 2-inch I.D. concrete pump hose. Fine aggregate concrete shall be pumped between the top and bottom layers of fabric, filling the forms to the recommended thickness and configuration.

Holes in the fabric forms left by the removal of the filling pipe shall be temporarily closed by inserting a piece of fabric. The 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.

4.5.2 Fine aggregate concrete coverage for US1200 shall net 25 ft^2/yd^3 (see Section 2.3).

4.5.3 Fine aggregate concrete shall be pumped in such a manner that excessive pressure on the fabric forms is avoided. Consultation with the fabric form manufacturer with regard to the selection of grout/concrete pumps is recommended.

4.5.4 Cold joints shall be avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given section of form is discontinued or interrupted for an interval of forty-five (45) or more minutes.

4.5.5 The sequence of fine aggregate concrete shall be such as to ensure complete filling of the fabric formed concrete lining to the thickness specified by the Engineer. The flow of the fine aggregate concrete shall first be directed into the lower edge of the fabric form and working back up the slope, followed by redirecting the flow into the anchor trench.

4.5.6 Prior to removing the filling pipe from the current concrete lining section and proceeding to the fine aggregate concrete filling of the adjacent lining section, the thickness of the current lining section shall be measured by inserting a length of stiff wire through the lining at several locations from the crest to the toe of the slope. The average of all thickness measurements shall be not less than the specified average thickness of the concrete lining. Should the measurements not meet the specified average thickness, pumping shall continue until the specified average thickness has been attained.

4.5.7 Excessive fine aggregate concrete that has inadvertently spilled on the concrete lining surface shall be removed. The use of a high-pressure water hose to remove spilled fine aggregate concrete from the surface of the freshly pumped concrete lining shall not be permitted.

4.5.8 Foot traffic will not be permitted on the freshly pumped concrete lining when such traffic will cause permanent indentations in the lining surface. Walk boards shall be used where necessary.

4.5.9 After the fine aggregate concrete has set, all anchor, flank and toe trenches shall be backfilled and compacted flush with the top of the concrete lining. The integrity of the trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the concrete lining for its entire service life. Toe trenches shall be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches shall be completed in a timely fashion to protect the completed concrete lining. No more than five hundred (500) linear feet of pumped concrete lining with non-completed anchor, anchor, flank, or toe trenches will be permitted at any time.

PART 5.0: Method of Measurement

The fabric formed concrete erosion control lining shall be measured by the number of square feet or yards computed from the lines and cross sections shown on the Contract Drawings or from payment lines established in writing by the Engineer. This includes fabric forms, fine aggregate concrete, and filter fabric used in the aprons, overlaps, anchor, terminal, or toe trenches. Slope preparation, excavation and backfilling, and bedding are separate pay items.

Hydrotex products are manufactured and sold by:

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