Section _____

# FABRIC FORMED CONCRETE
# EROSION CONTROL LINING SYSTEM SPECIFICATION

## PART 1: GENERAL

### 1.01 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.

### 1.02 Description

The work shall consist of installing an unreinforced concrete lining by positioning specially woven, double-layer synthetic fabric forms on the surface to be protected and filling them with a pumpable fine aggregate concrete (structural grout) in such a manner as to form a stable lining of required thickness, weight and configuration.

### 1.03 Referenced Documents

A. American Society for Testing and Materials (ASTM)

| | | |
|---|---|---|
| 1. | ASTM D 5261 | Test Method for Measuring Mass per Unit Area of Geotextiles |
| 2. | ASTM D 5199 | Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes |
| 3. | ASTM D 4595 | Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method |
| 4. | ASTM D 4632 | Test Method for Breaking Load and Elongation of Geotextiles (Grab Method) |
| 5. | ASTM D 4533 | Standard Test Method for Trapezoidal Tearing Strength of Geotextiles |
| 6. | ASTM D 4751 | Test Method for Determining Apparent Opening Size for a Geotextile |
| 7. | ASTM D 4491 | Standard Test Methods for Water Permeability of Geotextiles by Permittivity |
| 8. | ASTM D 4759 | Practice for Determining the Specification Conformance of Geotextiles |
| 9. | ASTM D 4354 | Practice for Sampling of Geotextiles for Testing |
| 10. | ASTM D 4884 | Test Method for seam Strength of Sewn Geotextiles |
| 11. | ASTM D 4873 | Standard Guide for Identification, Storage, and Handling of Geotextiles |
| 12. | ASTM D 6449 | |
| 13. | ASTM C 939 | Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method) |
| 14. | ASTM C 31 | Standard Practice for Making and Curing Concrete Test Specimens in the Field |
| 15. | ASTM C 39 | Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens |
| 16. | ASTM C 150 | Standard Specification for Portland Cement |
| 17. | ASTM C 33 | Standard Specification for Concrete Aggregates |
| 18. | ASTM C 618 | Standard Specification for Coal Fly Ash and Calcined Natural Pozzolan for Use in Concrete |
| 19. | ASTM C 494 | Standard Specification for Chemical Admixtures for Concrete |
| 20. | ASTM C 260 | Standard Specification for Air-Entraining Admixtures for Concrete |

### 1.04 Submittal

A. The Contractor shall submit to the Engineer the fabric form manufacture's full scale flume hydraulic testing and calculations in support of the proposed fabric formed concrete lining system.

B. 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.

C. 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 fifteen (15) days prior to the bid date. Submittal packages must include, as a minimum, the following:

1. Full-scale laboratory testing and associated engineering calculations quantifying the hydraulic capacity of the proposed fabric formed concrete lining system in similar conditions to the specified project.

2. 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 90 days of the bid date.

**Table 1.0 Uniform Section (US) CONCRETE LININGS**

| **Physical Properties** | **Units** | **US300** | **US400** | **US600** | **US800** | **US1000** |
|---|---|---|---|---|---|---|
| Average Thickness | in (mm) | 3.0 | 4.0 | 6.0 | 8.0 | 10.0 |
| Mass Per Unit Area | $lb/ft^2$ ($kg/m^2$) | 34 | 45 | 68 | 90 | 113 |
| **Hydraulic Design Properties** | | | | | | |
| Shear Resistance | $lb/ft^2$ ($kg/m^2$) | 13.8 | 18.4 | 27.6 | 36.8 | 46.0 |

## PART 2: PRODUCT

### 2.1 General - Fabric Formed Concrete Lining

A. Fabric formed concrete lining(s) shall be Uniform Section (US) type and have a finished average thickness of (*see Table 1.0*) inches (mm), a nominal mass per unit area of (*see Table 1.0*) $lb/ft^2$ ($kg/m^2$). The shear resistance of the concrete lining shall be (*see table 1.0*) $lb/ft^2$ ($kg/m^2$).

### 2.2 Fabric Forms

A. The fabric forms for casting the concrete lining(s) shall be as specified, HYDROTEX® Uniform Section (see Note A) fabric forms as manufactured by Synthetex, LLC; 4151 Ashford Dunwoody Road, Suite 510, Atlanta, Georgia 30319 Tel: 800.253.0561, 770.399.5051; or approved equal. The fabric forms shall consist of woven double-layer, open salvage fabric joined into panels. Fabric shall be woven of high-tenacity, continuous multifilament polyester of which a minimum of 50%, by weight, shall be textured yarn. Partially-oriented (POY), draw-textured, and/or staple yarns shall not be used in the manufacture of the fabric. The fabric shall conform to the physical, mechanical and hydraulic requirements as listed in Table 2.0 and reported by an independent testing agency within 6 months of date of manufacture. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

*Note A: The engineer shall indicate the Uniform Section Lining size required (see Table 1.0). Example: US400.*

| **Table 2.0 PROPERTY REQUIREMENTS – FILTER POINT (FP) FABRIC [1, 2]** | | | |
|---|---|---|---|
| | **Test Method** | **Units** | **Values** |
| **Physical Properties** | | | |
| Composition of Yarns | | | Polyester |
| Mass Per Unit Area (double-layer) | ASTM D 5261 | oz/yd$^2$ (g/m$^2$) | 11.3 (319) |
| Thickness | ASTM D 5199 | mils (mm) | 25 (0.6) |
| Mill Width | | in (m) | 84 (2.1) |
| **Mechanical Properties** | | | |
| **Wide-Width Strip Tensile Strength** | ASTM D 4595 | | |
| Machine Direction | | lbf/in (kN/m) | 295 (51.7) |
| Cross Machine Direction | | lbf/in (kN/m) | 269 (45.7) |
| **Elongation at Break** | ASTM D 4595 | | |
| Machine Direction | | % | 13 |
| Cross Machine Direction | | % | 13 |
| **Grab Tensile Strength** | ASTM D 4632 | | |
| Machine Direction | | lbf (N) | 310 (54.3) |
| Cross Machine Direction | | lbf (N) | 228 (39.9) |
| **Elongation at Break** | ASTM D 4632 | | |
| Machine Direction | | % | 23 |
| Cross Machine Direction | | % | 20 |
| **Trapezoidal Tear Strength** | ASTM D 4533 | | |
| Machine Direction | | lbs (N) | 125 (556) |
| Cross machine Direction | | lbs (N) | 105 (467) |
| **Hydraulic Properties** | | | |
| Apparent Opening Size (AOS) | ASTM D 4751 | U.S. Standard Sieve (mm) | 16 (1.18) |
| Permittivity | ASTM D 4491 | sec$^{-1}$ | 2.4 |
| Flow Rate | ASTM D 4491 | gal/min/ft$^2$ (l/min/m$^2$) | 180 (7330) |

Notes:

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

A. 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 in pairs so that there are two (2) cords together in the top layer and two (2) cords together in the bottom layer. Each cord shall have a minimum breaking strength of 160 lbf when tested in accordance with ASTM D 2256.

B. Mill widths of fabric shall be a minimum of 84 inches (2.13 m). Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 1.35 inches (34 mm) by adding a minimum of 6 warp yarns to each selvage construction. Mill width rolls shall be cut to the length required, and the double-layer fabric separately joined, bottom layer to bottom layer and top layer to top layer, by means of sewing thread, to form multiple mill width panels with sewn seams on not less than 80 inch (2.03 m) centers.

E. The fabric forms shall be factory sewn, by joining the together top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. All factory sewn seam shall be downward facing. Factory sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. Both lines of stitches shall be sewn simultaneously and be parallel to each other, spaced between 0.25 inches (6 mm) to 0.75 inches (19 mm) apart. Each row of stitching shall consist of 4 to 7 stitches per inch (per 25.4 mm). Thread used for seaming shall be nylon and/or polyester. All factory sewn seams strengths shall not be less than 90 lbf/in (15.7 kN/m) when tested in accordance with ASTM D 4884.

F. If required, 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.

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

H. The Contractor shall submit the fabric form 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**

A. Fine aggregate concrete shall consist of a proportioned mixture of Portland cement, fine aggregate (sand) and water. The consistency of the fine aggregate concrete delivered to the concrete pump shall be proportioned and mixed as to have a flow time of 9-12 seconds when passed through the 0.75 inch (19 mm) orifice of the standard flow cone that is described in ASTM C 939. Pozzolan and/or admixtures may be used with the approval of the Engineer. The mix shall exhibit a compressive strength of 2,500 lb/in$^2$ (17 MPa) at 28 days, when made and tested in accordance with ASTM C 31 and C 39.

B. At the direction of the Engineer, the Contractor shall demonstrate the suitability of the fine aggregate concrete mix design by pumping the proposed fine aggregate concrete into 51/2” (140 mm) diameter sleeves. The sleeves shall be constructed of the same fabric as the forms. Cylinders, 12” (300 mm) long, shall be cut from each specimen and tested in accordance with ASTM C 39. The test shall be performed at the start of the project unless directed by the engineer. The average compressive strength of the fabric cast cylinders, as described in Paragraph A above, shall be at least 20% higher at 7 days than that of the companion test cylinders made in accordance with ASTM C 31, and not less than 3,000 psi (21 MPa) at 28 days.

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

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

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

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

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

### 2.4 Filter Fabrics

A. 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 and shall contain stabilizers and/or inhibitors added to the base plastic, if necessary, to make filaments resistant to deterioration due to ultraviolet and heat exposure. . They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages. These materials shall conform to the physical requirements listed in Table 3.0 of these Specifications. The geotextile shall be free of defects or flaws which significantly affect its mechanical or hydraulic properties.

B. 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.

C. 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, “Guide for Identification, Storage and Handling of Geosynthetic Rolls.”

## PART 3.0: DESIGN REQUIREMENTS

### 3.1 Certification (Open Channel Flow)

A. Fabric formed concrete lining will only be accepted when accompanied by documented hydraulic 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.”

B. 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 1.5 shall be required.

### 3.2 Performance (Open Channel Flow)

A. 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 physical laboratory testing, measurements, and documentation of the hydraulic performance under high-velocity, unidirectional overtopping flow conditions on an earthen embankment.

## PART 4.0: CONSTRUCTION AND INSTALLATION REQUIREMENTS

### 4.1 Site Preparation

A. Areas on which fabric formed concrete lining are to be installed shall be constructed to the lines, grades, contours, and dimensions shown on the Contract Drawings. The areas shall be free of all obstructions and organic material such as projecting stones and roots. Where required by the Engineer, soft and otherwise unsuitable subgrade soils shall be identified, excavated and replaced with select materials in accordance with the Contract Specifications. Where such areas are below the allowable grades, they shall be brought to grade by placing compacted layers of engineered fill or a drainage stone as specified by the Engineer. The thickness of layers and the amount of compaction, if required, shall be as specified by the Engineer.

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

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

**4.2 Fabric Form Placement**

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

B. 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.

C. 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. 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.

D. 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 (1 m) to form a lap joint, pending approval by the Engineer. Based on the predominant flow direction, the downstream edge of the form shall overlap the upstream edge of the next form. In no case shall simple butt joints between forms be permitted. Simple butt joints between panels shall not be allowed.

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

F. 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 placement and field 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 days.

**4.3 Fine Aggregate Concrete Placement**

A. 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 be cut in the top layer of the fabric form. These slits shall be of the minimum length to allow proper insertion of a filling pipe inserted at the end of the fine aggregate 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.

B. Fine aggregate concrete shall be pumped in such a manner that excessive pressure on the fabric forms and cold joints are avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given form is discontinued or interrupted for an interval of forty-five or more minutes.

C. 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 upper edge of the fabric form which has been placed in the anchor trench followed by redirecting the flow into the lower edge, working back up the slope.

D. Prior to removing the filling pipe from the current concrete lining section and proceeding to the fine aggregate concrete filling of the adjacent lining sectioan, 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.

E. 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. 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.

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

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

**PART 5: MEASUREMENT AND PAYMENT**

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

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