CITY OF FORT WAYNE MASTER UPDATED: 03/12/2018

SECTION 31 32 20

Channel Protection SystemS

NTS: This Section is intended for projects that are restoring or protecting stormwater channels. There are various products, including GeoWeb, concrete A-jacks, concrete cloth and fillable concrete fabric, listed within this section, delete unused products as necessary. Edit as required based on project specific requirements.

Products included in 32 05 19.19 Geogrids for Exterior Improvements can be used as Channel Protection Systems and should carefully be coordinated with to meet Project specific needs.

1. GENERAL
	1. DESCRIPTION
		1. This section includes providing all material, labor, tools and equipment for installation of Cellular Confinement System, Concrete Cloth, Concrete Fabric, and Interlocking Concrete Units as shown in the Contract Documents and as specified in this Section.

NTS: Include at (--1--) type of system that should be used for channel protection.

* + 1. The (--1--) System shall be used for channel protection.

NTS: List below only sections covering products, construction and equipment that a user might expect to find in this section, but are specified elsewhere. Do not list administrative and procedural Division 01 sections. Insert at (--1--) the number and name of any referenced sections.

* + 1. Related Sections:
			1. Section 03 00 05, Concrete.
			2. Section 31 00 05, Trenching and Earthwork.
			3. Section 31 05 19, Geosynthetics for Earthwork.
			4. Section 31 32 21, Vegetated Coir Logs.
			5. Section 32 05 19.19, Geogrids for Exterior Improvements.
			6. Section 32 90 00, Planting.
			7. Section (--1--).

NTS: Section “1.2” is to be included if project is bid on unit price basis. Section to be deleted or revised if project is to be bid on lump sum basis.

NTS: Adjust Section “1.2” below for additional work item numbers as needed. Delete unused work items.

* 1. MEASUREMENT AND PAYMENT
		1. Stream Lining
			1. Work Item Title and Number

**31 32 20-A Cellular Confinement System**

 **31 32 20-B Concrete Cloth**

 **31 32 20-C Concrete Fabric**

 **31 32 20-D Interlocking Concrete Units**

* + - 1. The quantity of channel protection systems installed shall be per the square foot of successfully installed protection systems.
			2. Payment shall constitute full compensation for laying and securing channel protection system according to the Contract Documents.
			3. These Work items shall include all costs to furnish all labor, materials, tools, and equipment, both permanent and temporary, to install the channel protection system as shown and specified. The Work includes, but is not limited to, channel protection surface treatment placement, required anchoring and jointing systems, infill material, infill material installation, surface preparation, restoration/replacement of all disturbed items not included under other Work items, protection of existing utilities and structures, incidentals for performing all Work as specified unless otherwise outlined as a separate Work item.
	1. REFERENCES

NTS: Retain applicable standards and add others as required.

* + 1. American Association of State Highway and Transportation Officials (AASHTO)
			1. AASHTO M 218 - Steel Sheet, Zinc-Coated (Galvanized) for Corrugated Steel Pipe.
			2. AASHTO M 288 - Geotextile Specification for Highway Applications.
		2. American Society of Testing and Materials (ASTM)
			1. ASTM D 1505 – Standard Test Method for Density of Plastics by the Density-Gradient Technique.
			2. ASTM D 1603 – Standard Test Method for Carbon Black in Olefin Plastics.
			3. ASTM D 1693 – Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.
			4. ASTM D 5199 – Standard Test Method for Measuring Nominal Thickness of Geosynthetics.
			5. ASTM E 41 – Terminology Relating to Conditioning.
	1. SUBMITTALS

NTS: Retain applicable submittals and add others as required.

* + 1. Action Submittals: Submit the following:
			1. Product Data
				1. Submit channel protection system manufacturer's data, installation instructions, and dimensions.
			2. Shop Drawings
				1. Submit Manufacturer’s shop drawings and section layout for channel protection system.
			3. Samples
				1. Submit Manufacturer’s product samples.
		2. Informational Submittals: Submit the following:
			1. Qualifications Data
				1. Certifying the installer is experienced in the installation of the specified products.
				2. Qualifications of Manufacturer’s field representative certifying the field representative is experienced in the installation of the specified products.
			2. Certificates
				1. Manufacturer's certification of polyethylene used to make cellular confinement system including;

Manufacturer's certification of percentage of carbon black.

Resin manufacturer's certification of polyethylene density and environmental stress crack resistance (ESCR).

* + - 1. Source Quality Control
				1. As requested, Submit Manufacturer’s certification of compliance to all applicable testing procedures and related specifications. Request for certification shall be submitted no later than the date of order placement.
		1. Closeout Submittals: Submit the following:
			1. Warranty Documentation
				1. Submit written warranty, signed by Contractor and installer, as specified.
	1. QUALITY ASSURANCE
		1. The channel protection system material shall be provided from a single Manufacturer for the entire project.
		2. The Manufacturer shall have a minimum of 10 years’ experience producing channel protection system .
		3. Pre-Installation Meeting: Prior to installation of any materials, conduct a pre-installation meeting to discuss the scope of work and review installation requirements. The pre-installation meeting shall be attended by all parties involved in the installation of the channel protection system .
		4. Manufacturer's Field Representative Qualifications:
			1. Manufacturer shall provide a qualified field representative on site at the start of construction to ensure the channel protection system is installed in accordance with the Contract Documents.
			2. Manufacturer’s field representative shall have a minimum 5 years installation experience with the specified products in the specified application.
	2. DELIVERY, STORAGE, AND HANDLING
		1. Material delivery, storage and handling must conform to requirements in Contract Documents. Refer to Section 01 65 00 Product Delivery Requirements and Section 01 66 00 Product Storage and Handling Requirements.

NTS: Delete or edit product warranty requirements listed below.

* 1. WARRANTY
		1. The Manufacturer shall warrant each channel protection system section that it ships to be free from defects in materials and workmanship at the time of manufacture. The Manufacturer’s exclusive liability under this warranty will be to provide without charge the replacement for any section which proves to be defective under normal use and service during the 10-year period which begins on the date of shipment. The Manufacturer reserves the right to inspect any allegedly defective section in order to verify the defect and ascertain its cause.

NTS: Various products are listed below coordinate the products and locations with the Drawings. Delete products not required for project.

1. PRODUCTS

NTS: Article “2.1” below contains specifications for Geoweb cellular confinement systems, this product has many different applications, including slope armoring, channel storage area and driving surface. Careful editing of the materials and installation requirements is needed based on the project specific application. Include the material and installation information in other sections as required. The product is specified in Section 32 05 19.19- Geogrids for Exterior Improvements, the installation requirements are different. If project required both applications, coordinate between each Section.

* 1. CELLULAR CONFINEMENT SYSTEM
		1. Cellular Confinement System General
			1. Cellular confinement system shall be polyethylene stabilized black and a perforated textured cell, and shall control shearing lateral and vertical movement of the surface. Carbon Black content shall be 1.5 to 2 percent by weight, through addition of a carrier with certified carbon black content.
			2. Cellular confinement system shall conform to the Drawings and the following:

|  |  |  |  |
| --- | --- | --- | --- |
| **Geoweb Property** | **Test Method** | **Unit** | **Min****Value** |
| Density | ASTM D 1505 | lb/ft3 | 58.4-60.2 |
| ESCR | ASTM D 1693 | hours | 5000 |
| Strip Sheet Thickness | ASTM D 5199 | mil | 50(-5%,+10%) |
| Textured Sheet Thickness | ASTM D 5199 | mil | 60 ± 6 |

* + 1. Cellular Confinement System Manufacturer:
			1. Geoweb by Presto Geosystems
			2. Or equal
		2. Base Materials
			1. Polyethylene Stabilized with Carbon Black
		3. Cell Properties
			1. Individual cells shall be uniform in shape and size when expanded.
			2. Individual cell dimensions (nominal) shall be dimensions ± 10%.

NTS: Retain one version of Paragraph “3” below, based on project specific requirements. Cell properties dimensions vary based on intended application and infill material. Coordinate with manufacturer for appropriate cell sizing and application.

* + - 1. GW20V-Cell Dimensions
				1. Length shall be 8.8 inches
				2. Width shall be 10.2 inches.
				3. Nominal area shall be 44.8 in2± 1%.

NTS: Insert at (--1--) the appropriate cell depth for project. Product is manufactured in 3, 4, 6 and 8-inch depths. Coordinate with supplier for application and availability:

* + - * 1. Nominal depth shall be (--1--)-inches.
			1. GW30V-Cell Dimensions
				1. Length shall be 11.3 inches
				2. Width shall be 12.6 inches.
				3. Nominal area shall be 71.3 in2± 1%.

NTS: Insert at (--1--) the appropriate cell depth for project. Product is manufactured in 3, 4, 6 and 8-inch depths. Coordinate with supplier for application and availability:

* + - * 1. Nominal depth shall be (--1--)-inches.
			1. GW40V-Cell Dimensions
				1. Length shall be 18.7 inches
				2. Width shall be 20.0 inches.
				3. Nominal area shall be 187.0 in2± 1%.

NTS: Insert at (--1--) the appropriate cell depth for project. Product is manufactured in 3, 4, 6 and 8-inch depths. Coordinate with supplier for application and availability:

* + - * 1. Nominal depth shall be (--1--)-inches.
		1. Strip Properties and Assembly
			1. Perforated Textured Strip/Cell
				1. Strip sheet thickness shall be 50 mil, minus 5 percent, plus 10 percent in accordance with ASTM D 5199. Determine thickness flat, before surface disruption.
				2. Polyethylene strips shall be textured surface with a multitude of rhomboidal (diamond shape) indentations.
				3. Textured sheet thickness shall be 60 mil plus or minus 6 mil.
				4. Indentation surface density shall be 140 to 200 per in2.
				5. Perforated with horizontal rows of 0.4 inch diameter holes.
				6. Perforations within each row shall be 0.75 inches on-center.
				7. Horizontal rows shall be staggered and separated 0.50 inches relative to hole centers.
				8. Edge of strip to nearest edge of perforation shall be a minimum of 0.3 inches.
				9. Centerline of spot weld to nearest edge of perforation shall be a minimum of 0.7 inches.
				10. A slot with a dimension of 3/8 inch x 1-3/8 inch is standard in the center of the non-perforated areas and at the center of each weld.
		2. Integral components:
			1. ATRA® Clip
				1. The ATRA Clip is a molded, high-strength polyethylene device available in standard (0.5 inch).
				2. ATRA clips can be installed as an end cap on standard (0.5 inch) steel reinforcing rods to form ATRA Anchors.
			2. ATRA® Key
				1. ATRA keys shall be constructed of polyethylene and provide a high strength connection.
				2. ATRA keys shall be used to connect cellular confinement panels together at each interleaf and end to end connection.

NTS: Select the desired stake anchorage and delete the others. No stake anchorage may be necessary. Use the Glass Fiber Reinforced Polymer anchors where there is a corrosion potential.

* + 1. Stake anchorage:
			1. ATRA® Anchors
				1. ATRA Anchors shall consist of standard (0.5 inch) steel reinforcing rod with an ATRA® Clip attached as an end cap.
				2. ATRA anchors shall be assembled by inserting the ATRA Clip onto the reinforcing rod so that the end is flush with the top of the ATRA Clip. Prior to attaching the ATRA Clip, the reinforcing rod shall be free from all burrs and beveled.
				3. Stake length shall be as shown in the Drawings.
			2. ATRA® Glass Fiber Reinforced Polymer (GFRP) Anchors
				1. ATRA GFRP Anchors shall be pre-assembled units consisting of the ATRA Stake Clip inserted onto a GFRP stake.
				2. The glass reinforcement content shall be 75% minimum by weight and shall be continuous longitudinal filament.
				3. Polymer shall be vinyl ester, isophthalic polyester or other matrix material.
				4. The outer surface shall be sand coated and deformed by a helical wrap of glass.
				5. The minimum compressive strength shall be 95 kips in accordance with ASTM D 638.
				6. The anchor shall be non-magnetic, non-conducting and corrosion resistant.
				7. The anchor length and placement shall be as shown in the Drawings.
		2. Tendon anchorage:

NTS: Retain one Paragraph “a” below, select the desired tendon and corresponding break-strength and delete the others. Coordinate with the manufacturer as required for appropriate break strength based on project specific conditions. Note that if a greater break strength than 2,090 lbf needs to be obtained the manufacture can supply three different strength woven Kevlar, with break strengths ranging from 2,000 to 4,000 lbf, include product requirements below based on project specific needs.

* + - 1. Tendon Type
				1. Woven Polypropylene - TPP‑55

Material shall be bright yellow, high-tenacity, industrial-continuous-filament, polypropylene yarn woven into a braided strap.

Minimum break strength shall be 1250 lbf

* + - * 1. Woven Polyester - TP‑67

Material shall be bright, high-tenacity, industrial-continuous-filament, polyester yarn woven into a braided strap.

Elongation shall be 9 to 15 percent at break.

Minimum break strength shall be 1506 lbf for TP-67.

* + - * 1. Woven Polyester -TP‑93

Material shall be bright, high-tenacity, industrial-continuous-filament, polyester yarn woven into a braided strap.

Elongation shall be 9 to 15 percent at break.

Minimum break strength shall be 2090 lbf for TP-93.

NTS: Retain one Paragraph “a” below, Select the anchorage system being used with the tendons and delete the others. If no tendon anchorage system is required, delete the complete section.

* + - 1. Tendon Anchorage
				1. Tendons, ATRA Tendon Clips and Geoweb Buried at Crest.
				2. Tendons, ATRA Tendon Clips and ATRA Anchors.
				3. Tendons, ATRA Tendon Clips and ATRA GFRP Anchors.
				4. Tendons, ATRA Tendon Clips and Deadman Pipe Anchorage.
				5. Tendons, ATRA Tendon Clips and Earth Anchors.
		1. Source Quality Control - Cell Seam Strength Tests
			1. Minimum seam strengths are required by design and shall be reported in test results. Materials submitted with average or typical values will not be accepted. Written certification of minimum strengths must be supplied to the Engineer at the time of submittals.
			2. Short-Term Seam Peel-Strength Test
				1. Cell seam strength shall be uniform over full depth of cell.
				2. Minimum seam peel strength shall be 480 lbf for 6 inch depth
			3. Long-Term Seam Peel-Strength Test
				1. Conditions: Minimum of 7 days in a temperature-controlled environment that undergoes change on a 1 hour cycle from room temperature to 130 degrees F.
				2. Room temperature shall be in accordance with ASTM E41.
				3. Test samples shall consist of two, 4 inch wide strips welded together.
				4. Test sample consisting of 2 carbon black stabilized strips shall support a 160 pound load for test period.

NTS: Insert at (--1--) below the appropriate geosynthetic material for aggregate separation between the units and subbase. Typically, a non-woven geo synthetic used for aggregate separation is appropriate. The geosynthetic material requirements are specified in Section 31 05 19, which is referenced below, careful coordination and editing is required based on selected geosynthetic.

* + 1. Geo-synthetic Separation Layer:
			1. Provide the following (--1--) as specified in Section 31 05 19-Geosynthics for Earthwork.

NTS: Insert at (--1—) below the appropriate cell infill material based on the intended use. Typical infill materials are INDOT #53, #8, topsoil or concrete. Number 53 gravel contains fines that will compact a create more of a smooth driving surface, but will limit infiltration. Number 8 stone does not contain the fines, but creates void space for water storage. Edit article as required based on project specific requirements.

* + 1. Cell Infill Materials:
			1. Provide the following material for cell infill:
				1. (--1--)

NTS. Paragraph “2” below references Section 31 00 05, Trenching and Earthwork, based on selected infill material coordinate the material requirements with the Trenching and Earthwork Section. Edit or delete as required.

* + - 1. Cell infill material shall meet the requirements specified in Section 31 00 05, Trenching and Earthwork.
			2. Infill material shall be free of any foreign material.
			3. Infill material shall be free-flowing and not frozen when placed in the cellular confinement system sections.

NTS: Concrete cloth is a flexible, cement impregnated fabric that hardens when hydrated to form a thin, durable, water, and fire resistant concrete layer. Milliken Infrastructure Solutions, LLC has three different thicknesses for concrete cloth. Including 0.20-inch (CC5), 0.3-inch(CC8) and 0.5-inch(CC13). Listed below is the minimum concrete cloth thickness. The 0.2-inch thickness is acceptable for the minor non-vehicular surfaces, such as outfall protection, slope armoring and ditch liming. Coordinate with manufacturer for appropriate material thickness. Delete concrete cloth if not required.

* 1. CONCRETE CLOTH
		1. Acceptable applications include:
			1. Slope Protection
			2. Mud Mat
			3. Ditch Lining
			4. Secondary Containment Berm Lining
			5. Gabion Reinforcement
			6. Pipe Protection
		2. Concrete Cloth Materials:
			1. Provide the following concrete cloth:
				1. CC5 (0.20-inch thickness) as manufactured by Milliken Infrastructure Solutions, LLC
				2. Or equal.

NTS: A range of surface treatments can be provided including color finishes, hydrophobic protection against staining and organic growth and fire retardant paints. Add project specific finishes at (--1--) below. Delete if not required.

* + 1. Finishing
			1. (--1--)

NTS: A range of anchoring and jointing devices are available for the concrete cloth. Edit or delete as required. Additionally, coordination location and spacing of concrete cloth accessories with the drawings.

* + 1. Accessories
			1. Anchoring Devices:
				1. Provide heavy-duty metal staples or spikes. The metal staples shall be U-shaped, a minimum of 6 inch long (each leg), 1-1/2- inches wide, and shall be fabricated from 9 gauge diameter metal wire.
				2. In loose soil conditions use, 8-12 inch long staples or pins or 7 inch gutter spike with 1-1/2 inch diameter washer.
			2. Fastening Screws:
				1. Stainless Steel #10 or #12 Hex head self-tapping course thread, ½ to 1 inch in length (depending on subsurface conditions) used for securing all overlaps together. See Drawings for placement and frequency.
			3. Adhesive Caulk (As required):
				1. Loctite PL Premium Polyurethane, Sikaflex 1A or other adhesive that has been demonstrated in laboratory tests to adhere to both sides of the Concrete Cloth. Strictly comply with manufacturer's installation instructions and recommendations. See Drawing for placement.
			4. Earth Percussion Anchors (As required):
				1. Gripple Inc., Platipus or equal. Strictly comply with manufacturer’s installation instruction and recommendations to determine load capacity. See Drawing for placement

NTS: Concrete fabric forms are filled in place with fine aggregate concrete. Geostar corporation provides a wide variety of products including filter point lining, filter band lining, uniform section lining, enviromat lining, and articulating block mat. The enviromat product is specified below and is intended to provide protection against periodic high flows. After installation, vegetation can be planted within the open structure of the liming. enviromat linings can be used on upper slopes of channels, lakes rivers and other water courses and embankments subject to heavy run off. Edit or delete concrete fabric as required.

* 1. FABRIC FORMED CONCRETE ARMORING SYSTEM
		1. Provide the following Concrete Fabric :
			1. Enviromat Lining as manufactured by Geostar Corporation
			2. Or equal
		2. Acceptable applications include:
			1. Drainage ditches
			2. Channels and canals
			3. Stream and rivers
			4. Embankments
			5. Check dams
			6. Water control structures
		3. Materials:
			1. Filter Fabric
				1. Grab Tensile Strength: 90 lbs per ASTM D 4632
				2. Elongation at Break: 15% per ASTM D 4632
				3. Trapezoidal Tear Strength: 30 lbs per ASTM D 4533
				4. Permittivity: 0.5 sec-1 per ASTM D 4491
			2. Fine aggregate concrete shall have a water ratio of 0.65 to 0.75.
			3. Portland cement shall conform to ASTM C150, Type I or II.
			4. Fine aggregate shall conform to ASTM C33, except as to grading. Grading shall be based on pumping equipment.
			5. Air entrainment: 5% to 8%

NTS: Delete Pozzolan and Plasticizing and air entraining add mixture if not used.

* + - 1. Pozzolan shall conform to ASTM C 618. Pozzolan may be substituted for up to 35% of the cement.
			2. Plasticizing and air entraining add mixture shall conform to ASTM C494 and ASTM C260.
			3. Minimum average compressive strength of concrete shall be 2,000 psi for three tests. An individual test shall not be less than 1,400 psi.

NTS: Interlocking concrete units are based on A-Jacks. Delete interlocking concrete units if not required.

* 1. INTERLOCKING CONCRETE UNITS
		1. Acceptable applications include:
			1. Drop Structures
			2. Weirs
			3. Bridge scour protection
			4. Energy dissipation
			5. Toe stabilization
			6. Streambank protection
		2. Materials:
			1. Concrete Units
				1. Pre-determined concrete block machine and will conform to ASTM D 6684-04, Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Revetment Systems.
				2. Provide the following concrete blocks:

A- Jacks, as manufactured ARMORTEC.

Or equal.

NTS: Sizing Specified in Paragraph “c” below is based on A-Jacks AJ-24 units. Edit if project requires different concrete unit sizes edit Paragraph “c” below. Typical sizes that Armotec produces is: AJ-48 (48-inch), AJ-72 (72-inch), AJ-96 (96-inch) and AJ-120 (120-inch).

* + - * 1. Concrete Unit Type

A-Jacks Unit AJ-24

Length: 24-inches

Arm Thickness:3.68-inches

Fillet Length: 1.44-inches

Volume: 0.56 cubic feet

Weight: 78 lbs

* + - * 1. The concrete units will be produced by a dry cast method. The dry cast units obtain strength in a shorter duration as well as an increase in the durability and overall quality of product. Material and manufacture standards will be compliant with ASTM D6684

Cementitious Materials - Materials shall conform to the following applicable ASTM specifications:

Portland Cements - Specification C 150, for Portland Cement.

Blended Cements - Specification C 595, for Blended Hydraulic Cements.

Hydrated Lime Types - Specification C 207, for Hydrated Lime Types.

Pozzolans - Specification C 618, for Fly Ash and Raw or Calcined Natural Pozzolans for use in Portland Cement Concrete.

* + - * 1. Aggregates shall conform to the following ASTM specifications, except that grading requirements shall not necessarily apply:

Normal Weight - Specification C 33, for Concrete Aggregates. Filter Fabric

* + - * 1. Minimum average compressive strength of concrete shall be 4,000 psi for three tests. An individual test shall not be less than 3,500 psi.
			1. Cabling
				1. Termination or transition of the interlocking concrete units, as identified in the submittal and contract drawings will require additional field cabling. Cable type will be minimum 1/4” galvanized or polyester, as approved by the Engineer.
				2. Cable orientation of the recommended 3-unit minimum (i.e. perpendicular or parallel to a slope) will be identified and agreed upon in the field by the Contractor and Engineer’s representative.

NTS: Insert at (--1--) below the appropriate geosynthetic material for aggregate separation between the concrete units and subbase. Typically, a non-woven geo synthetic used for aggregate separation is appropriate. The geosynthetic material requirements are specified in Section 31 05 19, which is referenced below, careful coordination and editing is required based on selected geosynthetic.

* + - 1. Geo-synthetic Separation Layer:
				1. Provide the following (--1--) as specified in Section 31 05 19-Geosynthics for Earthwork.

NTS: Edit or delete Paragraph “4” below based on project specific requirements.

* + - 1. Concrete Unit Bedding:
				1. Provide INDOT No. 8 aggregate as specified in 31 00 05- Trenching and Earthwork.
1. EXECUTION
	1. EXAMINATION
		1. Verify site conditions are as indicated on the drawings. Notify the Engineer if site conditions are not acceptable. Do not begin preparation or installation until unacceptable conditions have been corrected.
		2. Verify layout of structure is as indicated on the drawings. Notify the Engineer if layout of structure is not acceptable. Do not begin preparation or installation until unacceptable conditions have been corrected.
	2. INSTALLATION OF THE CELLULAR CONFINEMENT SYSTEM
		1. Prepare subgrade and install channel protection system in accordance with Manufacturer's recommendations.
		2. Subgrade Preparation:
			1. Excavate or fill foundation soils so top of installed cellular confinement section is flush with or slightly lower than adjacent terrain or final grade as indicated on the Drawings or as directed by the Engineer.
			2. Install non-woven geotextile separation layer on prepared surfaces ensuring required overlaps are maintained and outer edges of geotextile are buried at least 4-inches into the surrounding surface.
		3. Cellular confinement Section Anchorage- Slope Protection:
			1. Anchorage requirements for the cellular confinement sections shall be as shown on the Contract Documents and as directed by the Engineer.

NTS: Retain one paragraph “2” below based on the preferred anchorage method and delete the others. Listed below are common installation requirements for slope protection systems. Based on project conditions if a different installation method is preferred, coordinate with the manufacturer.

* + - 1. Anchorage with ATRA and ATRA GFRP Anchors
				1. Position collapsed cellular confinement sections at the crest of the slope.
				2. If required, excavate the anchor trench at the top of the slope to the depth as shown on the Drawings.
				3. Drive the required anchors at the crest of the slope to secure the cellular confinement sections in place and allow expansion of the cellular confinement sections into position.
				4. After the cellular confinement sections are expanded as desired, drive the required anchors so the arm of the ATRA Stake Clip is through the internal slots in the cellular confinement cell wall and do not protrude over the top of the cell wall.
				5. Anchorage pattern and stake length shall be as indicated on the Contract Documents.
				6. Fill the anchorage trench with the specified material and compact as required by the Drawings.
			2. Anchorage with Tendons, ATRA Tendon Clips and Buried at Crest (Top of Slope Installation)
				1. Excavate the anchor trench at the top of the slope to the depth as shown on the Contract Documents.
				2. Position the collapsed sections at the crest of the slope.
				3. Measure and cut the tendon run lengths for each tendon location.
				4. Mark the tendons with a black permanent marker per the ATRA Tendon Clip Location Chart.
				5. Starting from the first cell, count the number of cells to the next ATRA Tendon Clip location and repeat along that cell row.
				6. Repeat this procedure for each additional cell row Tendon/ATRA Tendon Clip run.
				7. With all the ATRA Tendon Clips placed in the section, thread the tendons through the cell wall I-slots in the unexpanded section.
				8. Locate the corresponding mark on the tendon and position it in front of the cell wall. Hold the tendon and connect to the ATRA Tendon Clip. Refer to the Slope Installation Manual for ATRA Tendon Clip tie-off instructions.
				9. Leave the trailing length of the tendon on the upslope side of the section to allow connection to ATRA Tendon Clip.
				10. Repeat this process on each cell row Tendon/ATRA Tendon Clip run.
				11. Place the collapsed section in the anchor trench, secure with temporary stakes or ATRA Anchors and expand down the slope.
				12. Adjust the section (i.e. a shake or two of the expanded section works well for this) so that the section and tendons are uniformly taut.
				13. Terminate the bottom of the tendons with ATRA Tendon Clips.
				14. Fill the anchorage trench with the specified material and compact as required by the Drawings.
			3. Anchorage with Tendons, ATRA Tendon Clips and ATRA Anchors (Top of Slope Installation)
				1. Excavate the anchor trench at the top of the slope to the depth as shown on the Drawings.
				2. Position the collapsed sections at the crest of the slope.
				3. Measure and cut the tendon run lengths for each tendon location.
				4. Mark the tendons with a black permanent marker per the ATRA Tendon Clip Location Chart.
				5. Thread the tendons through the unexpanded section.
				6. Starting from the first cell, count the number of cells to the next ATRA Tendon Clip location and repeat along that cell row.
				7. Repeat this procedure for each additional cell row Tendon/ATRA Tendon Clip run.
				8. With all the ATRA Tendon Clips placed in the section, thread the tendons through the cell wall I-slots in the unexpanded section.
				9. Locate the corresponding mark on the Tendon and position it in front of the cell wall. Hold the tendon and connect to the ATRA Tendon Clip. Refer to the Slope Installation Manual for ATRA Tendon Clip tie-off instructions.
				10. Repeat this process on each cell row Tendon/ATRA Tendon Clip run.
				11. Place the collapsed section in the anchor trench, drive ATRA Anchors in the first row of cells so the arm of the anchor engages with the top of the cell wall and expand down the slope. Number of anchors shall be per the Drawings.
				12. Adjust the section (i.e. a shake or two of the expanded section works well for this) so that the section and tendons are uniformly taut.
				13. After the sections are expanded, drive ATRA Anchors so the arm of the anchor engages with the top of the cell wall.
				14. Anchorage pattern and stake length shall be as indicated on the Drawings.
				15. Terminate the bottom of the tendons with ATRA Tendon Clips.
				16. Fill the anchorage trench with the specified material and compact as required by the Drawings.
		1. Cellular confinement Section Placement and Connection
			1. Verify all cellular confinement sections are expanded uniformly to required dimensions and that outer cells of each section are correctly aligned. Interleaf or overlap edges of adjacent sections. Ensure upper surfaces of adjoining cellular confinement sections are flush at joint and adjoining cells are fully aligned at the cell wall slot.
			2. Connect the cellular confinement sections with ATRA keys at each interleaf and end to end connection. Insert the ATRA key through the cell wall slot before inserting through the adjacent cell. Turn the ATRA key 90 degrees to lock the panels together.

NTS: Retain one paragraph “E” below based on the required infill material and delete the other. The “Infill Placement” paragraph is intended for Topsoil, Aggregate and Engineered infill materials. Edit paragraphs as required based on project specific conditions.

* + 1. Infill Placement
			1. Place specified infill in expanded cells with suitable material handling equipment, such as a backhoe, front-end loader, conveyor, or crane-mounted skip.
			2. Limit drop height to a maximum of 3 feet (1 m) to avoid damage or displacement of the cell walls.
			3. Fill cellular confinement sections from the crest of the slope to toe.
			4. Infill material shall be free-flowing and not frozen when placed into the cellular confinement sections.
			5. Evenly spread infill and tamp into place.

NTS: Paragraph “E” below references Section 03 00 05 – Concrete, include in Project manual as required. If project is using concrete as the infill material, coordinate Paragraph “E” below with the Concrete Section for required concrete material and finishes.

* + 1. Concrete Infill Placement
			1. Concrete shall be placed, finished and cured in accordance with Section 03 00 05- Concrete.
			2. Once placing operation commences, it shall be carried out as a continuous operation until a designated section is completed or as approved by the Engineer.
			3. Limit the drop height of concrete to 3 feet to prevent panel distortion. Elephant trunks and/or tremies shall be used to prevent free fall of concrete.
			4. Where concrete chutes are used, the end of the chute shall be baffled to prevent segregation of the concrete.
			5. The concrete shall be thoroughly compacted by means of an approved vibrator. The period of vibration shall not be less than 2 seconds nor more than 5 seconds at any one point.
			6. Concrete shall be flush with the top of the walls.
			7. Apply specified finish.
		2. Surface Treatment

NTS: Retain one version of Paragraph “1” below, delete the other. If planting vegetation is required coordinate with Section 32 90 00 – Planting.

* + - 1. Vegetation shall be as specified in Section 32 90 00 - Planting, and installed immediately after the infill is placed and protected with mulch.
			2. Surface protection shall be installed immediately after placement of the infill material and secured per the Manufacturer’s instructions.
	1. CONCRETE CLOTH INSTALLATION
		1. General Installation
			1. Each panel of the concrete cloth shall be rolled out and installed in accordance with the Contract Documents. The layout shall be designed to keep field seams of the concrete cloth to a minimum and consistent with proper methods of manufacturer's installation requirements. The concrete cloth shall be free of tensile stresses, folds, and wrinkles.
			2. Concrete cloth rolls shall be placed using proper spreader and rolling bars so that the concrete cloth would not be stretched during deployment.
			3. Inspect each panel, after placement and prior to seaming, for damage and/or defects. Defective or damaged panels shall be replaced or repaired.
			4. Do not drag the concrete cloth sheets on rough soil subbase.
			5. Contractor shall not wear damaging shoes or involve themselves in any activity that may damage the concrete cloth.
			6. Vehicular traffic across the concrete cloth shall not be allowed, except as specified herein. When the subgrade has been prepared and is stiff enough to carry vehicle traffic or a designed base is constructed to carry the vehicle traffic, vehicle traffic will be allowed. Otherwise vehicle traffic over the concrete cloth may very well deform into ruts that form in the subgrade.
			7. The concrete cloth shall be kept free of debris, unnecessary tools and materials. In general, the concrete cloth area shall remain neat in appearance.
			8. If required to place equipment required to perform the installation on top of the concrete cloth, a scrap piece of the concrete cloth shall be placed under the equipment and between the equipment and the concrete cloth being installed in order to protect from possible damage.
			9. Do not store equipment on the installed concrete cloth.
			10. Care shall be taken during installation to avoid damage occurring to the concrete cloth as a result of the installation process. Should the concrete cloth be damaged during installation, a concrete cloth patch shall be placed over the damaged area extending a minimum of 6 inches in all directions beyond the damaged area and attach the concrete cloth in place according to the manufacturer’s instructions.
			11. Remove the protective plastic cover of each concrete cloth roll only when ready to deploy and install to prevent undue exposure to humidity, precipitation or other construction activities that would cause the concrete cloth to start to hydrate prior to completing the installation of the roll.
			12. Subgrade should be prepared to the lines and tolerances of the engineered drawing for the installation.
			13. Soil should be clear of surface vegetation, debris, rocks, and branches.
			14. Concrete Cloth material should be in intimate contact with the subsurface to which it is being applied.
		2. Anchoring Methods
			+ 1. Install the approved anchoring devices if required (at a minimum frequency of 0.25 pins/staples per square yard. Additional anchoring devices may be required depending on site conditions or alignment of the slope or channel. See Drawings for required anchor systems and spacing.
		3. Joining Adjacent Sheets:
			+ 1. Concrete cloth shall be overlapped a minimum of 4-inches.
				2. When overlapping successive concrete cloth rolls or edge rolls, the rolls shall be overlapped upstream over downstream and/or upslope over downslope to allow for shingling and to prevent water from striking exposed edges in the direction of water flow.

NTS: Retain one version of Paragraph “c” below. Non-mechanical fasteners are used to improve water proof rating.

* + - * 1. Utilize mechanical fasteners such as staples, nails, self-tapping screws, hog-rings, staking and pinning.
				2. Non-mechanical fasteners such as bonding sealant and grout are acceptable ways to join adjacent sheets together.

NTS: Retain one version of Paragraph “D” below based on project specific installation application. Coordinate the required staking and jointing layout with the drawings and these paragraphs.

* + 1. Channel Applications – Installations:
			1. Begin placement at the downstream end of the channel.
			2. Inspect trenches for position accuracy and depth and re-dig to required dimensions. If trenches have not yet been constructed, dig termination anchor trench, check slot trenches and longitudinal anchor trenches as illustrated in installation guidelines or as directed on the Drawings.
			3. Unroll and cut the concrete cloth to the desired length.
			4. Position and deploy the concrete cloth over the termination trench, see Drawings for overlap directions – PVC side should always be facing down). Secure the concrete cloth within the termination trench and longitudinal trench with the appropriate anchor device when required. See Drawing for placement and frequency.
			5. Position the next panel, overlap and join as required.
			6. Continue deploying the concrete cloth upstream to the next check slot.
			7. If significant water has accumulated within the anchor trench, remove excess water as directed by Engineer or Owner.
			8. Install anchoring devices and fasten screws as shown on Drawings.
			9. Always backfill intermediate check slots prior to deploying the next concrete cloth panel over the backfill check slot.
			10. Only install what can be fully installed and hydrated (including anchor devices) before the end of construction day to minimize any adverse effect on the installation and/or performance capabilities of the product.
		2. Slope Application – Installation
			1. For slope applications, construct top anchor trench 1-3 ft beyond crest of slope, or as shown on Drawings.
			2. Position concrete cloth roll at crest of slope with sufficient material to line the anchor trench as illustrated in the Drawings.
			3. Position adjacent rolls to facilitate 4 inch overlaps.
			4. Anchor concrete cloth in trench with appropriate pins/staples at the required intervals as shown on the Drawings.
			5. The preferred method of deployment is to roll the concrete cloth down slope and stand on the uphill side of the roll and install the anchoring devices as it rolls out down the slope, minimizing foot traffic until concrete cloth is secured with anchor devices and fastening screws at the overlaps.
			6. Always allow the mat to drape over the soil, never pulling it taut, to ensure contact with the surface.
			7. Place additional pins into any apparent depressions to maintain contact with the soil.
			8. During the anchor trench backfill compact the soil alongside the concrete cloth and spray the concrete cloth within the anchor trenches with water to start the hydration process.
			9. Do not backfill soils into trench if significant water has accumulated within the anchor trench. Remove excess water as directed by Engineer or Owner.
			10. Apply Mechanical Channel/Adhesive Caulk or Adhesive Tape (as required) concurrently during the overlap process of deploying the next concrete cloth over the previous concrete cloth installation panel.
			11. Only install what can be fully installed and hydrated (including anchor devices) before the end of construction day.
		3. Hydration
			- 1. Concrete cloth cannot be over hydrated and an excess of water is recommended.
				2. Minimum ratio of water shall be 1:2 by weight.
				3. Do not spray high pressure water directly onto the concrete cloth
				4. Do not move concrete cloth once concrete cloth begins to set.
				5. Saturate the top-side of the Concrete Cloth material. This will take multiple passes of a moderate spray of water from a garden hose or other source.

Note: More water will be required to saturate the product as the slope of the installation increases.

* + - * 1. Ensure that the Concrete Cloth material has been saturated by means of the “thumb test”, where a thumb is pressed into the Concrete Cloth material and water is observed to pool in the indentation.
				2. Wait 30-60 minutes then put a final dose of water onto the Concrete Cloth material to ensure complete hydration.
				3. In special applications where it is important not to allow excess water runoff, or water is scarce, water troughs of appropriate size may be used. Submerge the Concrete Cloth material in the water filled trough for a period of 5-10 minutes, remove and install.
	1. FABRIC FORMED CONCRETE ARMORING SYSTEM – INSTALLATION
		1. Installation
			1. Subgrade should be prepared to the lines and tolerances of the engineered drawing for the installation.
			2. Soil should be clear of surface vegetation, debris, rocks, and branches.
			3. Filter fabric shall be placed loosely but without wrinkle or folds. Filter fabric shall be held in place by sandbags or “U”-shaped staples.
			4. Lapped Joints
				1. Overlap fabric minimum of 18 inches and 36 inches for underwater applications. Overlap should be parallel to the slope.
			5. Seamed Joints
				1. Use handheld sewing machine with nylon or polyester sewing thread to make joint. Federal type 101 stitch shall be used.
	2. INTERLOCKING CONCRETE UNITS- INSTALLATION
		1. Foundation Preparation
			1. The slope will be graded to a smooth plane surface to ensure that intimate contact is achieved between the slope face and the geotextile (filter fabric).
			2. All slope deformities, roots, grade stakes, and stones which project normal to the local slope face must be re-graded or removed.
			3. Immediately prior to placing the filter fabric and remaining subgrade components, the prepared subgrade will be inspected by the Engineer and the Owner's representative.
		2. Placement on Geotextile Fabric
			1. The filtration geotextile will be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles.
			2. The geotextile filter fabric will be placed so that the upstream strip of fabric overlaps the downstream strip.
		3. Placement of Interlocking Concrete Units
			1. Place a minimum 2” layer of clean stone directly on the specified geotextile.
			2. Individual Unit Placement (24” Units)–
				1. Place units in a consistent repeatable fashion to aid in efficiency. Recommended in-place orientation of the units emphasizes pointing exposed projecting unit arm (vertical or horizontal) downstream whenever practical during construction.
				2. Standard spacing between unit center in both the x and y dimension is 12”, which represents a 0.5 packing ratio.
			3. Bundle Unit Placement (24” Units)–
				1. Place bundles in a pre-determined matrix, spacing them as closely as possible, approximating the maximum packing ratio of 0.4 (9.6” center spacing in x and y directions).
				2. Install cable around the pre-determined matrix at the mid-section.
				3. Hand tighten and connect cable using standard cable hardware supplied by the manufacturer.
				4. Place Bundles as closely as possible, with recommended tolerance requirement of 4” between bundles.
				5. Spacing will be measured from center of bundle to middle of installed bundle, in the horizontal plane, before additional (stacked) units are placed.
			4. Bedding stone material can be utilized for bridging interior voids and establishing consistent bedding layer for additional lifts of units, both hand placed or bundles. Vertical fluctuations occurring from unit to unit or bundle to bundle will be compensated for by utilizing bedding.

++END OF SECTION++