

(Rev. April 08, 2013 SH)

January 1, 2015

SPECIAL PROVISION
REGARDING
ROCKFALL SLOPE DRAPE

The work under this special provision consists of installing rockfall slope drape protection (wire mesh, cable net and wire rope fabric drape) and anchors as shown on the plans, to the manufacturer's recommendations and as approved by the Engineer. Separate Special Provisions shall be used for Rockfall Barrier Systems (707H) or for Pinned Rockfall Slope Mesh (707E)

The wire mesh and rockfall drape is to be suspended from grouted anchors and wire rope cables along the crest of a slope and draped down the face so as to restrain falling loose and broken rock trajectories between the drape and the rock slope. The drape fabric shall have the structural strength to retain and redirect the load imposed by rock fall trajectories in-plane with the drape configuration shown on the plans with no distress to the system. The rockfall drape shall be resistant to corrosion, UV degradation, and thermal deterioration. The rockfall drape shall be capable of being pulled on/out at the bottom to clear rocks retained upslope from the draped slope and for rock removal. The fabric/rockfall drape shall drape to the bottom of the slope, and according to the plans, fabric curling up at the bottom of the slope is not acceptable.

The contractor shall submit in writing documentation that the supplied system has performed satisfactorily in similar applications including field-testing, performance history, and locations of similar installations. The contractor shall submit shop drawings showing installation details provided by the manufacturer of the rockfall drapery system for approval to the TDOT Geotechnical Engineering Section prior to use on the project. Contractor or subcontractor installing system shall also demonstrate at least 3 years' experience with installation of similar rockfall drapery systems and installation of rock slope stabilization measures including ground anchors

Materials

The rockfall drape and all hardware used with the system shall be protected from corrosion by galvanization. All structural steel components, including anchors and

clamps, shall conform to the requirements in ASTM Designation: A36. All bolts, nuts, and washers shall conform to the requirements in ASTM Designation: A 325. Where coloring is required for the system, rockfall drape may be either powder coated or PVC coated as specified in the plans.

The wire ropes, cable net, and support ropes shall be galvanized in conformance with the requirements of Federal Specification RR-W-410F and ASTM A 153-09 or equivalent approved by the TDOT Geotechnical Engineering Section.

Installation of rockfall drape shall include anchors, clamps, clips, wires, hog rings, shackles, other steel rings, wire rope, and miscellaneous hardware required to install the system in accordance with the design and to manufacturer's recommendations for the rockfall drapery system to be installed on the project. All clamps, clips, wires, hog rings, shackles, steel rings, wire rope, and miscellaneous hardware shall be supplied by the system manufacturer.

Wire Mesh – Standard

The standard wire mesh fabric shall be galvanized, hexagonal, double twisted 3 mm (0.12 inch) soft tempered steel wire with a maximum Tensile Strength 75,000 psi in accordance with ASTM A975-11). The maximum size of the opening shall be four inches in the largest dimension. Mesh tensile strength shall be a minimum of 3500 lb./ft. parallel to twist.

Wire Mesh – High Tensile

Wire mesh fabric other than hexagonal double twisted wire mesh shall be acceptable for high tensile wire mesh. This material shall be galvanized, have a nominal wire diameter of no less than 0.12-inch (3-mm) and have a minimum wire breaking strength of 250,000 psi. The maximum size of the opening shall be four inches in the largest dimension. The mesh shall have a minimum longitudinal tensile strength or load capacity of at least 10,000 lbs./ft. Seaming of mesh panels shall be in accordance with manufacturer's recommendations and the drape design drawings. Seaming methods shall be supplied to the Engineer and approved before use.

Cable Net – Standard

Cable net shall be comprised of square or rectangular cable mesh panels joined at the panel boundaries to form a continuous drapery. Each cable net panel shall incorporate a uniform grid pattern of square or rectangular shaped openings of no more than approximately 24 inches by 24 inches formed by the woven crossing of nearly continuous cable strands.

The major axis of any opening shall not exceed 24 inches and the area of any opening shall not exceed 576 square inch. Each perpendicular cable crossing shall be securely fastened at an angle of approximately 90 degrees using high tensile steel wire ties of sufficient strength to resist slippage or breakage of the crossing connection when subject to the loads generated by the controlled rock fall. Fastener type shall be approved by the

Geotechnical Engineering Section. Cable net cable shall have a minimum diameter of 5/16-inch and have a minimum breaking strength of 9,200 pounds. Cable net shall have a nominal load capacity or tensile strength of 8,000 lb./ft. Where cable net has an opening of greater than 4 inches, wire mesh shall be required to be attached to the cable net to prevent passage of rocks greater than 4 inches. Cable net with wire mesh pre-installed on panels is acceptable as is attachment of wire mesh to cable net at the time of installation. Attachment of wire mesh conforming to Wire Mesh – Standard or Wire Mesh – High Tensile to the cable net shall be accomplished according to manufacturer's recommendations and approved by the Engineer before use. The cost of this additional wire mesh fabric, where needed, shall be included in the cost of the cable net fabric.

High Tensile Cable / Rope Net

High Tensile Cable / Rope Net shall be comprised of square or diamond mesh panels joined at the panel boundaries to form a continuous drapery. Each panel shall incorporate a uniform diamond or square shaped pattern with maximum diameter of the opening no more than 12 inches for square mesh or 12x12 inches for diagonal. High tensile cable / rope net shall have a minimum net tensile strength of at least 15,000 lb./ft. Unless otherwise stated on the plans, where high tensile cable / rope net has an opening greater than 4 inches, wire mesh shall be required to be attached to the cable net to prevent passage of rocks greater than 4 inches. Cable net with wire mesh pre-installed on panels is acceptable as is attachment of wire mesh to cable net at the time of installation. Attachment of wire mesh conforming to Wire Mesh – Standard or Wire Mesh – High Tensile to the cable net shall be accomplished according to manufacturer's specifications. The cost of this additional wire mesh fabric, where needed, shall be included in the cost of the cable net fabric.

Anchors

Wire Rope Anchors shall be fabricated from a minimum 3/4" diameter wire rope with a minimum breaking strength of 52,920 lbs., unless otherwise stated on the plans, and be folded over on itself and fastened every three feet with a thimble at the termination end. These anchors shall be placed as shown on the plans or as directed by the Engineer but in no case shall anchors have a spacing exceeding 25 feet unless specifically directed by TDOT Geotechnical Engineering Section and as shown on the plans. Bar anchors shall be continuously threaded (grade 150 steel) minimum 1" diameter, and anchor details will be as per the detail in the plans of Type I and Type II Anchor unless otherwise specified; however, the length of the anchor required shall be determined or modified in the field based upon the result of pullout tests or by the Engineer. Wire rope anchors for drapery support may be substituted for continuously threaded bar anchors at the agreement of the Engineer provided that these are not specifically disallowed on the plans.

Minimum bonded length in rock shall be at least 10 feet into rock. These anchors may be installed in rock or soil as specified on the plans. Where allowed on the plans a 3/4" or larger wire rope anchor may be used in place of the deformed steel threaded bar. Where

the wire rope anchor is installed in rock it shall be paid under Type I anchor, where the wire rope anchor is installed in rock and soil or only in soil it shall be paid under Type II anchor.

All anchors shall be installed in drilled holes using centralizers that shall adequately support the anchor in the center of the drilled hole, the centralizers shall be spaced at a maximum of 3 feet. The anchor hole shall be at least 2 ½ inches in diameter or as directed by the Engineer. Type I anchor is installed in rock, type II anchors are installed in a combination of rock and soil. Both bar anchors and cable anchors are classified as Type I or Type II anchors based on whether they are installed in rock or in a combination of soil and/or rock. The full length of the anchors installed below ground shall be encased in grout and all anchors shall be galvanized.

Contractor's drillers shall keep and provide a borehole log for each borehole drilled for rock and soil anchors. The log shall include, but not be limited to the following: hole location, hole diameter, hole length, angle from horizontal, date/time of drilling, drilling equipment used, encountered subsurface conditions (groundwater, joints, voids, soil/weak rock, etc.), and name of driller. Contractor shall submit the logs to the Engineer on a daily basis.

Anchor grout shall be tremmied into drill-holes from the bottom of the hole. All Portland cement used to make grout shall, at a minimum, comply with the requirements of ASTM C150, Type II or III. The water used for mixing shall be potable and free from substances, which might be deleterious, corrosive to concrete, or steel, and shall be furnished by Contractor. Contractor, if requested by the Engineer, shall submit reports of tests, made by a competent laboratory, on samples of the water proposed for use. Cement grout shall consist of a maximum of five gallons of clean potable water per sack consisting of 94 pounds of Type II or III Portland Cement. The grout shall be mixed for a minimum of five minutes in a paddle type grout mixer, and passed through a #4 size sieve before being used. It may be pumped or fed by gravity into the tremmie pipe or grout tube. Grout that contains lumps or has been in the grout mixer for more than 30 minutes shall not be used. No chemical additives shall be used unless approved in writing by the Engineer.

Installation and Testing Requirements

All rockfall drapery systems shall be installed in accordance with the recommendations and requirements of the manufacturer, as shown on the plans, as specified in these special provisions and as directed by the Engineer.

Vegetation, particularly trees and large shrubs shall be removed within the draped area where its presence would compromise the effectiveness and integrity of the rockfall drapery or as directed by the Engineer. Vegetation above the anchored area shall be removed only to the point necessary for installation of the anchoring system and shall be limited to 20 feet upslope of the rockfall drapery limits, unless specifically directed by

the Engineer. The Contractor shall dress out disturbed areas of the slope to match existing ground surface to prevent jumping ramps for falling rocks.

Wire Mesh Installation (Standard and High Tensile)

If wire mesh is used with cable net it shall be placed between on the back side of the net (between the net and the slope) and securely fastened to each cable net panel and to the cable net infrastructure. Tie wires and/or connectors securing the mesh to a cable net system shall be spaced no more than 12 inch centers on either the horizontal or vertical direction. The wire mesh and cable net shall be flush with no gaps between the two elements exceeding 4 inches. Where wire mesh is attached to cable net, these shall be connected prior to placing the drape on the slope.

The top of the wire mesh drapery shall be secured to a top support cable. The top support cable shall be wire rope with a minimum diameter of ¾-in; be of 6x19 construction (or equivalent), IWRC with a minimum breaking strength of 52,920 lbs.; and shall be positioned as shown in the plans or as directed by the Engineer. Wire rope shackles shall be used to connect the top support rope to the anchors and fixed on the cable to prevent the wire mesh from sliding on the cable.

The horizontal cable is then attached by vertical cables to anchors located upslope and spaced at maximum 25' intervals, or as specified on the plans. Where there is a change in the topography and in order to maintain contact with the slope, additional anchors may be added to reduce this spacing at the direction of the Engineer. The wire mesh is to be draped over the horizontal cable of the net so that 1 foot overlap is achieved. The wire meshing is to be attached to the horizontal cable by continuously weaving tie wire and with high tensile steel rings or fence clips.

The wire mesh shall be installed in vertical panels and slope coverage shall be continuous on slope such that no gaps are present. Tie wires or connectors used to fasten the wire mesh to either cable net or adjacent panels shall have a connection strength equal to or greater than the strength of the wire mesh. Mesh panels shall be seamed together in accordance with the manufacturer's recommendation with the concurrence of the Engineer. All seaming and connecting material shall be approved by the Engineer.

Horizontal seams shall not be allowed without approval from the Geotechnical Engineering Section and should not be used except under unusual circumstances. Where horizontal seams are approved, these seams shall be closed with fasteners and lacing wire – with the lower panel placed on the outside of the mesh. A minimum overlap of 1 foot shall be used.

Cable Net, High Tensile Cable Net, and Rope Net Installation

Connection of the panels or sections shall be made with wire rope which shall have a diameter of 5/16" lacing cable and cable clamps on a 5 foot spacing. The lacing cables shall be of 7x19 construction (or equivalent), GAC with a minimum breaking strength of 9,800 lbs. The rockfall drapery shall be placed on the slope in a manner that will follow

the contours of the slope and minimize gaps and large spaces between the drapery and the ground surface as determined by the Engineer

The top of the wire mesh and net drapery shall be secured to a top support cable. The top support cable shall be wire rope with a minimum diameter of ¾-in; be of 6x19 construction (or equivalent), IWRC with a minimum breaking strength of 52,920 lbs; and shall be positioned as shown on the plans or directed by the Engineer. Wire rope shackles shall be used to connect the top support rope to the anchors.

All wire rope for the support ropes, seam ropes, and wire rope anchors shall meet the Federal Specifications RR-W-410F or equivalent.

Anchor Field Testing

Anchors shall have a minimum pullout strength of 11 tons or 1.5 times the allowable design load, whichever is greater and must be verified by the contractor and approved by the Engineer in the field. The testing shall consist of a pullout test incorporating 20 % of the total number of anchors. If more than 20% of the tested anchors fail, all anchors shall be re-evaluated and tested. Failed anchors shall be replaced by the contractor at no additional cost. Testing shall be performed against a temporary yoke or load frame. No part of the yoke or load frame shall bear within 3 feet of the anchor. The maximum test load acting on the anchor shall not exceed 80 percent of the guaranteed ultimate tensile strength of the anchor steel.

Anchors tested shall have pullout tests done by the Contractor in the presence of the Engineer. The Geotechnical Engineering Section shall have at least 72 hours' notice prior to actual load tests. A pullout test consists of incrementally loading the anchor assembly to the maximum test load or failure point, whichever occurs first. Failure point shall be the point where the movement of the anchor continues without an increase in the load or when the anchor has displaced 2 inches. The failure load corresponding to the failure point shall be recorded as part of the test data.

During the load test, the Contractor shall monitor and record displacement of the anchors relative to a stable reference point which is founded at a minimum distance of 3 feet from the anchor and test load reaction points. The pullout test shall be conducted by measuring the test load applied to the anchor and the anchor end movement at each load.

Applied test loads shall be measured by the Contractor with either a calibrated pressure gage or a load cell. Movements of the end of the anchor shall be measured and recorded during the load tests. The pressure gage shall have an accurately reading dial at least 150 mm in diameter and each jack and its gage shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force, and shall be accompanied by a certified calibration chart. The jack gauge shall have been calibrated within 30 days prior to use on the project. The anchor shall be unloaded only after completion of the test. Contractor shall submit a sketch of the test frame, jack and dial gauge arrangement for approval to the Engineer before use.

Types of Rockfall Drape Systems

Rockfall drape systems shall be specified on the plans as Tennessee Drape Type I, II, III or IV. Tennessee Drape Type system criteria are listed below:

Tennessee Drape Type	Description	Rockfall Drape Material Allowed
I	Standard	Wire mesh
II	Moderate	High Tensile Wire Mesh, Wire Rope Net
III	High	High Tensile Wire Mesh, High Tensile Cable Net
IV	Very High	High Tensile Rope and Cable Net

Qualified Rockfall Drape Suppliers and Products:

Note: Systems and manufacturers not on this list may be submitted for consideration to the Geotechnical Engineering Section at least 30 days prior to letting in order to be added to the qualified products list. No system shall be approved as substitution for those on this list without prior concurrence and acceptance by the TDOT Geotechnical Engineering Section.

Required for submittal to add product to list:

1. Name, specifications, drawings, and design details for rockfall drape system including materials used and anchoring system. Designs as submitted to the TDOT Geotechnical Engineering Section shall comply with this Special Provision.
2. Date and location of previous installations for the drape system to be considered as well as contact information for an “owner” representative for whom this system was installed.
3. Test reports of rockfall drape materials and system verifying that the system and elements can withstand the tensile requirements and block sizes specified in this provision.

Geobruigg North America, LLC

22 Centro Algodones
Algodones, NM 87001
Phone: 505-771-4080

Tennessee Drape Type I	Double Twisted Wire Mesh 8x10 Galvanized High Tensile Steel Wire Mesh DELTAX G80/2 mm)
Tennessee Drape Type II	High Tensile Steel Wire Mesh Tecco G 65/3 (3 mm)
Tennessee Drape Type III	High Tensile Steel Wire Mesh Tecco G 65/4 (4 mm) Rolled Cable Net 0/8.6/250 with Double Twisted Wire Mesh 8x10 or 2mm
Tennessee Drape Type IV	A. High Tensile Spiral Rope Net S4-130 B. High Tensile Spiral Rope Net S4-230

Maccaferri

10303 Governor Lane Boulevard
Williamsport, MD 21795
301-223-6910

Tennessee Drape Type I	Double Twisted Wire Mesh 8x10 Galvanized
Tennessee Drape Type II	Rock Mesh B-600
Tennessee Drape Type III	HEA Panel 3/8" Type 7x7 Galvanized with DT Mesh T 8x10 Galvanized
Tennessee Drape Type IV	A. HEA Panel 3/8" Type 7x7 Galvanized 8x8 in. B. HEA Panel 3/8" Type 7x7 Galvanized 12x12 in.

Mountain Management
Financial Plaza Building
1135 Terminal Way, Suite 106
Reno, Nevada, 89502-2145
Phone: 866-466-7223
Fax: 450-455-8762

Tennessee Drape Type I	Hexagonal Wire Mesh
Tennessee Drape Type II	Draped Wire Rope Net System (8 x 8 or 12 x 12 wire rope mesh size)
Tennessee Drape Type III	No Product Submitted
Tennessee Drape Type IV	No Product Submitted

Terra Aqua Gabions, Inc.
1415 N 32nd Street
Fort Smith, AK 72904
Phone: 800-736-9089

Tennessee Drape Type I	Hexagonal Wire Mesh
Tennessee Drape Type II	No Product Submitted
Tennessee Drape Type III	No Product Submitted
Tennessee Drape Type IV	No Product Submitted

Quantities and Pay Items

The quantity of rockfall drapery to be paid for will be the number of square yards, measured along the surface over which mesh has been acceptably placed. The quantity of rock anchors to be paid for will be the actual number linear footage of anchors installed in the completed work.

The quantity of rockfall drapery, measured as provided for above, will be paid for at the contract unit price per square yard for “Rockfall Drape”. Such price and payment will be full compensation for all work covered by this special provision, including but not limited to labor, materials and equipment (furnishing all wire mesh, hog rings, clamps, rings, wire, placing and securing the wire mesh), and for all incidentals necessary to complete the work satisfactorily. It also includes pruning, excavating, and removing any vegetation required to satisfactorily install rockfall drape system. Where rockfall fabric that has a greater than 4 inches opening, Wire Mesh – Standard or Wire Mesh – High Tensile with a maximum opening size of 4 inches shall be required and this additional mesh is included in the item cost for Rockfall Drape.

The quantity of rock anchors measured as provided for above will be paid for at the contract unit price per either each or per linear foot as indicated in the plans and Quantity Estimate Table for Rock Anchors, Type I or Type II. Such price and payment will be full compensation for furnishing all labor, materials, equipment, and supervision necessary for the actual installation of the rock bolts and the performance of pull tests as specified by the Engineer.

Payment will be made under:

<u>Item No.</u>	<u>Pay Item</u>	<u>Pay Unit</u>
-	-	
707-10.05	Rockfall Drape, Type I	S.Y.
707-10.06	Rockfall Drape, Type II	S.Y.
707-10.07	Rockfall Drape, Type III	S.Y.
707-10.21	Rockfall Drape Type IV (A)	S.Y.
707-10.22	Rockfall Drape Type IV (B)	S.Y.
707-02.41	Rock Anchor, Type I	EACH
707-02.42	Rock Anchor Type II	EACH
707-02.43	Rock Anchor, Type I	L.F.
707-02.44	Rock Anchor, Type II	L.F.