

Republic of the Philippines DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS OFFICE OF THE SECRETARY



097.13 DPWH

02.28.00

Bonifacio Drive, Port Area Manila

JAN 30 2024

DEPARTMENT ORDER

NO. Series of 2024

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SUBJECT: Revised DPWH Standard Specification for Item 522 – PROTECTION SYSTEMS FOR UNSTABLE SLOPE

In line with the continuing efforts of the Department to update existing guidelines and standard specifications, the attached revised **DPWH Standard Specification for Item 522** – **Active and Passive Protection Systems for Unstable Slope**, renamed as **Item 522** – **Protection Systems for Unstable Slope**, is hereby prescribed for adoption in Government infrastructure projects.

The revised Pay Item Subscripts are now included in the Project and Contract Management Application (PCMA) and shall form part of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

This Order supersedes the following issuances and shall take effect immediately:

- 1. Department Order No. 32, Series of 2019, *Item 522 Active and Passive Protection Systems* for Unstable Slope (Amendments to Item 522 - DPWH Generic Specification for Rockfall Protection System and Item 522A - DPWH Standard Specification for Protection Systems for Unstable Slope)
- 2. Department Order No. 22, 2022, Series of 2022, Amendment to Department Order No. 32, Series of 2019, re: Item 522 - Active and Passive Systems for Unstable Slope

MANUEL M. BONOAN Secretary

14.1.2 MLL/JDV/RPF Department of Public Works and Highways Office of the Secretary

WIN4U01934



Revised DPWH Standard Specification for ITEM 522 – PROTECTION SYSTEMS FOR UNSTABLE SLOPE

522.1 Description

This Item shall consist of furnishing and installing active and passive protection systems on an unstable slope in accordance with this Specification and as shown on the Plans.

522.2 Material Requirements

522.2.1 Active System

522.2.1.1 Non-mesh System

The components of active non-mesh system shall conform to Table 522.1.

Components	Property	Requirement	Specification	Test Method
	Thickness, Min.	6 mm	ASTM A6M	-
	Yield Strength, Min.	245 MPa	ASTM A36M /	ASTM A370M
	Tensile Strength	400-550 MPa	JIS G 3101	
Steel Plate	Bending Moment Resistance	>Factory Production Control	_	EAD 230025- 00-0106, Annex A
		Zinc (Hot-dip galvanized)		
	Coating Weight of Coating, Min.: 530 g/m ²	JIS H 8641	ASTM A90M/ ISO 1461	
	Diameter, Min.	8 mm		
Wire Rope	Breaking Force	Shall be based on the minimum requirement per rope designation	ASTM A1023M / JIS G 3525	ASTM A931
		Zinc-alloy coating		
	Coating	Shall be based on the minimum requirement per size of wire (single wire)	ASTM A603 / JIS G 3525	ASTM A90M/ ISO 1461

Table 522.1 Non-Mesh System Components

Components	Property	Requirement	Specification	Test Method	
	Corrosion resistance	Accelerated weathering (salt spray) test: 95% of breaking force shall be retained after 1,000 h	_	ASTM B368/ ASTM B117/ JIS Z 2371	
		For Hot-Dip Galvaniz	ed:		
	Coating	Weight of Coating, Min.: 550 g/m ²	ASTM A123M / JIS G 3112	ASTM A90M/ ISO 1461	
		For Epoxy-coated:			
		Coating Thickness: 175 µm to 300 µm	ASTM A934M	ASTM A934M	
Soil Nail	A. Self-drilling type				
	Diameter, Min.	28 mm	-	-	
	Yield strength, Min.	345 MPa	ASTM A615M / JIS G 3112	ASTM A370M	
	B. Insert-afte	er-drilling type			
	Diameter, Min.	19 mm	-	-	
	Yield strength, Min.	345 MPa	ASTM A615M / JIS G 3112	ASTM A370M	
Grout	Compressive Strength, Min.	25 MPa in 7 days	-	ASTM C109M/ AASHTO T 106	

Note:

AASHTO T 106M - Standard Method of Test for Compressive Strength of Hydraulic Cement Mortar (Using 50-mm or 2-in. Cube Specimens

ASTM A1023M - Standard Specification for Carbon Steel Wire Ropes for General Purposes

ASTM A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products ASTM A36M - Standard Specification for Carbon Structural Steel

ASTM A370M - Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM A6M - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

ASTM A603 - Standard Specification for Metallic-Coated Steel Structural Wire Rope

ASTM A615M - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement ASTM A90M - Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

ASTM A931 - Standard Test Method for Tension Testing of Wire Ropes and Strand

ASTM A934M - Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars

ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM B368 - Standard Test Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test)

ASTM C109M - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens)

EAD 230025-00-0106 - Flexible facing systems for slope stabilization and rock protection ISO 1461 - Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods JIS G 3101 - Rolled Steels for General Reinforcement JIS G 3112 - Steel Bars for Concrete Reinforcement JIS G 3525 - Wire Ropes JIS H 8641 - Hot-dip Galvanized Coatings JIS Z 2371 - Methods of Salt Spray Testing

522.2.1.2 Mesh System

The main components of active mesh systems shall conform to Table 522.2. Additional components or accessories can be allowed as per manufacturer's recommendations and for approval by the Engineer.

Component	Property	Requirement	Specification	Test Method
Mesh	See Table 522.3			
	Thickness, Min.	7 mm	ASTM A6M	-
	Yield Strength, Min.	245 MPa	ASTM A36M /	ASTM A370M
	Tensile Strength	400-550 MPa	JIS G 3101	
Steel Plate	Bending Moment Resistance:	>Factory Production Control	-	EAD 230025- 00-0106, Annex A
		Zinc (Hot-dip galvanized)	ASTM A123M /	ACTM A00M/
	Coating	Weight of ISO 1461 / Coating, Min.: JIS H 8641 530 g/m ²	ISO 1461	
Wire Rope	Diameter, Min.	6 mm		
	Breaking Force	Shall be based on the minimum requirement per rope designation	ASTM A1023M / JIS G 3525 ASTM AS	
		Zinc-alloy coating		
	Coating	Shall be based on the minimum requirement per size of wire (single wire)	ASTM A603 / JIS G 3525	ASTM A90M/ ISO 1461

Table 522.2 Mesh System Components

Component	Property	Requirement	Specification	Test Method
	Corrosion resistance	Accelerated weathering (salt spray) test: 95% of breaking force shall be retained after 1,000 h	-	ASTM B368/ ASTM B117/ JIS Z 2371
	Diameter, Min.	20 mm	-	ASTM A615M
	Yield strength, Min.	345 MPa	ASTM A615M / JIS G 3112	ASTM A370M
	Coating	For Hot-Dip Galvanized:		
Soil Nail		Weight of Coating, Min.: 550 g/m ²	ASTM A123M / ISO 1461 / JIS G 3112	ASTM A90M/ ISO 1461
		For Epoxy-coated:		
		Thickness: 175 µm to 300 µm	ASTM A934M	ASTM A934M
Grout	Compressive Strength, Min.	25 MPa in 7 days	-	ASTM C109M / AASHTO T 106

Notes:

AASHTO T 106M - Standard Method of Test for Compressive Strength of Hydraulic Cement Mortar (Using 50-mm or 2-in. Cube Specimens

ASTM A1023M - Standard Specification for Carbon Steel Wire Ropes for General Purposes

ASTM A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A36M - Standard Specification for Carbon Structural Steel

ASTM A370M - Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM A6M - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

ASTM A603 - Standard Specification for Metallic-Coated Steel Structural Wire Rope

ASTM A615M - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

ASTM A90M - Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

ASTM A931 - Standard Test Method for Tension Testing of Wire Ropes and Strand

ASTM A934M - Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars

ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM B368 - Standard Test Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test)

ASTM C109M - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens)

EAD 230025-00-0106 - Flexible facing systems for slope stabilization and rock protection

ISO 1461 - Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods

JIS G 3101 - Rolled Steels for General Reinforcement

JIS G 3112 - Steel Bars for Concrete Reinforcement

JIS G 3525 - Wire Ropes

JIS H 8641 - Hot-dip Galvanized Coatings

JIS Z 2371 - Methods of Salt Spray Testing

Property	Requirement	Specification	Test Method
Diameter			
A. Wire, Min.	2 mm	ASTM A854M	-
B. High Tensile, Min.	2 mm	ASTM A854M	-
C. Wire Rope, Min.	6 mm	ASTM A1023M	ASTM A931
Weight of Coating			
A. Wire, Min.	128 g/m²	ASTM A856M / ASTM A641M / JIS G 3552	ASTM A90M/ ISO 1461
B. High Tensile, Min.	244 g/m ²	ASTM A854M	
C. Wire Rope, Min.	Shall be based on the minimum requirement per size of wire (single wire)	ASTM A603	
	Accelerated Weathering (Salt Spray Test):	-	
Corrosion Resistance	For wire mesh, 95% of tensile strength shall be retained after 1000 h		ASTM B368/ ASTM B117 / JIS Z 2371
	For wire rope, 95% of breaking force shall be retained after 1,000 h		
Wire Tensile Strength:			
A. Wire, Min.	290 MPa	ASTM A641M / ASTM A856M / JIS G 3547	ASTM A370M
B. High Tensile Wire, Min.	970 MPa	ASTM A854	
C. Wire Rope, Min. Breaking Force	Shall be based on the minimum requirement per rope designation	ASTM A1023M / JIS G 3525	ASTM A931

Table 522.3 Wire Mesh Requirements

Property	Requirement	Specification	Test Method
Mesh Tensile Strength:			
A. Wire Mesh, Min.	90 KN/m	-	EAD 230008-00- 0106 /
B. High Tensile Wire Mesh, Min	150 KN/m	-	EAD 230025-00- 0106
C. Wire Rope Mesh, Min.	150 KN/m	-	

Notes:

ASTM A1023M - Standard Specification for Carbon Steel Wire Ropes for General Purposes

ASTM A370M - Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM A603 - Standard Specification for Metallic-Coated Steel Structural Wire Rope

ASTM A641M - Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire

ASTM A854M - Standard Specification for Metallic-Coated Steel Smooth High-Tensile Fence and Trellis Wire

ASTM A856M - Standard Specification for Zinc-5 % Aluminum-Mischmetal Alloy-Coated Carbon Steel Wire

ASTM A90M - Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

ASTM A931 - Standard Test Method for Tension Testing of Wire Ropes and Strand

ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM B368 - Standard Test Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test)

EAD 230025-00-0106 - Flexible Facing Systems for Slope Stabilization and Rock Protection

EAD 230008-00-0106 - Double Twisted Steel Wire Mesh Reinforced or Note with Ropes

ISO 1461 - Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods JIS G 3525 - Wire Ropes

JIS G 3547 – Zinc-Coated Low Carbon Steel Wires

JIS G 3552 - Chain Link Wire Netting

JIS Z 2371 - Methods of Salt Spray Testing

522.2.1.3 Anchorage (for border wire rope)

Anchorage for the border wire rope shall conform to the requirements of Item 513 – Permanent Ground Anchor or soil nail specified in Table 522.2, Mesh System Components, whichever is applicable.

If soil nail is used, rope grip of the border wire rope shall be fixed with steel plate, wherein connection details shall be provided on the Plans. Steel plate shall have rope guide unless the rope grip is installed underneath the steel plate.

522.2.1.4 Miscellaneous Materials

All miscellaneous materials such as screw bolts, nuts and washer (if applicable), clips/shackles, earth claw, turnbuckles, ropes/cables grips, and rope guide shall be hot-dipped galvanized per AASHTO M 111 (ASTM A123M), Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products or equivalent.

Centralizers shall be fabricated from any type of material, except wood, and shall be approved by the Engineer.

522.2.2 Passive System

522.2.2.1 Simple Drapery

Wire mesh components of simple drapery passive system shall conform to Table 522.3 Wire Mesh Requirements. Top and bottom anchors shall conform to the applicable requirements of Subsection 522.2.1.3, Anchor Bolt (for border wire rope). Other components shall conform to the applicable requirements Subsection 522.2.1.4, Miscellaneous Materials.

522.2.2.2 Hybrid Drapery (Curtain Net)

Excavation for the foundation shall conform to the applicable requirements of Item 102, Excavation. The foundation of the posts shall be Class A concrete and shall conform to the applicable requirements of Item 405, Structural Concrete. The main components of hybrid drapery (curtain net) passive system shall conform to Table 522.4. Anchorage for the wire ropes shall conform to the applicable requirements of Subsection 522.2.1.3, Anchor Bolt (for border wire rope).

Component	Property	Requirement	Specification	Test Method
	Diameter, Min.	2 mm	ASTM A392 /	
	Mesh Size (Hole), Min.	Shall be based on the wire diameter	JIS G 3552	ASTM A392
	Tensile Strength, Min.:			
	a. Wire	290 MPa	ASTM A392 / JIS G 3547	ASTM A370
Wire Mesh	b. High Tensile Wire	970 MPa	ASTM A854	
	Weight of Coating, Min.:			
	a. Wire	147 g/m²	ASTM A817 / JIS G 3552	ASTM A90M /
	b. High Tensile Wire	244 g/m ²	ASTM A854	ISO 1461
	Corrosion Resistance	Accelerated weathering (salt spray test):	-	ASTM B368/
		95% of tensile strength shall be retained after 1000 h		JIS Z 2371

 Table 522.4 Passive System, Hybrid Drapery (Curtain Net) Components

Component	Property	Requirement	Specification	Test Method
	Diameter, Min.	8 mm	ASTM A1023M / JIS G 3525	ASTM A931
	Weight of Coating, Min.	Shall be based on the minimum requirement per size of wire (single wire)	ASTM A603 / JIS G 3525	ASTM A90M / ISO 1461
Wire rope	Breaking Force, Min.	Shall be based on the minimum requirement per rope designation	ASTM A1023M / JIS G 3525	ASTM A931
	Corrosion Resistance	Accelerated weathering (salt spray test): 95% of breaking force shall be retained after 1,000 h		ASTM B368 / ASTM B117 / JIS Z 2371
Steel Post, Base Plate and Concrete Anchors (for Anchor Plates and Post Base Plates, and for Horizontal Ropes and Post Side Stay Ropes)	Dimension	As per Plan	-	-
	Tensile Strength	400 - 550 MPa		
	Yield point, Min. a. Steel Post & Base Plate b. Concrete Anchors and Anchor Plate Elongation in 200 mm, Min.	245 MPa 235 MPa 20%	ASTM A36M / JIS G 3101	ASTM A370M
	Weight of Coating, g/m ²	Shall be based on thickness	ASTM A123M / JIS H 8641	ASTM A90M/ ISO 1461

Notes:

ASTM A1023M - Standard Specification for Carbon Steel Wire Ropes for General Purposes

ASTM A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A36M - Standard Specification for Carbon Structural Steel ASTM A370M, Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM A370 - Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM A392 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric

ASTM A603 - Standard Specification for Metallic-Coated Steel Structural Wire Rope

ASMT A817 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric

ASTM A854 - Standard Specification for Metallic-Coated Steel Smooth High-Tensile Fence and Trellis Wire

ASTM A90M - Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings ASTM A931 - Standard Test Method for Tension Testing of Wire Ropes and Strand ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus ASTM B368 - Standard Test Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test) ISO 1461 - Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods JIS G 3101 - Rolled Steels for General Reinforcement JIS G 3525 - Wire Ropes JIS G 3547 – Zinc-Coated Low Carbon Steel Wires JIS G 3552 - Chain Link Wire Netting JIS H 8641 - Hot-dip Galvanized Coatings

JIS Z 2371 - Methods of Salt Spray Testing

Coupling coils, bolts, nuts and washers and other miscellaneous materials shall conform to the applicable requirements of Subsection 522.2.1.4, Miscellaneous Materials.

522.2.2.3 Catch Fences

The catch fence system shall comply with the requirements for Category 'A' - Falling Rock Protection Kits under Guideline for European Technical Approval (ETAG 027) by the European Organisation for Technical Approvals (EOTA) or similar guidelines. Certificate from a recognized and independent authority attesting to the impact energy absorbing capacity of the flexible catch fence system under ETAG 027 or similar guidelines shall be submitted to the Engineer for approval.

Catch fence system with similar components to hybrid drapery (curtain net) shall have the same requirements as specified in Table 522.4.

The catch fence system for debris flow shall be designed based on information of the physical characteristics of the debris material, the nature of the debris flow event and the site geometry. These fences are normally constructed in-channel, perpendicular to the flow direction. A simple gully net is often sufficient for narrow spans e.g., less than 15 m, whereas a post and net system is required for wide channels applications.

A standardized stress model for design of torrential barriers under impact by debris flow under ONR 24801, Protection Works for Torrent Control - Static and Dynamic Actions on Structures or equivalent, is already in place for the application for this type of catch fences.

	Values shall comply with ETAG 027 or similar	
Energy (kJ)	guidelines supported by design analysis and	
	shall be verified during implementation.	
Intercepting Panel Type	As per design specifications	
Post Type	As per design specifications	
Post Height & Distances	As per design calculation	
	Posts/support structures, base plates,	
	ring not otc) support wire repose (uppor	
	ing net, etc), support wire ropes (upper,	
Components	lower, lateral & junction bracing cables,	
	etc.), energy-dissipating device, shackles,	
	wire rope grips, wire rope anchors, bar	
	anchors and turnbuckles	

Table 522.5 Catch Fence Energy Levels

522.3 Construction Requirements

522.3.1 Active System

The construction methodology for active protection systems for unstable slope (mesh / non-mesh) shall follow the sequence below:

- 1. Temporary Works
 - a. Preparation Work
 - b. Hole Position Pinning
 - c. Scaffolding
- 2. Soil Nail Works
 - a. Drilling
 - b. Hole Cleaning
 - c. Bolt Installation and grout injection
 - d. Pull-out test of Soil Nail
- 3. Superstructure Works
 - a. Mesh laying, if applicable
 - b. Base Plate Installation
 - c. Soil Nail Networking Works, if applicable

The location, inclination, and alignment of the drilled hole shall be as shown on the plans. Inclination and alignment shall be within \pm 3 degrees of the planned angle at the steel plate, and within \pm 30cm of the planned location at the ground surface (point of entry).

For insert-after-drilling type of soil nail, grout shall be provided through pressurized mortar injection to allow the grout to flow throughout the length of the soil nail. A minimum of two (2) centralizers that do not impede the flow of grout up to the drilled hole shall be provided to hold the bolt in place while grout is being poured and to ensure sufficient minimum thickness of 13 mm of grout. It shall be located at 3 m maximum center-to-center spacing with the upper one located a maximum of 1.5 m from the top of the soil nail bond length and the lower one located 0.30 m from the bottom of the soil nail bond length.

Pull-out test shall be carried out at least 72 h after grouting or at least the specified 7 days strength (>25 MPa) is attained. Two (2) types of soil nail pull-out test shall be performed; (1) Conformity Pull-out test which is performed for trial soil nails prior to actual soil nails installation for the verification of peripheral surface friction resistance, and (2) Proof Pull-out test which is performed for selected set of installed soil nails for the verification of their anchoring strength to meet the required performance.

The Contractor shall install preliminary soil nails and carry out conformity (verification) pullout test at locations selected by the Engineer. The number of soil nails to be tested shall be three (3). Test conditions shall meet the requirements specified in Subsection 522.3.4.1, Conformity Pull-out Test.

If at least one (1) out of three (3) preliminary soil nails failed the conformity pull-out test and the cause of failure is a result of poor construction methodology (i.e., non-uniformity or inadequacy of grout of the pulled soil nail) as per the Engineer's evaluation, three (3) additional soil nails per failed soil nail shall be installed and also undergo conformity pull-out test. Replacement of three (3) additional soil nails per failed soil nails per fail

occurred with no error in the construction methodology as per Engineer's evaluation, the design of the system shall be re-evaluated.

The installation of the succeeding soil nails shall not commence until the conformity pull-out test is satisfied.

After the installation of the soil nails, the proof pull-out test shall be conducted to three percent (3%) or a minimum of three (3) installed soil nails, whichever is higher, arbitrarily selected by the Engineer. If at least one (1) of three (3) selected soil nail failed the proof pull out test, all installed soil nails shall be subjected to proof pull-out test. All soil nails that failed the test shall be reinstalled within the same location and retested until it passed the proof pull-out test. Test conditions shall meet the requirements specified in Subsection 522.3.4.2, Proof Pull-out Test.

If the conduct of the pull-out tests resulted satisfactory performance, the mesh panels shall then be installed. The rolls of the mesh panel shall be positioned and fixed by the steel plate as per Plans. Steel plates shall be securely in contact with the slope surface. On the slope face, the side of mesh panels shall be securely and continuously joined together using connection clips or shackles with minimum overlap of 0.3 m.

Anchorage (for boundary wire ropes) shall be installed in accordance to Section 513.4, Construction Requirements. Permanent ground anchors, if used, shall be tested in accordance to Subsection 513.4.3.2, Performance Test, and Subsection 513.4.3.3, Proof Test of Item 513, Permanent Ground Anchors.

In case where the wire rope passes through the steel plate, the steel plate shall preferably have a rope guide. Otherwise, the wire rope shall be positioned underneath the steel plate.

Nuts of the soil nail shall be spot welded to the soil nail to which weld details shall be shown in the Plans.

After the installation, all galvanized steel components such as but not limited to clips, shackles, wire rope grips, bolts and nuts, as well as repairs to galvanization coating for other steel parts shall be treated with zinc-rich cold-galvanizing paint.

522.3.2 Passive System

522.3.2.1 Simple Drapery

For simple drapery (passive), a minimum anchorage shall be installed on top and/or bottom of the slope. The distribution of the top and/or bottom anchorage shall be calculated based on the maximum load that may occur at each anchorage, bearing in mind the breaking strain of the drapery mesh panel. It shall be better to link the individual anchor bolt with a steel rope (crest and bottom cable), where the mesh is securely connected. Close the ends of drapery at the toe of the slope with anchorage and bottom cable to contain loose material. The bottom fixing shall allow for periodic removal of accumulated debris after which the mesh panel must be anchored again. On the slope face, the mesh panel shall be securely and continuously joined together using clips or shackles, with the provision of additional pins against the wind. Depending on the slope face condition, additional anchorage shall be installed. The rolls of drapery shall be rolled into position as per Plans. New rolls shall be placed in the same direction directly overlapping the adjacent roll such that the selvedge of both rolls can joined together using clips or shackles as shown in the Plans.

If the permanent ground anchors (for boundary wire ropes) are used, it shall be installed in accordance to Section 513.4, Construction Requirements and shall be tested in accordance to Subsection 513.4.3.2, Performance Test, and Subsection 513.4.3.3, Proof Test of Item 513, Permanent Ground Anchors.

After the installation, all galvanized steel components such as but not limited to clips, shackles, wire rope grips, bolts and nuts, as well as repairs to galvanization coating for other steel parts shall be treated with zinc-rich cold-galvanizing paint.

522.3.2.2 Hybrid Drapery (Curtain Net)

The construction methodology for hybrid drapery (curtain net) passive protection systems for unstable slope shall follow the sequence in accordance with the Road Slope Protection Manual 2019 as stated below:

- 1. Install post anchor for base plate, suspension rope and top horizontal rope.
- 2. Install posts, suspension ropes and post side stay ropes.
- 3. Install the top horizontal rope.
- 4. Install wire netting.
- 5. Install hanger bracket.
- 6. Install vertical and horizontal reinforcement ropes.

For hybrid drapery (curtain net), posts shall be installed as per construction drawings. Prior to installation, the Contractor shall place simulation posts that are of the same height as the actual ones and mark the anchorage points for wire ropes on site for the Engineer's verification. The post position and the anchorage points for wire ropes shall not be adjusted without the Engineer's approval.

After the installation, all galvanized steel components such as but not limited to clips, shackles, wire rope grips, bolts and nuts, as well as repairs to galvanization coating for other steel parts shall be treated with zinc-rich cold-galvanizing paint.

522.3.2.3 Catch Fences

Detailed drawings for construction of the catch fence system shall be submitted to the Engineer for approval before commencement of the construction.

In-situ boulder stabilization/splitting works along the proposed alignment of the catch fence system should be completed prior to the construction of the catch fence.

The Contractor shall provide and install the catch fence systems at locations indicated in the Plans. Prior to installation, the Contractor shall mark the alignment of the fence and the positions of the steel posts and the anchorage points for wire ropes on site for the Engineer's verification. The fence location and the anchorage points for wire ropes shall not be adjusted without the Engineer's approval.

After the installation, all galvanized steel components such as but not limited to clips, shackles, wire rope grips, bolts and nuts, as well as repairs to galvanization coating for other steel parts shall be treated with zinc-rich cold-galvanizing paint.

522.3.3 Submittals

For systems with soil nailing works, the Contractor shall keep records for each soil nail installed for each day of operation for approval of the Engineer prior to the next soil nail installation. The record for each soil nail shall include but not limited to:

- 1. Key plan with soil nail reference number, soil nail lengths
- 2. Necessary drilling (with or without grouting) details
- 3. Date/time of commencement and completion of:
 - a. drilling
 - b. cleaning of holes
 - c. insertion of soil nails
 - d. grouting, if necessary
 - e. pull-out tests

522.3.4 Quality Control and Assurance

522.3.4.1 Conformity Pull-out test

Conformity Pull-out test shall be conducted in accordance with the following condition:

a. Maximum load: 90 % of the yield strength of the soil nail

b. Loading cycle: single cycle

c. Loading condition: incremental load of 10.0 kN with 5-minute hold at each step

d. Record items: load value, soil nail displacement, settlement of reaction plate, and time of testing

522.3.4.2 Proof Pull-out test

Proof Pull-out test shall be conducted in accordance with the following conditions:

- a. Maximum load: design load
- b. Loading cycle: single cycle
- c. Loading condition: incremental load of 5.0kN with 1-minute hold at each step except for 5-minute hold at maximum load
- d. Record items: load value and time of testing

522.3.5 Handling & Storage

Rolls or panels of meshes, soil nails, cement, and all other materials shall be marked, kept dry, and protected against possible damage during periods of shipment and storage.

522.4 Method of Measurement

Soil Nail (Self-Drilling Type) shall be measured in linear meter including the necessary drilling installed and accepted and as shown in the Plans.

Soil Nail (Insert-After-Drilling Type) shall be measured in linear meter including the necessary drilling, grouting and centralizers installed and accepted and as shown in the Plans.

Wire Mesh shall be measured in square meters including the necessary clips or shackles installed and accepted and as shown in the Plans.

Wire Rope shall be measured in linear meters including the necessary grips, turnbuckles, installed and accepted and as shown in the Plans.

Steel Plate, nut and washer (if necessary), shall be measured in kilogram including the necessary weld installed and accepted and as shown in the Plans.

Steel post, base plate and concrete anchors (for anchor plates and post base plates, and for horizontal ropes and post side stay ropes) for Hybrid Drapery (Curtain Net) shall be measured in kilogram including the necessary weld installed and accepted and as shown in the Plans.

Catch fences shall be the number of square meters or lump sum including the posts/support structures, base plates, intercepting panels (mesh, rope/cable net or ring net, etc), space keepers, support wire ropes (upper, lower, lateral & junction bracing cables, etc.), energy-dissipating device, shackles, wire rope grips, wire rope anchors, bar anchors and turnbuckles erected/installed and accepted, and related accessories or components.

522.5 Basis of Payment

The quantities measured as determined in Section 522.4, Method of Measurement shall be paid for at the Contract Unit Price shown in the Bid Schedule, which price and payment shall be full compensation for the necessary furnishing and installing active and/or passive protection systems, including all labor, equipment, tools and incidentals necessary to complete the Item.

Payment shall be made under:

Pay Item Number	Description	Unit of Measurement
522 (1)a	Soil Nail (Self-Drilling Type)	Linear Meter
522 (1)b	Soil Nail (Insert-After-Drilling Type)	Linear Meter
522 (2)a	Wire Mesh (Ordinary)	Square meter
522 (2)b	Wire Mesh (High Tensile)	Square meter
522 (3)	Wire Rope	Linear Meter
522 (4)a	Steel Plate and nut, with washer	Kilogram

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Pay Item Number	Description	Unit of Measurement
522 (4)b	Steel Plate and nut, without washer	Kilogram
522 (5)	Steel post, base plate and concrete anchors for Hybrid Drapery (Curtain Net)	Kilogram
522 (6)a	Catch Fences, Falling Rock	Square meter
522 (6)b	Catch Fences, Debris Flow	Square meter
522 (7)a	Catch Fences, Falling Rock	Lump sum
522 (7)b	Catch Fences, Debris Flow	Lump sum