

**Slope Stabilization:
Slope Retention Systems**

Slope Mesh - *draped versus anchored systems*

Draped mesh systems serve a different purpose than slope retention systems (anchored mesh): where a draped mesh is meant to control the movement of debris along the slope, anchored mesh is designed to retain the masses in situ and prevent erosion and shallow landsliding. Which is best for a site is determined by considering not only the physical characteristics but also budgetary and maintenance requirements.



Draped mesh system using a rectangular netting that is supported only along the boundaries of the system.



Anchored mesh system (slope retention system) using a high tensile mesh and anchor system based on loading conditions.

Draped Mesh System

- + lower installation costs;
- + lower material costs;
- + dewatering of slope is uninhibited;
- + lower engineering efforts required;
- slope erodes (**hazard process ongoing**);
- re-vegetation not possible;
- catchment area/ditch required;
- higher maintenance costs.

Slope Retention System

- + slope retains geometry(**hazard process stopped**);
- + re-vegetation is possible;
- + dewatering of slope is uninhibited;
- + no catchment area/ditch required;
- + lower maintenance;
- more engineering efforts required;
- higher installation costs due to number of anchors;
- higher material costs.



A standard and single and double rope guide spike plates.

An integral part of a slope retention system is the method of connection between the mesh and soil/rock anchors. It is imperative that the strength of this connection is known through rigorous testing (puncture strength tests).

Plates used for the connections vary in form and function. In general, they use a combination of corner spikes and welded-on pins to ensure optimum interlocking with the mesh. Some have additional connections for bearing ropes.

For those systems using bearing ropes, positive and non-positive couplings are available for both boundary ropes as well as interior ropes. The style used is dependent on the reinforcement requirements and the boundary conditions at the site.



Corner plates are designed to receive bearing ropes using a shackle and thimble connection to ensure full strength and for ease of installation and maintenance.



A non-positive/fixed connection to a boundary rope of a system.

Anchor spacing is defined by analyzing the failure mechanism and defining the potential mass that can be mobilized in combination with the strength parameters of the anchors and mesh facing and their coupling. The slope is broken down into cells whereby the action forces must be lower than the resistance forces plus a factor of safety.



Rock wall reinforced using High Performance Netting.



An example of interior anchors using a standard spike plate for the coupling. Anchor points are typically set in topographical lows whenever possible.

Slope retention systems should be designed on a site-to-site basis since a single approach oversimplifies the design. Depending on the site characteristics and strength requirements, a large variety of net and netting products are available. Additionally, the orientation of the mesh, support cables, and cable connections can be arranged to suite virtually any condition.

Through the re-stabilization of the slope using mesh, natural re-vegetation is encouraged. Furthermore, netting can accommodate pre-existing vegetation such as tree trunks with little effort. Supplemental bio-mats and seeding mixtures can also be applied all of which produces a safer slope that blends in with nature.

The following nets and nettings are available:

	Diameter (mm)	Mesh (mm)	Galvanization		
			Regular	Heavy	Zn-Al
Omega-Net	4.5 - 10.5	100 to 350		✓	✓
Cable Net	6.0 - 10.0	200 to 500		✓	✓
HPN+	4.6	60 x 60			✓
HPN	4.6	50 x 50			✓
Rectangular	2.5/3.1/3.8	60 x 60	✓	✓	
Rectangular	3.1/3.8	50 x 50	✓	✓	
Rectangular	2.5	30 x 30	✓	✓	
Hexagonal	3.05	80 x 100		✓	
Hexagonal	2.7	60 x 80		✓	
Hexagonal	2.5	50 x 70		✓	



Railway cuts and existing walls stabilized using High Performance Netting.

Hexagonal Mesh - *the original stabilization*

Undisputed the most often used product, double-twisted wire mesh, has been used for decades to stabilize slopes across the world



The thick, malleable wires used for hexagonal mesh, along with the twisted interlocking of the strands, yields a flexible product with redundancies.



Hexagonal mesh can be used for slope retention systems where the forces are not high.



Example of a drape mesh system using hexagonal mesh.

Product Specifications

Mesh	Type	hexagonal
	Size	60x80/80x100 mm
Wire	Diameter	2.5 - 3.05 mm
	Tensile Strength	400 - 550 N/mm ²
	Elongation	min. 10%
	Galvanization (Zn/ZnAl)	min. 255 g/m ²
Roll	Weight	~ 1.75 kg/m ²
	Width	3.0 m
	Length	25 m

Other wire diameters and mesh sizes available upon request



The light weight, long rolls make them ideal for covering large areas of slopes that are affected by unraveling and other mass wasting processes.

Rectangular Netting - a multitude of mesh

There is a large variety of rectangular netting available that suits many low to moderate strength applications.

Rectangular netting is used for both draped and anchored mesh applications. Unlike hexagonal mesh, it has no roll “memory” and can more easily adapt to changes in topography. This allows the mesh to maximize the contact surface area which dictates the active portion of the mesh system. Like all mesh products from Trumer Schutzbauten, it is available with the highest class of galvanization according to EN 10223-6.

Its low cost, ease of handling and large variety of available products makes it a staple for low-strength applications.



Rectangular netting lays flat against the slope and can conform to changes in topography better than hexagonal mesh.

Anchors for slope retention systems can be drilled either prior to mesh installation or afterwards. This allows changes to be made during construction to increase the efficiency of the stabilization.



Slope stabilization using a combination of rectangular mesh and anchors.



An example of a slope mesh system designed to protect a highway from falling ice that builds up on the slopes during the winter.

Product Specifications

Mesh	Tensile Strength	Lengthwise	23 - 50 kN/m
		Crosswise	30 - 55 kN/m
	Type		rectangular
	Size		50 - 60 mm
Wire	Diameter		2.5 - 3.8 mm
	Tensile Strength		400 - 550 N/mm ²
	Galvanization (ZnAl)		245 - 275 g/m ²
Roll	Weight		1.6 - 3.85 kg/m ²
	Width		2.0 m - 3.0 m
	Length		12.5 m - 30 m

High Performance Netting - *reliable, effective*

Strength, durability and flexibility are its dominant characteristics and are the key elements for a reliable slope retention system.



Due to its flexible nature, High Performance Netting can easily be fit to even the most challenging topography.

High Performance Netting by Trumer Schutzbauten is the only wire mesh product on the market for slope retention systems that has 150 kN/m tensile strengths of the mesh in both horizontal and vertical directions and a tight mesh opening. In addition, it was tested with higher values during unsupported pull-through tests (78 kN) when compared to the next most similar product on the market. Combined with its 4.6 mm diameter wire, small mesh size (50 mm x 50 mm) and highest galvanization coating available (Class A according to EN 10244-2), the mesh is a very durable and efficient alternative to similar high-tensile wire mesh products that have lower tensile strengths of the system, lower puncture resistance, lower galvanization and made from thinner diameter wire.



Tensile strength test.



Puncture strength test under "open-air" conditions.



Puncture strength test under "supported" conditions.

Product Specifications

Mesh	Tensile Strength	Lengthwise	150 kN/m
		Crosswise	150 kN/m
	Puncture Strength*		78 kN
	Puncture Strength**		327 kN
	Type		rectangular
Wire	Size		50 mm x 50 mm
	Diameter		4.6 mm
	Tensile Strength		620 - 770 N/mm ²
Roll	Galvanization (ZnAl)		min. 280 g/m ²
	Weight		~ 5.6 kg/m ²
	Width		1.5 m - 3.5 m
Length		6 m - 15 m	

**"Open-air" test

** "Supported", deformable substrate test

High Performance Netting can be mounted in either the horizontal or vertical orientation due to its equal strengths in both directions.



Low-energy rockfall catchment fences by Trumer Schutzbauten also use the High Performance Netting, which has been tested for impacts up to 167 kJ (i.e. 545 kg traveling at 89 km/h).



HPN + - *improved strength and lower weight*

An even stronger rectangular netting that has a lower unit weight than its predecessor.

High Performance Netting Plus (HPN+) has evolved to be an even stronger product. A higher tensile wire is used that still gives it the desirable malleable characteristics but which yields a higher strength product. Puncture strength has increased to 102 kN when tested in open-air, 150 kN as per the ASTM A975 test and 392 kN with the supported puncture test. With a mesh opening of 60 x 60 mm, it is still small enough to work well with fine grained material. The wire maintains its highest class of zinc-aluminium galvanization (Class A according to EN 10244-2) for optimum corrosion protection.

There is no other single wire woven product on the market that has this level of strength, flexibility and corrosion protection.



HPN+ is highly flexible which allows it to maximize slope surface contact.



Slope stabilization works and low-energy rockfall fence using HPN+.

Product Specifications

Mesh	Tensile Strength	Lengthwise	150 kN/m
		Crosswise	150 kN/m
	Puncture Strength*		102 kN
	Puncture Strength**		392 kN
	Type		rectangular
	Size		60 mm x 60 mm
Wire	Diameter		4.6 mm
	Tensile Strength		840 - 990 N/mm ²
	Galvanization (ZnAl)		min. 280 g/m ²
Roll	Weight		~ 5.6 kg/m ²
	Width		1.5 m - 3.5 m
	Length		6 m - 15 m

*"Open-air" test

** "Supported", deformable substrate test



The use of HPN+ in combination with organic mats greatly reduces the lost of fine material and encourages revegetation.

Cable Nets - *traditional high-strength*

Constructed from steel wire ropes, these panels offer higher strengths than woven single wire products.

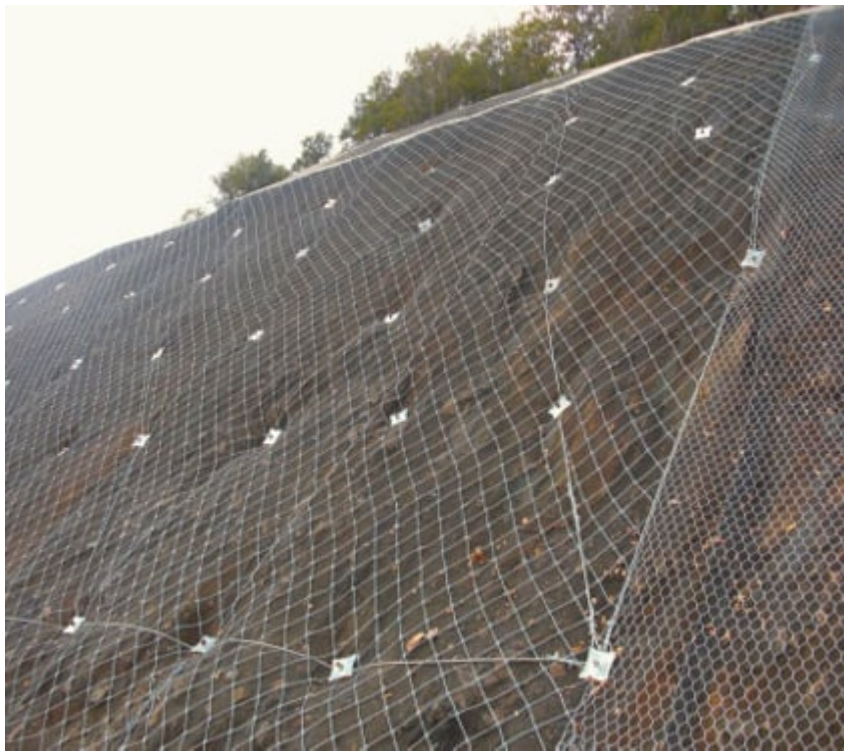
Cable nets have been used for stabilizing slopes and in high-energy rockfall catchment fences for decades. They have proven themselves as being robust and enduring. Panels consist of a single wire rope that is woven into a mesh and has cross clips that secure the mesh form.



The unique Isostop clip provides a strong connection between crossing cables.

For the first time, original cable nets from Pfeifer Isofer are available in North America using stronger clips and the highest quality workmanship.

Isofix nets come in a variety of mesh sizes with several steel wire rope diameters so that panels can be suited to the clients needs. Standard nets consist of either a 200 x 200 mm mesh with 6 mm wire ropes or 300 x 300 mm mesh with 8 mm wire ropes. A fine mesh layer, such as rectangular or hexagonal mesh, can be added if required.



The Isofix system is used for both soil and rock slope stabilization.

Product Specifications

			Isofix 6/200	Isofix 8/200	Isofix 9/200	Isofix 6/300	Isofix 8/300	Isofix 9/300
Mesh	Tensile Strength	Net	115 kN/m	204 kN/m	288 kN/m	77 kN/m	136 kN/m	192 kN/m
		Strand	23 kN	41 kN	52 kN	23 kN	41 kN	52 kN
	Type		rectangular	rectangular	rectangular	rectangular	rectangular	rectangular
	Size		200 mm x 200 mm	200 mm x 200 mm	200 mm x 200 mm	300 mm x 300 mm	300 mm x 300 mm	300 mm x 300 mm
Rope	Diameter		6 mm	8 mm	9 mm	6 mm	8 mm	9 mm
	Tensile Strength		1770 N/mm ²	1770 N/mm ²	1770 N/mm ²	1770 N/mm ²	1770 N/mm ²	1770 N/mm ²
Panel	Weight		~ 2.8 kg/m ²	~ 3.0 kg/m ²	~ 4.5 kg/m ²	~ 2.6 kg/m ²	~ 2.8 kg/m ²	~ 3.0 kg/m ²
	Width		made to order	made to order	made to order	made to order	made to order	made to order
	Length		made to order	made to order	made to order	made to order	made to order	made to order

Omega-Net - *where nothing else will do*

Derived from rockfall and avalanche technology, this is the ultimate solution to high-strength needs where flexibility is key.



The Omega-Net can be made with a variety of mesh openings and wire diameters to best suit the strength requirements of the project.



Installation of Omega-Net for slope stabilization.

The Omega-Net by Trumer Schutzbauten is the solution to higher strength applications. Various rope diameters are used to construct the nets, starting at 4.5 mm up to 10.5 mm, with a minimum mesh size of 100 mm. The nets are extremely flexible and panel sizes can be suited to individual projects, making it ideal for highly irregular rock slopes.

The structure of the Omega-Net is unique, consisting of pre-formed waves and interwoven strands of high-strength rope. The strands themselves are thick galvanized spiral ropes that - although meet at intersecting points - are not connected to each other, since no clamps are used.



The Omega-Net is a unique product that can easily fold together for transportation and installation.



Heavy rock stabilization using Omega-Net.

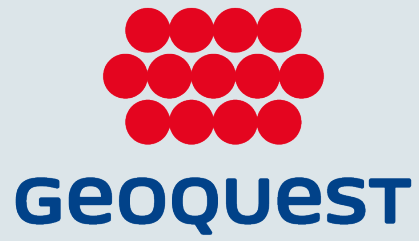
The Omega-Net is not only used for slope stabilisation but is also the primary interception structure for all of Trumer Schutzbauten's high-energy rockfall catchment fences, debris flow and avalanche protection structures.

Product Specifications

Omega-Net 7.5/350 Omega-Net 7.5/250 Omega-Net 9.0/185

Mesh	Tensile Strength	Net	183 kN/m	218 kN/m	465 kN/m
		Strand	55 kN	55 kN	76 kN
	Type		semi-circular	semi-circular	semi-circular
	Size		250 mm x 350 mm	250 mm x 250 mm	185 mm x 185 mm
Rope	Diameter		7.5 mm	7.5 mm	9.0 mm
	Tensile Strength		1750 N/mm ²	1750 N/mm ²	1750 N/mm ²
Panel	Weight		~ 3.05 kg/m ²	~ 3.3 kg/m ²	~ 6.0 kg/m ²
	Width		made to order	made to order	made to order
	Length		made to order	made to order	made to order

Note: specifications are for the 7.5 and 9.0 mm diameter nets. Please inquire for specifications of other nets.



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