

**TECCO®
Slope Stabilization**



Soil nailing and anchoring in a temporary shoring application

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ABSTRACT

One popular approach to achieving slope stabilization is covering the slope with flexible steel mesh facing. In North America these systems are typically anchored only at the top, allowing the mesh material to drape freely down the slope. The weight and friction of the mesh material provides stability, and allows controlled downward movement of material. More advanced installations provide deeper stabilization by holding the mesh to the surface with anchors or soil nails throughout. These designs are largely dependent on the ability of the system to transfer forces from the facing material to the anchor points. The low tensile strength of conventional wire mesh has led to the use of steel wire rope nets, but these nets tend to be relatively expensive.

These limitations have been overcome by the development of a cost-effective diagonal wire mesh manufactured from high tensile strength, highly corrosion-resistant wire. In extensive testing this mesh has demonstrated a strength approaching that of wire rope nets. Additional development has produced an anchor plate that optimizes force transfer from mesh to anchors. These factors allow the mesh to be pre-tensioned against the slope, which restricts deformations in critical surface sections and prevents movement along planes of weakness. Newly developed dimensioning models yield an engineered design of these systems, including anchor design. Numerous such systems have been installed throughout Europe and the U.S. A review of material properties and system performance will be presented in addition to a temporary shoring application.

INTRODUCTION

Anywhere a highway, railroad, or other infrastructure encroaches upon a slope, instability is bound to be a significant and recurring problem. Limited right of way frequently mandates the creation of over-steepened or truncated slopes. Other contributing factors can include groundwater conditions, the structural geology of the slope, or environmental factors such as heavy rainfall or erosion. These factors lead to two main types of instability: surficial degradation of the slope, and deeper instability along discontinuities.

Another application is temporary shoring for the installation of the foundations walls required for buildings under construction. Typically these temporary shoring walls or high-angle slopes are shotcreted to maintain their rigidity and prevent them from collapsing during the building's construction. After the construction is completed, the area between the walls and buildings are back-filled with soil.

Before selecting what type of mitigation is most appropriate for a particular slope, it is necessary to distinguish between surficial problems and deeper instability. Surface instability is characterized by material moving down the slope under the influence of gravity. Depending upon the site conditions, this material can include soil, mud and debris, or rocks and boulders. Deeper instability consists of the movement of a mass of material along planes of weakness.

A wide variety of mitigation measures are available to address stability concerns. Surficial problems can be addressed by use of a slope matting material (jute mesh, wire mesh, wire rope nets, etc.), shotcrete facing, catchment barriers, re-vegetation of the slope, and other methods. Deeper instability typically necessitates more extensive mitigation measures such as pattern anchoring both with and without a facing material (meshes, shotcrete, concrete panels, etc.), retaining walls, or excavation of the unstable material.

HIGH-TENSILE STRENGTH WIRE MESH AS SLOPE PROTECTION

The use of wire mesh and wire rope nets is an effective and widely accepted method of providing protection to the surface of slopes. These materials are typically draped freely on a slope in order to control downward movement of material. To provide protection against deeper instabilities, these flexible materials must be pinned throughout the slope with a pattern of anchors. Until recently, the wire meshes used in these types of applications have been manufactured from wire with a tensile strength of approximately 72 ksi. These relatively low-strength meshes do not have the high tensile strength that is required to retain an unstable slope and they ultimately require an anchor spacing that does not prove to be economical. Wire rope nets provide the strength necessary to maintain cost-effective anchor spacing, but they are comparatively expensive and require anchor points to be installed in specific locations.

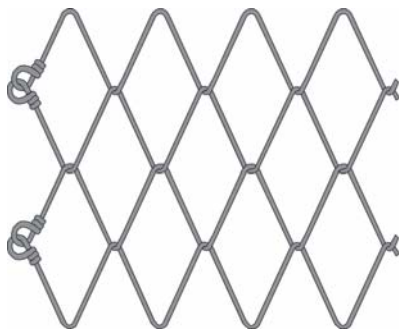


Figure 1: TECCO® Mesh

Wire Strength: 256 ksi (1770 N/mm²)
Wire diameter: 0.125 in (3 mm)

Corrosion protection: Supercoating
 (95% Zn / 5% Al)

Coating deposit: 0.41 oz/ft² min.
 (125g/m²)

Mesh opening: 3.3 in (83 mm) x 5.6 in
 (143 mm)

Mesh height: 0.43 in (11 mm)
Mesh strength: 10.2 kips/ft (150 kN/m)

THE TECCO® MESH SYSTEM—COMPONENTS

High tensile strength wire mesh

The mesh is produced in rolls measuring 11.5 ft (3.5 m) wide by 98.4 ft (30 m) long. The gentle deflection of the wire created by the bending process used to form the individual meshes results in a three-dimensionality in the mesh which improves the connection to the subsoil and aids in re-vegetation of the slope. The 10.2 kips/ft (150 kN/m) longitudinal strength of the TECCO® mesh represents a significant improvement over the 3.4 kips/ft (50 kN/m) strength of conventional meshes made with comparable mesh opening size and wire diameter.

Spike plates

To insure optimal transfer of forces from the mesh to the anchors, a special spike plate has been developed. These plates are placed over the anchor heads and tightened in order to pre-tension the mesh onto the slope. The plates are galvanized and have dimensions of 13.0 in x 7.5 in x 0.4 in (330 mm x 190 mm x 10 mm).

Figure 2: Spike plate



Compression claws

In order to take full advantage of the high tensile strength of the mesh, a special fastener is required to connect the individual mesh panels together. These claws are hot dip galvanized and consist of 0.25 in (6 mm) thick steel spiral.



Figure 3: Compression claws

Anchors

The main anchors of the system are installed in a grid typically ranging from 6.6 to 13.1 ft (2.0 m to 4.0 m) horizontal and vertical spacing. Actual spacing depends upon the results of site analysis and modeling. Anchors consist of commercially available steel bars ranging from 1.0 to 1.25 in (25 to 32 mm). Self-drilling grout injection anchors are also permitted. Additional anchors may also be used to provide added support at boundaries and in low points and hollows.

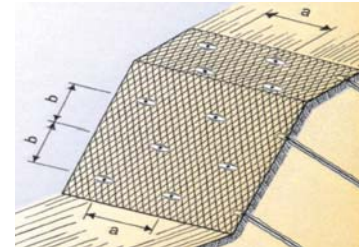


Figure 4: Anchors

SYSTEM DIMENSIONING

The RUVOLUM® dimensioning concept has been developed specifically for these types of systems. Using the material properties of the mesh along with the characteristics of a given slope as input, this model determines the optimum anchor spacing and dimensioning as well as the optimum mesh tensioning required to provide stability to the slope.

The dimensioning concept consists of two parts:

- Investigation of superficial instabilities parallel to the slope (Fig. 5)
- Investigation of local instabilities between the nails (Fig. 6)

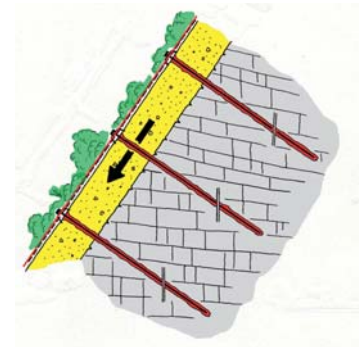


Figure 5: Slope-Parallel Stability

SYSTEM CONCEPT

The anchors and mesh act together as a system to provide stability to the slope, preventing deformations in the top layers and restricting movement along planes of weakness. As a result of the high strength of the mesh, it is possible to pre-tension the system against the slope. This pre-tensioning enables the mesh to provide active pressure against the slope, preventing break-outs between the nails.



Figure 6: Local Stability

Compared to other alternatives (particularly hard facings such as shotcrete or large retaining structures), this system offers the following advantages:

- Very effective
- More economically feasible
- Allows greening of the slope – resulting in a natural, aesthetically pleasing appearance
- Very long useful life (components have up to 100 years design life)

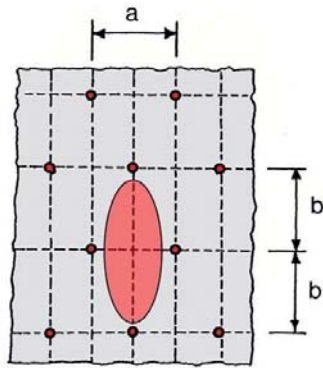


Figure 7: Anchor grid



Figure 8: Mesh connection with compression claws

SYSTEM INSTALLATION

The slope is first prepared by cleaning loose debris, leveling as much as possible, and shaping as needed.

The anchors are then installed in a defined grid (see Fig. 7). The mesh does not require the anchors to be placed in specific locations so it is possible to adjust anchor locations (while staying within the design spacing) to compensate for irregularities in the terrain. Additional, short anchors may be installed between the grid anchors to insure a tight fit of the mesh against the slope. This also helps the mesh conform to the terrain, limiting its visibility.

After the anchors have been installed, small depressions are created around each anchor in order to accommodate the installation of the spike plates. The mesh is then laid on the slope, and cut to size as needed. Adjacent panels of mesh are connected with the compression claws (see Fig. 8). The mesh is then pre-tensioned with a defined force against the anchors by tightening the spike plates down into the depressions (see Fig. 9).

This pre-tensioning firmly presses the mesh against the slope, preventing deformations, slippage, and pop-outs of the slope material.

Depending upon site conditions, it may be advantageous to lay the mesh on the slope prior to anchor installation. After the mesh is installed and tensioned, the slope is ready for hydro-seeding or other re-vegetation measures.

Figure 9: Pre-tensioning



CASE HISTORY – GEORGIA TECH NANOTECHNOLOGY RESEARCH FACILITY

In the summer of 2006, Extreme Technology’s, Inc. won the contract to install approximately 5,000 sq. ft. of a temporary shoring system along two roadways for the installation of the foundations walls for a new 4 story Nanotechnology Research Facility in the heart of the Georgia Tech Campus. The site was in an area of the campus that originally housed their nuclear reactor and research facility which was removed to make room for the new facility. The utilities in this area were highly saturated throughout the site and spanned the range from fiber optics to high-pressure steam lines to your usual electric, water, gas and phone lines. Given the special and critical issues of the nuclear and radioactive materials removal, the project was approximately 3 months behind schedule. At this time the General Contractor realized that the shoring of the roadside property lines were not in the plans; and was not even in the scope of work. Time had become critical in the site work portion of the project.

Extreme Technology’s, Inc. (ETI) was contacted and asked to develop a plan for the temporary shoring and to help make-up some of the project’s lost time by designing, installing and completing the scope of work in under 45 calendar days. Previously ETI had installed Geoblogg’s TECCO® mesh on other projects where low headroom was an issue so they were already familiar with a product that could possibly eliminate the need for Shotcrete for shoring needs.



Figure 10: Water service line embedded in the slope.

Figure 11: Soil evacuation



Figure 12: Hole drilling for soil nails



ETI first evacuated six (6) feet of material in front of the proposed wall that was only four (4) feet from the active roadway and utilities (See Figure 11). Holes were then drilled for soil nails on approximately five (5) foot centers (See Figure 12). This process is very similar to the steps necessary to install other slope face solutions. While this was on-going, other ETI personnel were rolling out the TECCO® mesh and cutting it to the length of the finished wall. After each TECCO® mesh panel was sized, it was laid atop a length of black geo-fabric that was then cut to the same size (see Figure 13). Each mesh/geo-fabric panel was then transported to the top of the proposed wall and then laid side by side with the necessary overlap for “stitching” together (See Figure 12).

Once the first two rows of nails were installed, each mesh/geo-fabric panel was lowered and installed on this 'short' wall section; all the while being careful to ensure each roll did not become unraveled and the proper two (2) diamond overlap was present for correct installation. As more soil was evacuated and the wall became taller, more nails were put in and each mesh/geo-fabric panel unrolled to cover the new wall length before the spike plates were installed (See Figure 14). This methodology was used until the entire wall length was evacuated and secured with the TECCO® System. Once all the panels were extended their entire length, the compression claws were installed to "stitch" the mesh into one contiguous panel.

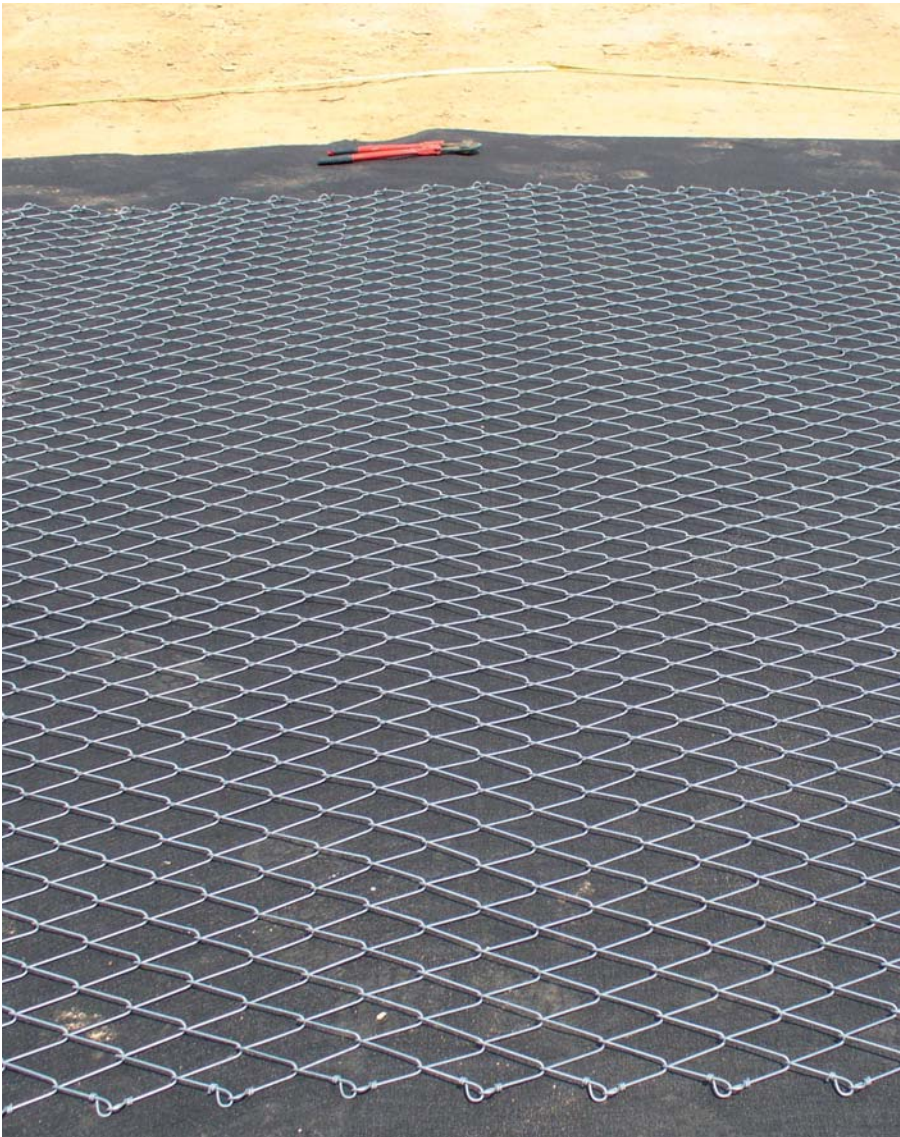


Fig. 13: Sizing the mesh/geo-fabric panels

This project was completed under the 45 days deadline and well under the budget of typical shoring projects. ETI found the TECCO® mesh is a great replacement for Shotcrete as there is no cure time and once the spike plates were installed that area could be excavated further. For most of the project, ETI could work simultaneously with the grading contractor to achieve their independent goals in a timely manner; significantly speeding the construction process. The only downside was once the temporary shoring wall was constructed, the wall was completely buried – never to be seen again.

CONCLUSION

Anchored slope stabilization systems using high strength steel wire mesh as a facing material are an effective and economical means of protecting unstable slopes and providing temporary shoring. These systems have demonstrated effectiveness in both rock and soil slopes. The high strength allows an economical spacing of anchor points; and the open mesh structure eliminates the need for drainage, and facilitates greening of the slope. As a result, this mesh offers the advantages of both rigid constructions and traditional meshes. This concept is only just beginning to gain acceptance in North America, but it has been successfully applied in Europe for several years.

Figure 14: Fabricating the temporary shoring wall



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Geobrugg protects people and infrastructures from the forces of nature

It is the task of our engineers and partners to analyze the problem together with you in detail and then, together with local consultants, to present solutions. Painstaking planning is not the only thing you can expect from us, however; since we have our own production plants on three continents, we can offer not only short delivery paths and times, but also optimal local customer service. With a view towards a trouble-free execution, we deliver preassembled and clearly identified system components right to the construction site. There we provide support, if desired, including technical support – from installation right on up until acceptance of the structure.

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