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CASE HISTORY

Erosion Control and vegetation of artificial slope trenches along
S.P. Route 44 at Lentate, Milan and connecting road to S.S. 35 "Dei Giovi", Italy

PRODUCT	TENAX TENWEB 3/300 geocells TENAX LBO 201 SAMP bi-oriented geogrids TENAX MULTIMAT 100 three-dimensional geomat
LOCATION	Lentate sul Seveso, Milan, ITALY, S.P. Route 44 at Lentate (Milan) and connecting road to S.S. 35 "Dei Giovi"
OWNER	Autostrada Serravalle S.p.A. - Milano - Ponte Chiasso
PROJECT	Dott. Ing. R. Formichi (Studio 3 Ingegneri Associati - MI)
CONTRACTOR	Verardi e C. S.r.L. (AL) and Peverelli S.r.L. (CO)

Overview of the S.P. 44 Road, few months after the end of construction

General view of the new S.P. 44 extension road, few months after project completion

PROBLEM

To reduce the environmental impact, a new highway was built by excavating it below the existing ground elevation. The cut slopes did not require any reinforcement; their height was usually below 6 m with an inclination varying between 40 and 43 degrees, with the exception of the initial sections that were 6 to 10 meters high. Chemical tests showed the local soil was infertile along the surface sections of the cut slopes, the organic content was also low or even totally lacking with a cationic exchange indicator varying from section to section. Long-term slope stability studies gave negative results, however short-term stability studies gave good safety factors due to the cohesiveness of the soil.
However, erosive forces on the surface layer undermined this stability and loss of soil cohesion. In the long term, the slope stability was going to be compromised starting from the cut face of the upper slope where run-off, superficial erosion and small soil sliding were more likely to happen. It was necessary to minimise the erosive effect of flowing water and enhance the shear resistance of the topsoil. It was also necessary to apply a suitable grass vegetation layer, hydro-seeding the slope with a mixture of seeds, organic material and fertilizers.
In addition, eroded soil and pebbles were sliding down the cut slope to the road side. In order to find the best possible solutions for the erosion control, consolidation and vegetation of the slopes on the S.P. 44 at Lentate (Milan), the consultant was commissioned to give a geologic and agronomic solution. Geological and geotechnical investigations, geo-morphologic surveys and chemical testing applied to soil samples taken from different sections, determined 5 different typical section types. These were grouped according to height and inclination of the slope, to litostratigraphic profiles, to water saturation persistence, to the main superficial erosion processes and to the fill soil characteristics both behind and surrounding the supporting concrete structures.

Detail of the extensive surface erosion

Slopes before anti-erosion treatment

Roadbed and slope profile cutting and preparation

SOLUTION

A drainage trench (1 x 0,50 m) was dug at the top of the slope to divert any surface water run-off from the cultivated fields adjacent to the site. The ground was then cleaned from debris, tree trunks, large stones and the slope smoothed and levelled. Below are the five different Section Types and their related technical solution is presented.

SECTION TYPE 1

This section includes areas close to the inlet of artificial galleries, wing walls and bridge supports.
The slopes close to the concrete structures were made up of imported fill material: loose granular soil with cobbles or fines. The high inclination and the low cohesion of the fill material indicated small landslips and rapid surface erosion with heavy soil transportation to the base of the slope could occur. Consolidation of this section was achieved using TENAX TENWEB 3/200 geocells (cell height 75 mm; cell inner diameter 200 mm), a honeycomb three-dimensional structure which provides an effective confinement for the imported vegetative soil placed in each single cell and thus preventing erosion by soil confinement. This product is made of polyethylene using a continuous extrusion process, it has a monolithic structure and is very resistant to tensile forces. TENAX TENWEB 3/200 was positioned opening the cells horizontally on the slope. It was then fixed to the top extending the geocells two metres beyond the crest and the cells secured with 1 m long anchors at the rate of one per square metre.
The cells were then filled with organic topsoil and the area was seeded with a mixture of grasses and deep rooting plants. To further decrease erosion, local shrubs (at least 0,6-1,0 m high) were planted within the cells at a rate of 1 shrub every 4 m2.

TENAX TENWEB geocells in place

Zoom over the drainage trench on top of the slopes

SECTION TYPE 2

This section includes slopes 3 to 6 m high with an inclination below 40°, composed of soil deposits of rounded gravel (maximum size 100-120 mm) and sand. This section type included areas at the beginning of the road on the Milano-Como side, and some fill soil areas located by the concrete structures as the previous section type, but less steep. All existing weeds, since they couldn't guarantee soil consolidation, were cut and after levelling the slope were replaced with a seed mixture of grasses and deep rooting plants. A geojute anti-erosion biomesh (mesh 20 x 20 mm; fixed with 2 pegs/m2) was installed to help prevent large cobbles sliding to the road and to promote healthy grass growth. The jute mesh was anchored to the soil extending it for 1 m over the crest.

"Light" anti- erosion protection using a bio-degradable jute net

SECTION TYPE 3

This section includes slopes less than 6 m high and with an inclination between 40° and 43°, with limited portions between 6 to 8 m high. The soil is composed of a deposit of rounded gravel with a superficial clay stratum in the first 2-3 m. In some stretches, there were lenses of very well compacted soil at the bottom of the slope. On the existing cut slope, it was necessary to level the slope and remove unstable cobbles. Slope reinforcement and stone containment was achieved using TENAX LBO 201 SAMP geogrid. This is a polypropylene geogrid especially designed for soil stabilization and manufactured from a unique process of extrusion and biaxial orientation to enhance its tensile properties. The geogrid was fixed with 400 mm metal pegs; 1 peg/m2 and covered with 25 mm of topsoil. The area was hydro-seeded with a mixture of grasses and deep rooting plants, inserting also local shrubs. Where possible, the same procedure was used also for extending the geogrid 2 m behind the crest.

Installation of TENAX LBO 201 SAMP geogrids for cobbles containment

Details of the vegetated TENAX LBO 201 SAMP geogrids

SECTION TYPE 4

Section type 4 includes slopes 7 to 10 m high and with a maximum inclination up to 45°. On the upper part, red compacted scaly clay layers could be found in horizontal lenses. Along these layers capillary water could occur diminishing stability and leading eventually to superficial detachment and face sloughing up to 200 mm deep. The lower portion of the slope was mainly composed of gravel and pebbles with a sand matrix. Soil was consolidated using TENAX MULTIMAT 100.

These are polypropylene erosion control geomats, designed for protection and grass growth on slopes subject to surface erosion. TENAX MULTIMAT 100 are three dimensional mats composed of extruded and bi-oriented polypropylene grids, laid one upon each another and tied up by means of a black polypropylene yarn.
The three dimensional structure of the mat shelters the layer of top soil and anchors the growing roots of the planted seeds, obtaining a reinforced block very resistant to rain run off and soil movement. The area was hydro seeded with a water mixture of grasses and deep-rooted plants (30-40 g/m2), emulsion, organic fertilizers (100 g/m2) and organic soil (peat, compost and cellulose 30% weight). To further decrease erosion, local shrubs were planted.

"Heavy" anti- erosion protection using TENAX MULTIMAT 100 geomat

SECTION TYPE 5

This section type includes slopes more than 8 m of height with inclination in excess of 45°. A clay layer, 4 m thick, was present with clear signs of superficial erosion due to persistent water saturation.
Along these layers, capillary water could rise diminishing stability and leading eventually to superficial detachment and face sloughing up to 200 mm deep.
Two techniques were used to consolidate the slope: TENAX MULTIMAT 100, as described in the previous Section Type 4, and the construction of a concrete prefabricated modular wall back filled with an appropriate granular free-draining soil.

Slope consolidation using TENAX MULTIMAT 100 and prefabricated walls

CONCLUSIONS

The total surface amounted to 50.000 m2, with 22.000 m2 of TENAX MULTIMAT 100 geomat, 2.500 m2 of TENAX TENWEB 3/200 geocell and 25.000 m2 of TENAX LBO 201 SAMP geogrid. After many months since the works were completed, no surface erosion or landslip was visible. The overall road structure blended into the local environment, due to the presence of the local shrubs that had been planted. The special technique used to prevent surface erosion allowed for relatively lower costs and high environmental performances.