

SCASCOLI GORGE LANDSLIDES BOLOGNA, ITALY

EROSION PROTECTION - ROCKFALL MITIGATION

Product: 1000KJ (MEL) Dynamic Rockfall Catch Fence, HEA Panels, Steelgrid

Problem

The Scascoli Gorge, close to Bologna, Italy, lies between sandstone and marl walls, with heights of between 40m and 80m. The local geology and topography exhibit numerous rockfall events. Evidence of this is the large Scascoli landslide, of approximately 20 million m³ moves 1-2 cm/year.

On the opposite side of the valley to the Scascoli landslide, a huge rockfall of approximately 30,000m³ occurred at Mammellone in March 2005. The landslide obstructed the River Savena in the valley below.

Following the rockfall, the River Savena eroded the toe of the large landslide and triggered a new faster landslide phenomenon of approximately 8,000 m³. After 15 days, the valley floor was devastated by erosion and rockfalls and hundreds of metres of road had been destroyed.

Therefore the problems in the valley consisted of;

- Instability of 10,000 m³ of rock on the left-hand slope
- Serious instability of the right-hand soil slope
- Hydraulic problems due to the presence of debris in the river bed
- Major erosion of the river
- Slow movements of the valley floor induced by the large landslide body

The problems would affect the safety of the site during the restoration phases, management of the road after completion of the works, service life of the works and their insertion into the environment.

Solution

It was decided to reprofile the slopes to solve the problem of the instability of the large rock masses. Debris was removed from the valley floor in conjunction with the slope reprofiling works, to resolve the hydraulic and erosion problems.

Due to the dangerous nature of the rock slope reprofiling activities, it was necessary to monitor the stability on the basis of numerical analyses. After completing the rock slope reprofiling activities, the residual risk of falling rock masses was mitigated by the installation of Steelgrid high tensile strength mesh and a 1000kJ rockfall catch fence.

Extensive soil nailing was carried out over a vast area for the

Client:

EMILIA ROMAGNA REGION

Main contractor:

EMERGENCY WORKS (VARIOUS CONTRACTORS)

Consultant:

ENSER S.R.L

Products used:

1000KJ CATCH FENCE, STEELGRID, HEA PANELS

Date of construction:

MARCH-NOVEMBER 2005



Before collapse of rock wall



After collapse of rock wall



Panoramic view of road just after collapse of rock wall

final profile of the soil slope using steel bars. Surface stabilisation between the soil nail heads was provided by double twist steel wire mesh and Maccaferri HEA Panels, used in conjunction with biodegradable erosion control blanket, Biomac to encourage regrowth of vegetation.

The roadway along the valley was reconstructed using Green Terramesh to provide a robust yet flexible structure, able to withstand the small continuous deformations by the large Scascoli landslide. The toe of the Green Terramesh reinforced soil slope, was protected from erosion by the River Savena, by means of rip-rap.

The retaining walls on the uphill side of the road, were constructed with gabions, taking into consideration the movements of the large landslide.

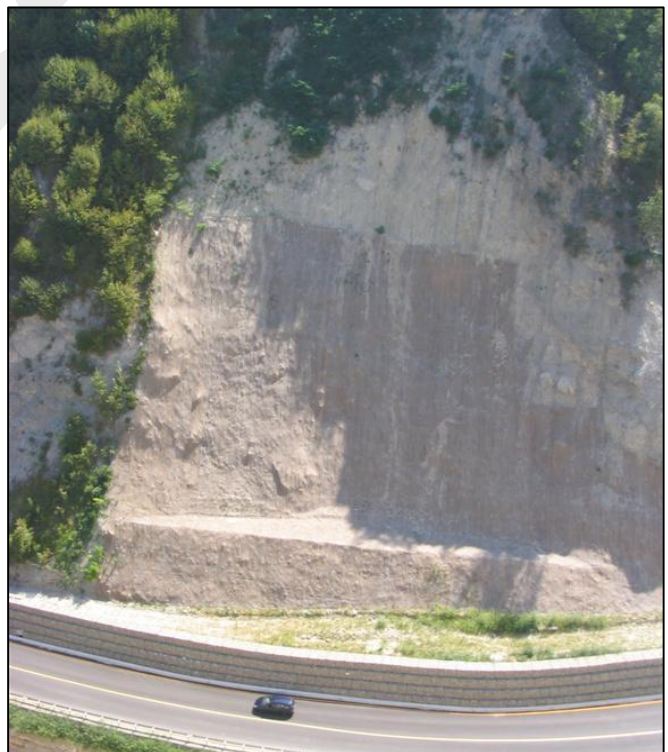
All the proposed solutions were selected to integrate within the environment of the Scascoli Gorge, which constitutes an area of high environmental value.



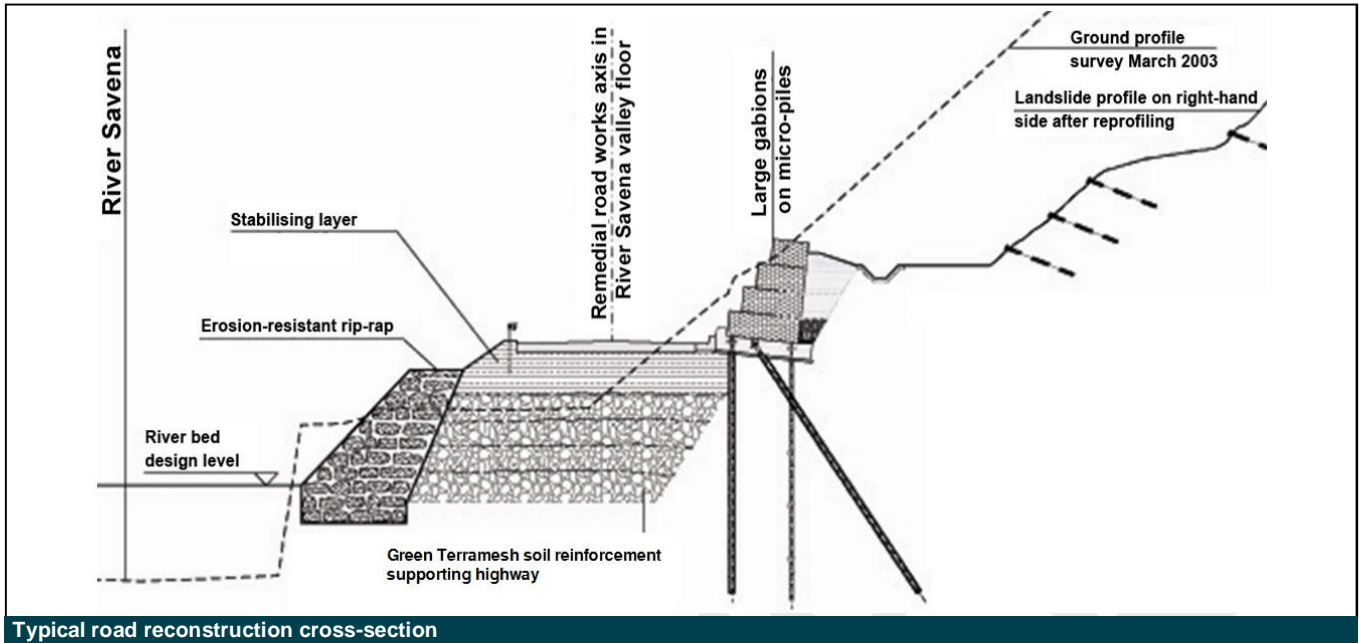
Close-up of road after collapse of rock wall



Panoramic view of the road 15 days after the rock fall with the soil landslide before remedial works.



Landslide on right hand side of River Savena after the remedial works



Typical road reconstruction cross-section

Works on the left-hand slope

The stability of the Mammellone 1 wall was improved by demolishing part of the rock mass. Following this reprofiling, potentially unstable parts of the rock wall remained and the risk of rockfall was addressed with the following works, selected to accommodate the specific problems (geological, access, function) found at each location:

- (a) At one end of the slope, a surface stabilisation layer was installed, to secure the rock masses which it had not been possible to remove;
- (b) At the opposite end of this slope, a Maccaferri 1000 kJ (MEL) rockfall catch fence was installed mid-way up the rock slope, to protect the road from falling rocks of less than 1 m³ in size.
- (c) The upper half of the rock slope was stabilised using high tensile strength Steelgrid mesh to control any falling rock masses and prevent rock debris falling towards the road.



Road construction using Green Terramesh

Works on the right-hand slope

The works on the debris flow/landslide on the right-hand slope of the gorge, included the removal of the unstable body and consolidation of the failure surfaces where there were outcrops of loose soil and weathered rock masses. Consolidation was achieved with lightweight soil nailing using 3m - 6m long, 430 N/mm² steel bars, installed at a frequency of 1 nail per 12 m² of surface area. Soil outcrops on the slope were stabilised by double twisted steel wire mesh, with a heavily galvanised Galmac coating for durability. The mesh was used in conjunction secondary steel cables and with Biomac biodegradable matting to prevent erosion due to surface water run-off and encourage the regrowth of vegetation. In areas where greater restraint was required, for example in the areas with weathered rock outcrops, high tensile steel cable HEA Panels, were installed.



Flexible gabion retaining wall at toe of landslide

Hydraulic remedial works and road reconstruction

Since the valley floor was very narrow, a single solution using Green Terramesh and gabions, provided both river remedial works and road reinstatement. This was functional from a hydraulic and roadway support perspective, yet are also environmentally compatible. In order to provide local stability of the toe of the large Scascoli landslide the gabion works were founded on micro-piles.

The main phases of the works were:

- (a) Remedial works for debris landslide on right-hand side;
- (b) Construction of gabions above road, with micro-pile foundations;
- (c) Construction of road embankment, consisting of suitably crushed material obtained from crushing the landslide debris from the Mammellone 1, compacted and reinforced with Maccaferri Green Terramesh soil reinforcement system;
- (d) Placing of erosion-resistant rip-rap on river bank, consisting of sandstone blocks squared off and saturated with lean concrete;
- (e) Completion of the upper part of road embankment with Green Terramesh;
- (f) Other completion works; black top and wearing course, profiling of river bed, etc.

The completed works satisfied the demands of appearance, geotechnical performance and structural functionality. The works to reinstate the road and river, however, can only be considered effective at a local level since they need to perform in harmony with the ongoing unstoppable movements of the large Scascoli landslide. The flexibility of the solutions was therefore important.

By providing specific systems appropriate to the risk and rockfall hazard encountered, Maccaferri was able to optimise the solutions, saving the client cost and time. Furthermore, by offering soil reinforcement, river training works and retaining structures, in addition to the rockfall protection solutions, Maccaferri was able to provide a seamless service to the clients on this project.



1000 kJ rockfall catch fence at mid-height on left-hand wall



Installation of anchors for soil nailing with double twist wire mesh and HEA panels

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