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The applications of geosynthetics and steel wire products in major Albanian roads

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Abstract. This paper presents an overview of projects carried out in Albania for the construction of new highways, where the use of steel products and geosynthetic materials has been successfully applied in reinforced soil structures, rockfall protection systems and basal reinforcement. The paper gives full details on the design criteria adopted for the use of reinforcements with different mechanical properties (i.e. strength and stiffness) for the construction of two important road infrastructures in the area:
- the Albania Motorway Project (AMP), from Rreshen to Kalimash across difficult mountainous terrain, where 30 walls were constructed by combining double twist steel wire mesh gabion facia with its tail extended as secondary reinforcement and high strength polyester geogrids as primary soil reinforcement, with a maximum height of 37 m.
- the Tirana-Elbasan Highway, which provides Albania with access to Pan European Corridor VIII; in this project the combination of steel wire mesh and geogrid reinforcements is used for the construction of several walls with a maximum height of 28 m.
In both projects, rockfall protection measures were incorporated on the slopes either to protect the new motorway or other existing infrastructures.

Keywords: Soil reinforcement, geogrid, basal reinforcement, rockfall protection

1 INTRODUCTION

Reinforced soil structures (RSS) and rockfall protection systems (RPS) are a key element in the design and maintenance of infrastructure networks.
RSS offer economic advantages over conventional retaining wall systems, which increase with the height of the wall. The cost of reinforcement constitutes an important part of the total cost and can be as great as about 30% of the cost of the wall, depending on the wall height, backfill type and design load conditions. This evidence has driven “Maccaferri” to develop innovative hybrid RSS made of a combination of steel wire mesh and geogrids, where the steel component provides a function as secondary reinforcement (modular ready-to-use facing units) and the geogrids provide the primary reinforcement functions, achieving the material a higher strength at moderately low cost with relatively simple installation requirement [1], [2]. In order to assure the required stability of the wire mesh facing units a minimum length of 3 m has to be assured, while the spacing between geogrids usually does not exceed the 2m distance to allow a wider distribution of the stabilizing forces given by the primary reinforcements into the structural embankment (Fig. 1)

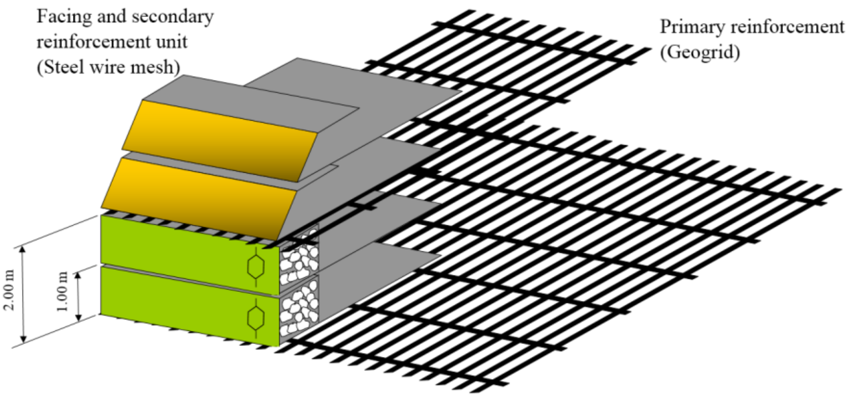

Figure 1. Typical layout of a hybrid RSS

2 APPLICATIONS IN ALBANIAN ROADS

2.1 Rreshen to Kalimash Motorway

The Rreshen to Kalimash motorway is the first to be built in Albania and it was the country’s largest infrastructure project: with more than 170 km in total length, it joins the port of Durres with Morine, close to the border with Kosovo. The route’s 61 km-long central section travels through some of the most isolated areas of the country with steep mountains and precipitous slopes to the valleys below. Here the dual carriageway motorway of 2x3.75 m lanes with a 2m emergency shoulder lane has been constructed by a 50/50 partnership between Bechtel and Enka. In order to traverse this central portion, Bechtel-Enka were required to construct no less than 4.4 km of bridges, 5.5 km of dual tunnels and 70 retaining walls totalling 6.4 km in length. Of the 70 retaining wall required, those up to 15 m in height were constructed in concrete, while the 30 walls over 15 m in height were designed as reinforced soil structures both because of the ready availability of fill generated by excavation works and also to reduce the visual impact of the construction.

One of these walls, constructed between the towns of Rreshen and Reps, is 37 m high and believed to be one of the tallest in its type in Europe. Maccaferri provided Bechtel-Enka with the design assistance, structural calculations and construction drawings for all the 30 reinforced soil structures. For 20 of the walls, Maccaferri also provided supervision and construction management through its local sub-contractor partner Albania Draht. The designs all follow the same basic specification for reinforcement and structural fill: the walls are designed as hybrid reinforced earth geogrid built in conjunction with a hard, stone-filled Terramesh System gabion facing wall (Nominal Break Load-NBL=50 kN/m, Long Term Design Strength-LTDS=35 kN/m). High strength Paralink 300 uniaxial polyester geogrid (Long Term Design Strength-NBL=300 kN/m, Long Term Design Strength-LTDS=191 kN/m) was used as primary reinforcement, sandwiched at 500 or 1000 mm vertical increments between layers of compacted structural fill. Ground conditions on the site varied from rock that was competent to frequently shattered and fractured: design soil parameters are shown in table 1. With more than 30 million m3 of material during construction, much of this was able to be reused as fill for the reinforced soil structures.

Table 1. Rreshen to Kalimash motorway: design soil parameters

Layer description	Unit weight	Friction angle	Cohesion
	kN/m3	°	kN/m2
Backfill	20.0	35.0	0.0
Foundation	25.8	46.0	40.0
Structural Fill	20.0	30.0	0.0

Construction works on the retaining walls began in June 2008, with walls built simultaneously and sequentially, employing up to 60 workers at any one time in crews of 10 to 12 people. For the tallest (37 m high, designated as WR6-7) wall construction began in mid-April 2009; as with the other walls, wall WR6-7 was designed with a 10:1 set back at each 1m high Terramesh course, creating an 84° back slope. Three intermediate horizontal berms were incorporated to give the wall a lighter visual aspect. Foundations are 1.5 m deep, while the vertical spacing of uniaxial polyester geogrid (Paralink 300) was set to 500 mm for the first 20 m, then at 1,000 m increments above (Fig. 2).

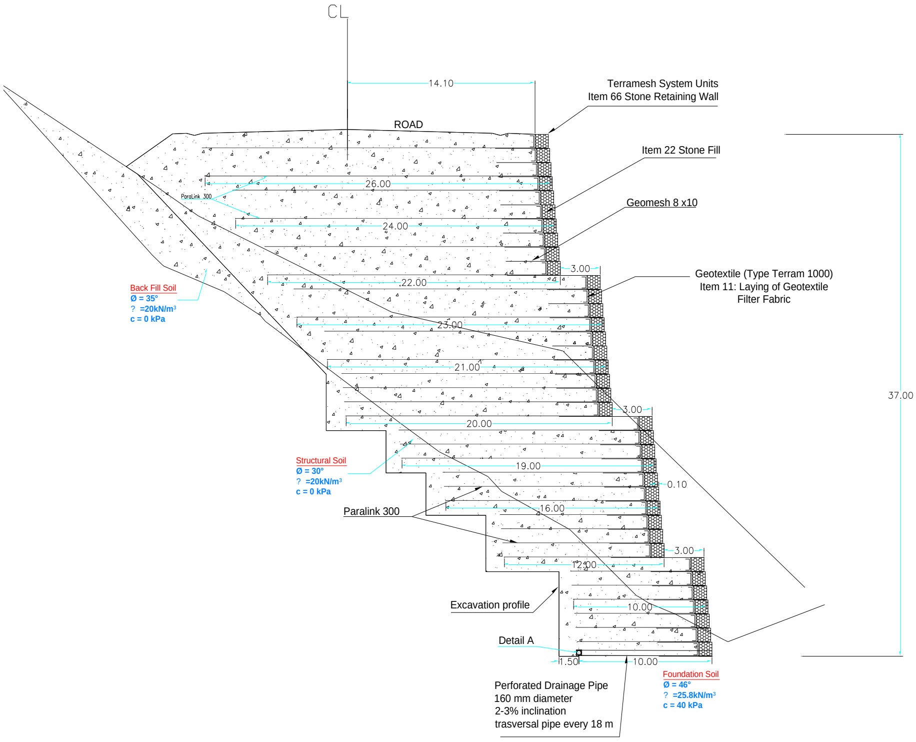

Figure 2. Cross-section of the 37m high WR6-7 wall

WR6-7 retains about 140,000 m3 of backfill, has a face area of 3,500 m2, a wall length of 200 m and 37 m in height: this makes WR6-7 one of the largest structure of this type in Europe. The wall was completed on schedule in mid-May. The design calculations were done in compliance with BS 8006-1: 1995 by using the MacStARS software, developed by "Maccaferri" for the analysis of hybrid reinforced soil structures [3]. Due to slope stability problems which affected the safety of the motorway with respect to rockfall, an upper retaining structure 30 m high made by a reinforced soil structure similar to the WR6-7 built above an anchored reinforced concrete was made in 2011 (Fig. 3).

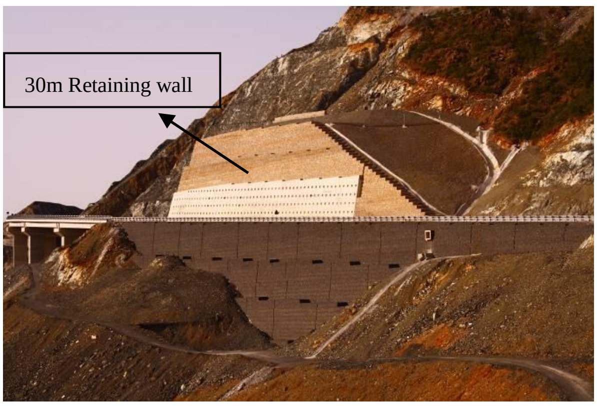

Figure 3. The WR6-7 wall with the upper 30 m high rockfall protection

On the slopes above the walls, rockfall protection, erosion control and re-vegetation measures were installed to protect the motorway below and to produce rapid establishment of stabilising, vegetative cover. For slope angles less than 40° at least 40,000 m2 of a reinforced geomat made by a three-dimensional polymer matrix extruded onto a double twist steel woven mesh (MacMat-R) were installed to produce rapid establishment of stabilising vegetative cover. In steeper slopes the protection was assured by passive or active solutions depending upon the location: double twist drapery system reinforced with steel cables (SteelGrid MO300) in conjunction with anchors and rock bolts; 500 kJ high resistance rockfall barrier (CTR 05-07-B) were installed as catch fences to dissipate the impact energy of falling boulders with system deformation (Fig. 4).

Figure 4. Rockfall protection systems: drapery and catch fences

2.2 Tirana to Elbasan Highway

The Tirana–Elbasan Highway is a four-lane highway in Albania. It connects the cities of Tirana and Elbasan in the shortest way possible and its total length is 26 kilometres. The highway is part of the planned A3 motorway of Albania and provide access to Pan European Corridor VIII. It is designed to take road traffic away from the mountains and to reduce journey time. The construction of highway started in 2012 and was divided in three sections. Two of them (section 2 and 3) have been already completed, but section 1 is under construction because of four big slides. Most of the highway was already built using Maccaferri solutions and products including 5 green terramesh walls, 3 terramesh system walls and slope protection. In section 1, there were two fill areas connected with one cut area. For this reason, were needed two huge embankments provided by soil reinforcment walls. These fill areas were located near to residential houses and a river. Considering these factors, the retaining wall should be structural and environmentally friendly at the same time. Two Green Terramesh back to back retaining walls were approached. These huge embankments will enable the length of the road to be reduced by 3 km. Maccaferri in cooperation with Copri-Aktor designed the embankment by using Macstars software and implementing Green Terramesh Light and geogrid MacGrid WG15. The retaining wall base measures 15 m and its height is 28 m. (Fig. 5)

Figure 5. Green Terramesh retaining wall at section 1

These soil reinforcement walls are connected with a U shape cut slope in the middle. The slopes were very huge and their global stability should be satisfied. Soil nailing was applied by using anchor bars RBS500/550 in combination with a geomat Macmat 19.1 approx. 100'000m2 to protect the slope against the erosion. (Fig.6). This flexible facing system was developed by "Maccaferri" using BIOS (Best Improvement of slope) software, a simplified calculation approach based on UNI 11437: 2012 standard.

Figure 5. Soil Nailing with flexible structural facing

In section 1 there are four big slides. Two of them have involved the support of "Maccaferri" in cooperation with "Copri Aktor". A big valley, where the highway passes through, is under continuously sliding and it affects not only the embankment of motorway but also the village above this slide. In the end of this valley is located a river which makes the situation worse.

One proposal was to fill the valley with soil and build a soil reinforcement wall in the toe of sliding plan increasing in this way the weight of valley and friction in failure surface and preventing the slide. The river bed alignment was moved near to the mountain and a 5m height retaining wall with Terramesh and Macgrid WG15 was built in the end of the valley to carry all the loads of soil filling and to protect the wall from the erosion of river. (Fig. 6)

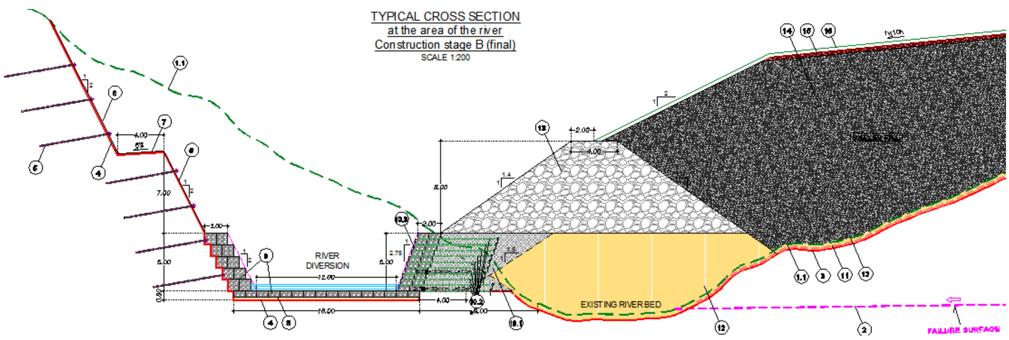

Figure 6. Proposed cross section at toe of sliding

The calculations were done with our internal software using Eurocode 7. This wall is under construction. See fig. 7.

Figure 7. Terramesh System at the toe of sliding plan

The other slide areas are being treated by building piles and anchors combined with Green Terramesh wall over them. This assures stability and cost-effective solution because the piles prevent the slide and the green terramesh wall helps to reach the design level of highway. See cross section at (Fig. 8)
In section 2, known as Krrabe tunnel, whose length is about 4.9 km “Maccaferri” proposed FS3N Steel fibers for shotcrete and Copri Aktor applied 600 tons fibers.

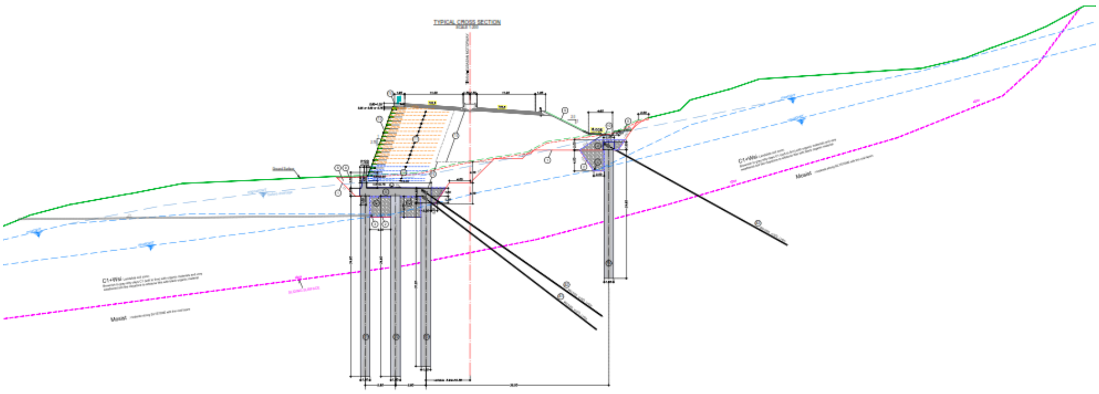

Figure 8. Cross section of Green Terramesh wall above concrete piles

In the end of tunnel or beginning of section 3 the client wanted to reach the design level in the entrance of the tunnel and decided to adopt a mixed RSS solution (wire mesh TMS+PET geogrids Macgrid WG8) as main type of retaining solution for this project. The max height of the wall was 20m and the base length 19m. Total facia area considering this wall is approximately 2’700 m2. (Fig. 9). In the upper slopes, steel grid MO300 with anchor bars RBS 500/550 were used as rockfall protection.

Figure 9. Terramesh System wall at the exit of Krrabe tunnel

3 CONCLUSIONS

Maccaferri has a long history of designing and providing reinforcement materials for mechanically stabilized earth structures, through the use of double twisted wire mesh units able to provide “stone facings” (Terramesh System) or vegetated external facing systems (Green Terramesh System).
For very tall MSE structures, Maccaferri’s state of practice, internationally, is to combine Terramesh System units and Green Terramesh units with geogrids, considering in this case the geogrids as “primary reinforcement” and the Terramesh units as a secondary reinforcement, mainly considered as “facing units”. In these “hybrid” structures the primary reinforcement is used to provide the tensile forces required to ensure global stability with the desired Factor of Safety; while the Terramesh units, which are produced with a “tail” of double twisted wire mesh as a secondary reinforcement, provide the local stability at the face, ensuring that no local mechanism of direct sliding, pullout or rotational failure can occur. Very tall hybrid structures have been built all over the world with this approach and this paper has shown some application of this solution in Albania roads such as the Rreshen-Kalimash and Tirana- Elbasan Highways, where many geotechnical problems and constraints have been present. These products have provided good experience not only from the stability, durability, cost-effective points of view but also in terms of environmentally-friendly solutions.

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