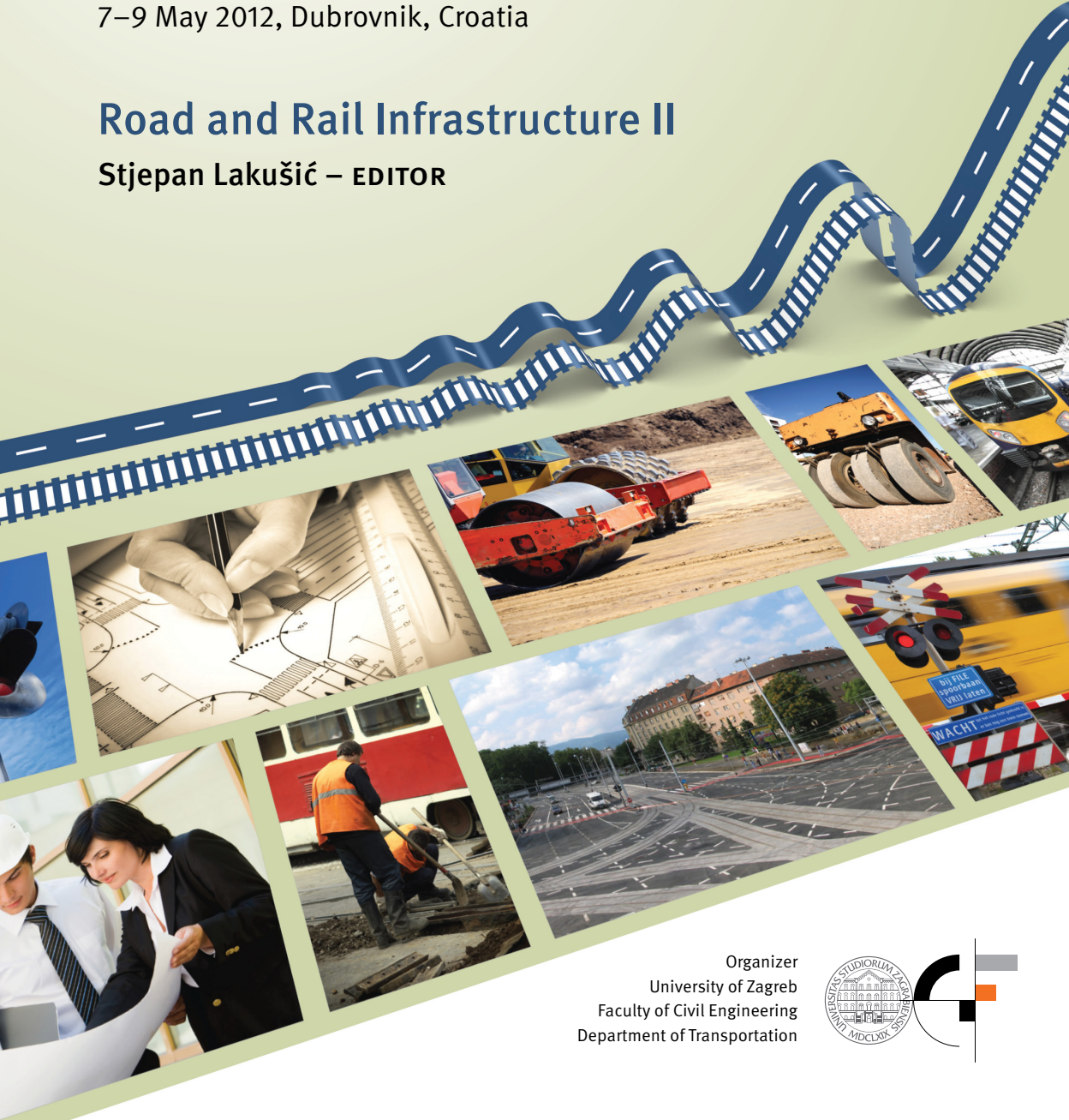


CETRA²⁰¹²

2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



Organizer
University of Zagreb
Faculty of Civil Engineering
Department of Transportation



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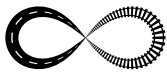
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LARGE EMBANKMENT NEAR SUHAREKË ON THE KOSOVO MOTORWAY

Verica Gjetvaj, Ljerka Bušelić
Institut IGH, Croatia

Abstract

Exploratory works in cuttings of Prizren – Suharekë section (Section 3) of Morinë–Merdare Motorway showed that the properties of material do not fulfill the required criteria without additional treatment, and that deep excavations in such materials will cause slope instabilities. For this reason the adopted vertical route alignment resulted in grade line elevation with the highest embankment height 19 m.

Faced with short construction deadlines a stone material embankment was designed with the intention to complete settling during construction works. A part of the consolidation settlement of the foundation soil was solved by replacement of material, while the consequences of the remaining settlement which will take place over a longer time period, will be treated within the motorway maintenance.

The problem arose when the contractor faced a shortage of stone material during construction and with already completed structures on the subject motorway part.

A solution for the embankment construction had to enable the embankment trunk or embankment body to settle during construction, at the same time keeping the already designed embankment geometry and the slopes resistant to the 100-year floods.

The embankment was designed and constructed with a combination of materials selected from cuts on the route (materials categories B and C) which were placed in layers with load bearing polycarbonate grids placed in between. Finishing parts of every layer on the slope are made of stone material.

Keywords: motorway, embankment, construction, consolidation, settlement.

1 Introduction

Within the South – East Europe Core Road Network, this Motorway links Kosovo and the South Balkans to the Port of Durres in Albanian, Corridor VIII to the south, and with Niš and further with the Pan European Corridor X in Serbia to the north.

Kosovo represented by the Ministry of Transport and Communications, and supported by the Directorate of Roads, assigned BPI–Consult GmbH (Germany) in June 2004 to provide Consultant and Engineering services for the Morinë – Merdare Motorway Project. As a result BPI prepared a Final Road Design which was completed and submitted in 2005. The planned motorway is 117 km long with two state borderline points, 8 junctions, 105 bridges and 3 tunnels. In April 2010 Bechtel–Enka General Partner signed a contract with the government of Kosovo for the construction of the Morinë–Merdare Motorway, which would be the backbone of the country's national transportation system. Subsequently, Bechtel – Enka GP signed a contract with Institut IGH for preparation of the Preliminary, Detailed and Implementation designs, including geotechnical data for sections 1, 2 and 3, which represent approximately 34.1 km of

motorway connecting the state borderline near Merdare with the town of Suharekë via Prizren. Section 3 from the Prizren Junction to Suharekë Junction is 14.8 km long.

Institut IGH started the analysis and design development for the subject motorway sections on the basis of the Technical Specifications and previously completed Final Road Design by BPI-Consult GmbH (Germany).

The four-lane motorway, from the state borderline with Albania at Morinë to the north of Suharekë, was officially opened on November 2011.

2 Why large embankments?

Basic activities, such as surveying, geotechnical investigation works and hydrological analysis were developed parallel to the 'fast tracking design'.

New surveying works were completed and used to prepare the digital terrain model. Surveying reports were submitted and approved by the Client. Geotechnical investigations were developed, as well as laboratory works. Geotechnical reports with designing and construction requirements and definition of slope for the motorway cuts, embankments, stability calculations, settlement, the replacement material, slope protection were prepared and submitted for approval. Hydrological analysis for the external and internal drainage or river diversion was developed in accordance with hydrological data collected for Kosovo. Hydrological reports were submitted for approval.

In the first stage, IGH prepared the Preliminary design on the basis of the adopted motorway corridor, geotechnical investigations and developing surveying data. Optimization of motorway alignment to reduce earthwork quantities and to decrease the length of bridges was the main goals of the design.

Three variants of motorway vertical profiles were analyzed for the developed horizontal alignments of this section. Variants were compared at their critical points like the cut in km 312+800 and embankment in km 313+200. With regard to this large embankment, two variants are significant:

2.1 VARIANT XA

This variant was developed in accordance with the original vertical alignment, but on the basis of new surveying data. This was only an initial variant, and not based on the geotechnical or hydrological data.

It is described at the control points as follows:

CUT	km 312+800	max. height is 21.2 m	suitability of material: unknown
EMBANKMENT	km 313+100	max. height is 18.2 m	

With regard to the final hydrological analysis and preliminary geotechnical results, it was concluded that this variant (vertical profile) should be changed.

2.2 VARIANT XC

XC variant is described at the control points as follows:

CUT	km 312+800	max. height is 16.9 m	suitability of material: 30%
EMBANKMENT	km 313+100	max. height is 18.8 m	

The variant XC has been developed as the more favorable variant. However, the geotechnical characteristics of the cut material show the possibility of slides.

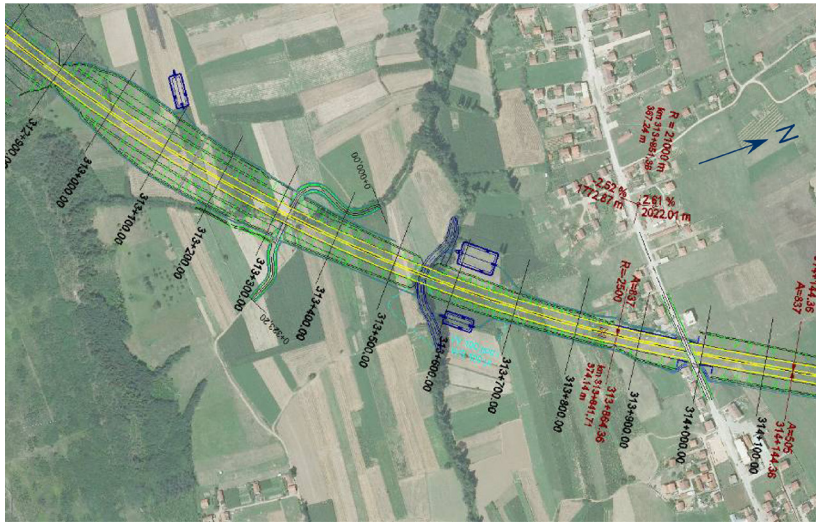


Figure 1 Layout, km 313 at Section 3 near Suharekë.

'Large' embankment location at km 313+100 crosses the Topluga River at the position where the embankment is not so high allowing the bridge to be shorter. The height of this embankment can not however be reduced because of the high water level, and the overpass clearance which should be approved for the existing road Suharekë–Studenčane.

3 Geotechnical properties of the location and the first variant of the embankment structure

The embankment, height >12m, spreads on the route part from km 312+958 to 313+368 (l = 410m). The embankment, height >15m, spreads on the route part from km 313+006 to 313+227 (l = 221m), $h_{max} = 18.8m$. Previous investigation works show that large embankments are executed at places where long-term settlements are expected. This is why additional investigations were requested for this part of the route. Borehole S₃_BHS_1320_1, up to 25 m depth, was performed at the beginning of October 2010. Results of the survey works are presented in Figure 2.

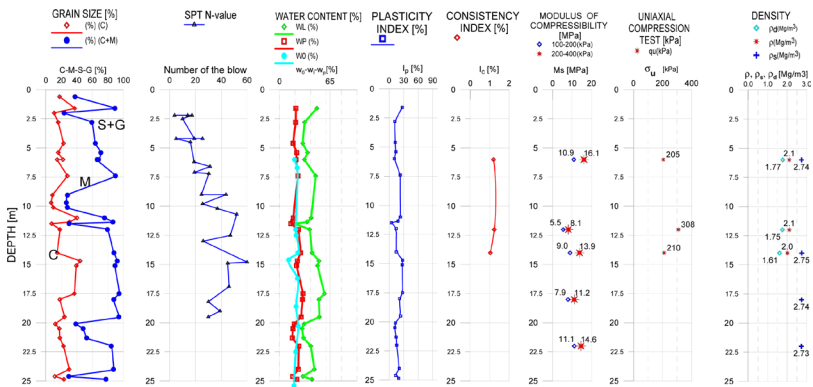


Figure 2 Graphic presentation of results of performed laboratory and in situ tests

The time schedule of embankment construction of a maximum of 10 months was a limiting factor during analysis and design development. The implemented stability analyses showed that the base has a sufficient bearing capacity. The settling and consolidation analyses showed that the smallest total settling occurs with embankments made of stone material with replacement of foundation soil thickness 2 m. Maximum settling of soil under the 18.8 m high embankment in the central embankment point is 46.7 cm. Out of this total settling height, app. 8 cm, will occur during the construction works, in the first layer of clayey gravel, which spreads up to 4.6 m depth. Another 38.7 cm of settling will take place in the clay and silt layers, and these are the layers where consolidation settling is expected to occur. Summarizing all investigation results the conclusion is that app. 90% of settling will occur in a time period exceeding 100 years. Assuming that the soil parameters used for analysis adequately describe the soil in the area from km 312+900 to km 313+852 and taking into account the analyzed total amount of settling, settling which will take place during construction, the service life of structure, periodic maintenance, time when settling will take place on the subject section, economic and technical feasibility of investment, it was concluded that the subject route section does not require improvement of foundation soil by gravel piles in order to enhance the time period required for settling.

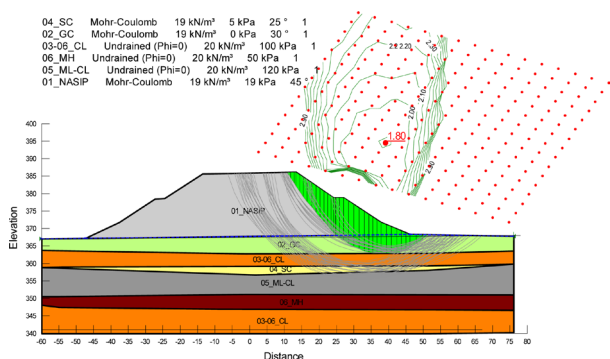


Figure 3 Geotechnical model and results of the calculations of embankment slope stability and the subsoil

4 Change of the embankment structure during construction works

The problem arose when the contractor faced a shortage of stone material during construction with already completed structures on the subject motorway part.

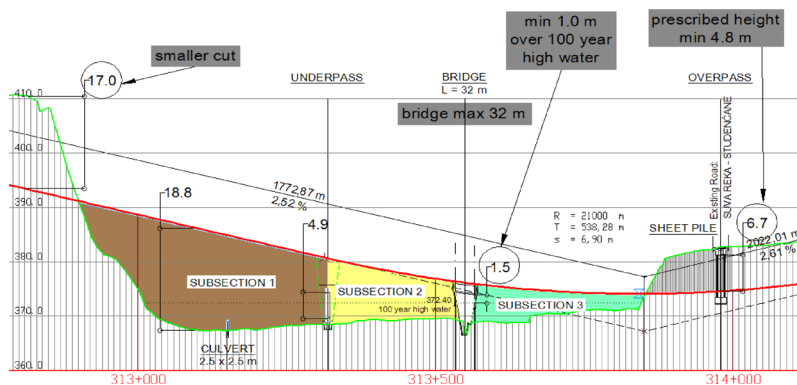


Figure 4 Longitudinal profile of a part of the large embankment.

A solution for the embankment construction had to be such, where the embankment trunk or embankment body will settle during construction (6 months), at the same time keeping the already designed embankment geometry, and where the slopes stay resistant to the 100-year floods. At the same time, the material from excavation had to be used, and the quantity of stone material minimized. Uneven deformation in the cross section had to be stopped as well as uneven settlement along the embankment route. The embankment route includes a bridge, underpass and power cable canal, all of which were in the construction stage. All structures have to function as one unit and settlement in uneven time intervals had to be prevented. The embankment area is divided in three subsections because of different embankment height and arrangement of the material courses according to cross-section height and technology of execution. The solution for the embankment was designed and constructed with a combination of materials selected from cuts on the route (materials categories B and C) which were placed in layers with load bearing polycarbonate grids placed in between. Finishing parts of every layer on the slope are made of stone material.

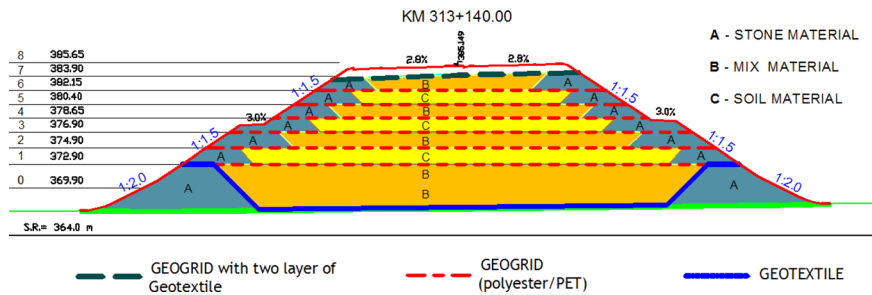


Figure 5 Cross-section of large embankment with combination of materials selected from cuts on the route (materials categories B and C).

The figures in continuation present the course of works on the embankment structure, samples of a part of used material, parts of tests for monitoring the properties and forecasting the behavior of material placed in the embankment.



Figure 6 View of the beginning of embankment construction with material from cutting, which was to be used as material category C, and a view of the test field where it was confirmed that this material is not to be placed in the embankment without improvement.

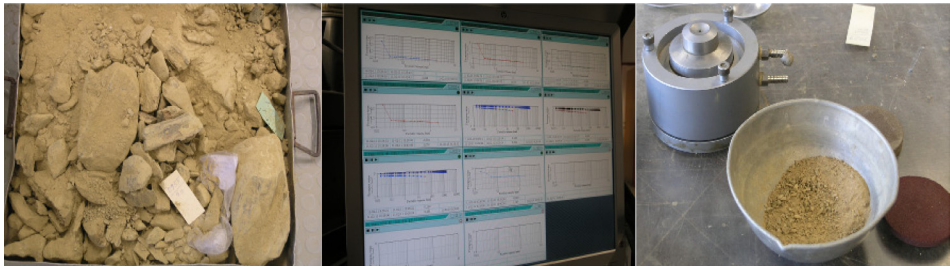


Figure 7 Sample of material which was placed as material category B. This sample was tested in three different tests: FR–fragmentability, MDE–degradability and the LA–Los Angeles Value test. It was finally placed in an oedometer where the settling time line was monitored.



Figure 8 Construction of layers of large embankment covered with geotextile.



Figure 9 The geogrids were placed over the full embankment width, starting at app. 373 m altitude, which is approx. 0.5 m above the 100–year flood level. A combigrig was installed underneath the road base course over a width of approx 30.9 m. A combigrig was installed transversely to the road axis, with an overlapping of a min 300 mm in both adjacent and longitudinal directions.

Reinforcement	Subsection 1	Subsection 2	Subsection 3	Total
Geogrid G>25kN/m	11.433	7.601	4.257	23.291
Geogrid G>100kN/m	106.948	27.601	0	134.549
Geogrid G>25kN/m with geotextile	0	0	8.467	8.467
Geotextile	47.803	27.416	9.211	84.430

Material	Subsection 1	Subsection 2	Subsection 3	Total
Stone Material	99.788	38.328	17.895	156.011
Mixed Material	145.940	23.746	0	169.687
Earth Material	66.119	37.470	18.653	122.242
Total	311.847	99.544	36.547	447.939

Figure 10 Data on the quantities of placed material



Figure 11 Completed motorway on the large embankment part.

5 Conclusion

The designed reinforced embankment was completed during September 2011. The information on the quantities of placed material show that the reinforcement of embankment structure brought down the quantity of stone material used to one third. The placed geogrids gave the embankment the required rigidity and brought the differential settling within the tolerated design limits. After the finishing works on the slope improvement have been completed the measuring points were installed in the defined profiles according to the embankment height. The design included monitoring of the displacements. We can only expect that the design assumptions will be confirmed during time on the basis of the measured data and that this will enable a similar form of embankment structure on other locations. The subject embankment is an '1: 1 scale experiment' and as such contributes to the application of reinforcement structures in embankment construction.

References

- [1] Final and Implementation design of Section 3 Kosovo Motorway Morinë – Merdare, Construction and Geotechnical Design, INSTITUT IGH d.d., Institute for Infrastructure, Zagreb, 2011