

## CASE STUDY: CONSOLIDATION OF THE A10 SEBEŞ - TURDA MOTORWAY ON THE SLIDING SLOPE SECTION BETWEEN KM 62 + 180 - KM 62 + 460

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**Abstract:** *The construction and development of transport infrastructure in Romania is a goal that cannot be achieved yet. Given the diversity of factors that interfere with the building of the national transport infrastructure, the causes of its deterioration are implicitly just as complex and are involving further costs, which more often than not will cause several times increase in the final construction cost. This article describes in detail the methodology applied for the consolidation works executed for Lot 4, road section 4, km 62 + 300, of the Sebeş-Turda motorway A10, where the road infrastructure has started to deteriorate due to the unstrutted excavations carried out up on the slope for the relocation of the medium voltage pole and the final shaping of the embankment for lane 2, where a land subsidence zone has appeared, which stretches beyond the boundaries of the expropriated land.*

**Key words:** *highway, slope consolidation, drains, roads.*

### 1. Introduction

The land on which new roads or highways are built does not have good foundation ground, therefore it is necessary to carry out works to improve the physical and mechanical characteristics to ensure the load bearing capacity that has to take over the static and dynamic loads of the construction and the related traffic.

The endogeomorpho system of the study area has revealed a strong erosion phenomenon, which has removed most of the piedmont formations and has reduced to a large extent the leveling surfaces, thus facilitating the development of erosion basins.

On the Mahaceni Plateau, the current modeling processes are highly dynamic and are closely interrelated and interdependent, causing extensive degradation in some places. Landslides, torrential erosion and surface erosion are the most active processes and the most likely to cause damages and hence to contribute to the loss in the production

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capacity of the agricultural lands and to soil quality degrading (Figure 2).

The hilly area, which comprises also the perimeter under study, is heavily deteriorated by landslides, torrents, streams and pluvio-denudation. In some places, the solifluxion phenomenon occurs in spring.

During the construction works carried out on the Sebeş-Turda Motorway, Lot 4, sector 4, km 62 + 300, the land has subsided before the relocation of the medium voltage pole and the final shaping of the slope for lane 2 (Figure 1), causing a wide crack that stretches beyond the boundaries of the expropriated land. The land subsidence site has been constantly monitored and the conclusion is that its size has not increased in the period March-July. However, in early August, stability loss phenomena have become apparent across the entire embankment and in the motorway platform area.



Fig. 1. *Landslide due to Loss of Stability*

## 2. Remedial Actions

From the analysis of the results of the technical expertise, the drilling records, the fact sheets and the laboratory analyzes, it results that these works have significant degradations such as horizontal displacements, vertical cracks and advanced degradations that have left some works, requiring checks at the ultimate limit state, restoration and consolidation under a new project (Figure 1).

The lithological sequence identified by field surveys and described from a geotechnical viewpoint by lab tests is as follows:

- On the top layer, i.e. the layer stretching from the ground surface down to the maximum depth of about 15.00 m (BH8), a brown marble clay bed was encountered, sometimes containing grey intercalations, consisting of alternating layers of stratified clays of variable plasticity (from plastically thick to plastically consistent and soft clays) and containing sandy lenses, there where water was encountered on the shale planes, showing a rough texture at the contact line with the underlying materials and comprising hard angular marl clasts trapped,

in some places, into the amorphous clayey mass;

- The bedrock underneath the brown clay layer, consisting of clays / marly-silty clays with arenaceous intercalations, altered at the top across variable thicknesses, with the upper part partially deformed and showing a well-developed networks of fissures, with frayed areas, where friction planes and underground water accumulations are present. The deeper materials are harder and more compact, with cracks here and there. At the elevation of approximately 300m-305m within the road territory, the boreholes encountered several deconstructed soil beds, confined in the mass of clays/ grey loamy-silty clays, showing 45° vertical cracks and zones of water infiltrations, which prove the reactivation of the old sliding planes.

On site, in addition to the geotechnical borehole drilling, a total of 16 geoelectric profiles have been prepared, to determine the physical properties of the lithological structures in the study area.

The geoelectric survey has provided an overview of the slope structure, from which the following conclusions have been drawn:

- Highly conductive areas associated with underground water accumulations, in the form of reservoirs developed along a network of cracks, causing geological structure displacements.
- Highly resistive zones associated with massive lithological bodies, with a poorly developed crack network and low moisture content. These areas might react as sliding planes for the overlying structures.



Fig. 2. Geoelectrical Survey Area

On the basis of the data obtained from field surveys and laboratory investigation, a combine stabilization-consolidation solution has been recommended for the area affected by slope sliding, consisting of a discontinuous abutment system made of columns laid embedded beneath the crack caused by the reactivation deep-down into the ground of old displacement planes (at elevations descending from 317 m, upstream of the cut, to 305 m towards mid height of the cut and reaching down to the elevation of approx. 300 m in the road territory area), coupled with a drainage system, designed to collect and drain out the water from the slope and from the motorway body.

Taking into account the cold and rainy weather following the dry summer season,

urgent measures are required, in addition to the consolidation solution described above, designed to seal the cracks and fissures on the ground surface and thus prevent rainwater from seeping deep down into the massif.

To check the slope stability, calculations have been made to determine the safety coefficient of the proposed consolidation solution [4, 5]. The calculations have been made according to the Eurocodes in force. The stability of slopes, cuts and fills has been verified by ultimate limit state geotechnical analysis, i.e. Limit State GEO (as defined by the SR EN 1990 standard).

### 3. Type of Consolidation Works

Taking into account the recommendations of the geotechnical study, the following slope stabilization works will be carried out [1,2,3]:

- A drainage system, built transversally to the motorway, consisting of deep drains laid down at spacing of 25 m inter-axis, across the motorway section stretching from km 62 + 200 to km 62 + 450 (Figure 3);
- A discontinuous abutment system, consisting of large diameter concrete columns (1200 mm) laid on the left side of the motorway, with the tops of the columns to be anchored to a 1.5 m high invert, between km 62 + 188 and km 62 + 460);
- A 3,00 m high abutment wall, MacMineral type, built on the foundation slab (invert), between km 62 + 240 and km 62 + 432 (Figure 4);
- A discontinuous abutment system consisting of large diameter concrete columns (1200 mm) laid on the right side of the motorway, with the tops of the columns to be anchored to a 1,00 m high foundation slab (invert);
- strengthening drains of a minimum width of 80 cm, to be laid at a spacing of 6 m across all the slopes of the embankment;
- Decreasing the embankment slope to 1: 2,5

By realizing these constructions, it is envisaged the removal of the sliding phenomena by new works and the bringing of the existing works to the normal operating parameters as well as the supplementation of the pushing capacity [3].



Fig. 3. *Drains*



Fig. 4. The sliding plane line

Figure 5 presents the results of the automatic calculation when the drains, the sliding retaining columns and the values obtained at the maximum displacement of 0.01234 m [6, 8, 9].

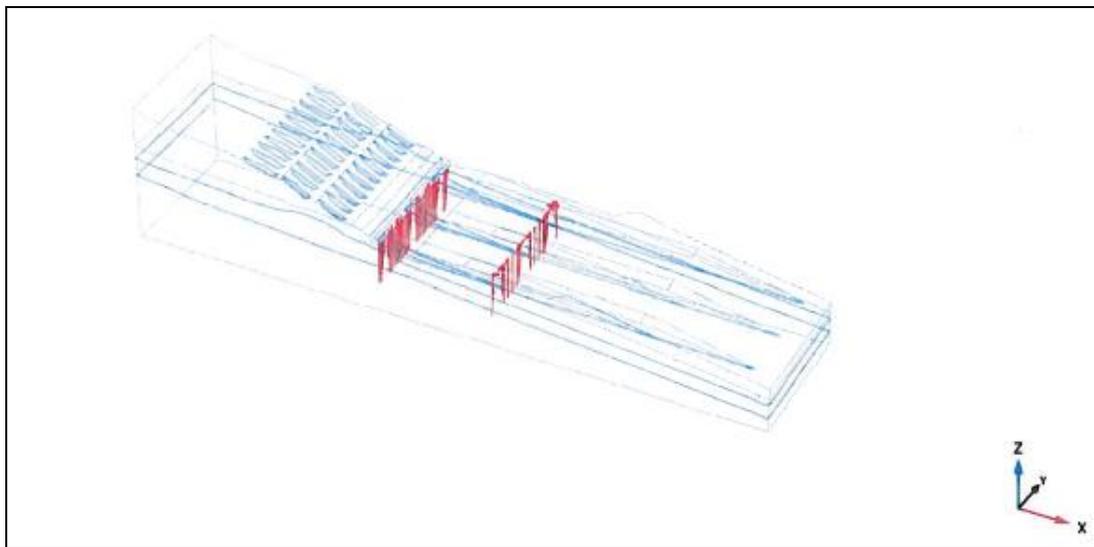


Fig. 5. Local total displacement

#### 4. Conclusions

In order to check the slopes, calculations were made to determine the safety coefficient for the proposed stabilization solution. The stability of the slopes and dump slopes has been verified at the geo limit state according to SR EN 1990 [8].

In terms of slope stability, the following measures have been taken:

- Eliminate the lateral stresses generated by water infiltrations;
- Stop the physical disintegration and chemical alteration processes;
- Stabilize the slope by constructing an abutment wall;

A combined stabilization & consolidation method has been applied on the slope affected by landslide, consisting of a discontinuous support systems made up of columns laid on the contour lines of the old displacement planes of the deep blocks. Elevations have been determined by means of a geoelectric survey and are as follows: 317 m in the upstream zone and 305 in the middle zone. The abutment system has been coupled with a drainage system, designed to collect and drain out the water from the slope and from the motorway during the cold and rainy season. Ground cracks and fissures have been sealed, so as to prevent rainwater from seeping down through the depth of the massif.

### References

1. Stematiu, D., *Mechanics of Rocks for Constructors*, Conspress Bucuresti, 2008.
2. Roman, F., *Geotechnical Engineering Applications*, Papyrus Print, Cluj-Napoca, 2011
3. Popa, A., Ilies, N.-M., *Foundations*, "Casa Cartii de Stiinta", Cluj-Napoca, 2013
4. Marinescu, C., *Ensuring the Stability of Embankments and Slopes*, "Editura Tehnică Bucureşti", 1988
5. Moldovan, I.M., Ilies, N.-M., *Stabilization of a Potentially Sliding Slope with the Aid of an Underground House*, Journal of Applied Engineering Sciences Vol. 4 (17) issue 2. Oradea: University of Oradea Publishing House; 2014
6. Farcas, S. V., Ilies, N.-M., Popa, A., M. C., Gherman Muresan, O. C., Molnar, I. C., *Landslide Stabilization Along a National Road*, Proceedings of the XV ECSMGE Conference on soil mechanics and geotechnical engineering, Athens, IOS Press-Mill Press, 2011
7. Popa, A., Ilies, N.-M., Chiorean, G.C., *Utilization of Analytical Methods in Slope Stability and Consolidation*. Proceedings of The 14th Danube-European Conference on Geotechnical Engineering "From Research to Design in European Practice". Bratislava, Slovakia; 2010.
8. SR EN 1997-1. Eurocode 7 Geotechnical design. General rules.
9. The A10 Sebeş – Turda Motorway Project, km 63+000, Sliding Slope Consolidation.