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ENVIRONMENTAL FRIENDLY CONSOLIDATIONS SOLUTIONS FOR THE NATIONAL ROAD1, ROMANIA, FROM KM 204+445 AT 204+700 AND BETWEEN KM 205+150 TO 205+250

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Abstract: *The DN 1 road sector at KM 204+445 to 205+250 is affected by a slow shift of the terrain. To intervene efficiently on the humidity and implicitly on the versant's stability, investigative workings are necessary. There will be 3 inclinometric drillings, all set in a line on the direction, and 4 piezometric drillings. Solusions consists in deep gravitational drains in association with an afforestation of the slope. The comparative analyze was based on technical and economical aspects, and also regarding the landscapes.*
Key words: *slope stability, underground water, inclinometer, piezometer*

1. INTRODUCTION

The DN 1 road sector at KM 204+445 to 205+250 is affected by a slow shift of the terrain. Firstly, this shift leads to the settling of the road downstream at the 205+150 km to 205+250. In the past decades, intervening in this portion has been only over the effects, by laying down of asphalt carpets so that the total thickness of the road exceeds one meter, without seeing a stopping of the phenomenon.

The digging for the creation of a new embankment on a depth of 6 meters, has reached under the underground water level, causing major problems regarding the bearing capacity of the road foundation. On the other hand, the presence of the water in itself is a major obstacle in obtaining the desired road quality.

The situation identified in the prior geotechnical study is in short the following:

From a lithological point of view, the encountered formations are made of mezozoic deposits set on the crystalline massif Leaota, and on the surface, on a relatively great thickness of an alteration blanket of these, the blanket consisting itself of a cohesive material – silty-sand.

From a geomorphological point of view, it overlaps the proluvial deposits of the Măgura Codlei. The stratification encountered is as follows:

- Vegetal soil with a thickness of 0.30 m;
- 0,30-4,00 (4,50) meters of sandy brown-yellow plastic, high plasticity, clay;
- 4-00-7,30 (8,00) meters of yellow-ashy soft, saturated clay;
- 7,30-9,50 sandy-clay brown-red plastic consistent;
- 9,50-12,00 hard, dark brown ash marl.

The underground water level was found at 4.00-4.50 m depth from the natural terrain quota. In addition, was found a preferential direction of the silty-clay lamine which leads to the idea that these would be super-consolidated. In any event, the existence of these separation planes favors the water flow.

Even though the announced title includes two different road portions, from a geological and geotechnical point of view, the problem is a single one. The two road portions are situated on the same slope of a hill that is drained at its base by a creek stream

We present the supposed factors that have triggered the instability phenomenons in order of their importance:

- gravity;
- the presence of underground water;
- the erosion of the downstream creek, although we believe that by not having a great transport energy, it has not had a major influence.

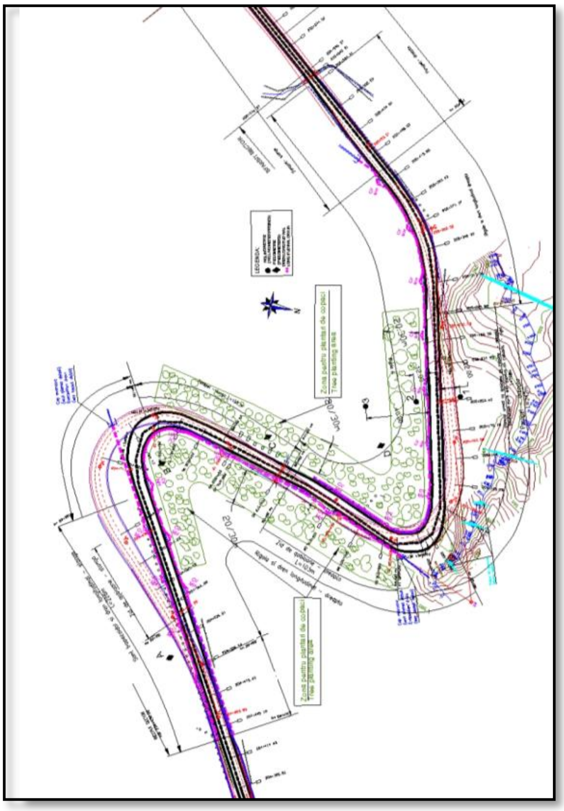

Fig. 1. Situation plan with proposals for provisional works

2. METHODS FOR STABILIZATION OF THE SLOPE

We set out with the aim of acting more upon the causes that have triggered the instability phenomenons and less upon the effects. The approach bases itself on the idea of collaborating with the environment.

From this point of view, we return to the clauses specified above and we determine the following:

-we cannot intervene on gravity itself. A change to the slope's geometry by creating taluses and embankments, besides being a brutal intervention on the environment, would not help the situation. In support of this statement, we have to consider the length of over 300 meters of the slope that has a monotonous inclination, which, as a consequence would not diminish by much, but would have relatively great costs.

Still, by creating of gabions thresholds along the downstream creek, besides diminishing the erosion effect, it would create a stabilization mass.

-we consider that the humidity, although being a secondary factor, is the only one liable to be improved in an efficient manner. A calculus simulation shows that a 3-4% diminishing of the humidity leads to a 0.2-0.3 increase of the safety factor, which is enough for stabilization. The estimation starts off from indicative data where the internal friction angle, as well as the soil cohesion are a lot greater for a low humidity soil than for a very wet or saturated one. At the same time, by lowering the underground water level, part of the terrain that is now saturated because of the capillary water will pass off to an unsaturated and dry state, thus, with a greatly lowered volumic weight, at about half.

The surface humidity can be reduced by the plants evapo-transpiration. Afforestation of the slope would lead on the one hand to retention of the vadose water and on the other hand to drawing the underground water to the surface. Also, the landscape-architectural aspect of the problem must be taken into account.

We insist on the humidity reduction solution because it can be accomplished without a brutal intervention on the environment (open diggings, fillings, massive structures of concrete or other materials).

3. INVESTIGATIVE WORKINGS

To intervene efficiently on the humidity and implicitly on the versant's stability, investigative workings are necessary through which the following will be determined:

a. The phenomenon's value, meaning the geometric sizes of the ground mass that is shifting, as well as its speed.

b. The aquifer system's characteristics, meaning the permeability coefficient, hydraulic transmitivity, the slope or the hydraulic gradient and the underground water flow direction.

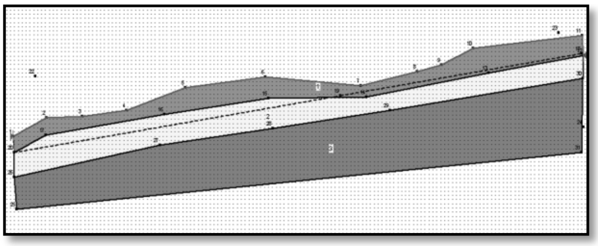

Fig. 2. The slope's discretization for calculating the stability

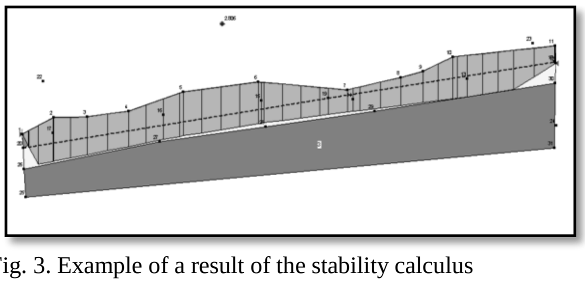

Fig. 3. Example of a result of the stability calculus

a. To determine the volume of the shifted ground mass, besides the plane extension that can be observed directly on the surface, it is necesarry to determine the depth on which the phenomenon takes place. The safest and most economically efficient method is by inclinometric measurments. We suppose that there is no plane or planes of shifting, rather a continuus labile zone that is the transition from a stable terrain to an unstable one. There will be 3 inclinometric drillings, all set in a line on the direction of the greatest slope, 2 in upstream of the national road and one in downstream. Their depth will be of 12 meters, thus being embedded in the hard marly dark ash clay layer that is supposed to be stable.

b. The underground water capture system sizing will be made according to the terrain permeability and the water flow direction. "In situ" test are the most eloquent ones and can be made by piezometric drills enhanced with Cassagrande cells. Besides looking for the actual water level, the flow speed and direction can be determined using traces. Thereby, we propose the execution of 4 piezometric drillings. To determine some planes, these can be theoretically grouped by 3 in upstream (A, B and C) and one (D) in downstream which can also be coupled with two inclinometers (see fig. 1).

4. WORKS PROPOSED FOR THE SLOPE'S STABILIZATION

At the moment, we estimate that the consolidation workings will be as follows:

On the upstream portion 204+445 to 205+250, parallel drains will be executed with a depth of about 2.00m.

Longitudinal drainage on the left side of the road in the downstream sector on the upstream portion at 205+150 to 205+250. Their dimensions, the depth, distance between depends on the results of investigations.

Afforestation with autochthonous tree species that currently make up the area's landscape.

5. CONCLUSIONS

On this conditions we have made a comparative analyze for possible consolidations as follow:

by some artificial elements for earth retentions;

by deep gravitational drains in association with an afforestation of the slope.

The comparative analyze was based on technical and economical aspects, and also regarding the landscapes.

On the first point was analyzed a retaining wall or a mechanical barrier of pile sheet wall witch follow the shifted massif. The deep mechanical works can assure the lope stability in correct conditions, but it claims a huge volume of earth works with permanent changes. On the other hand the expenses will be bigger then the second variant, with about 40%.

The second variant of slope stabilization is obvious more cheap and leads to the same safety factor as the first variant. Another side of the problem is that the natural landscape will be conserved for a long period of time and the time for execution will be much more shorter.

In conclusion, a most discrete intervention upon the massive will be pursued, without shifts of ground masses and without creating massive constructions that are foreign to the landscape. The works' monitoring will also be continued after the first interventions are made and, if needed, these will be completed. The intervention's success, that will consist only in reduction of the humidity will depend on the investigations' accuracy and, according to the geologist's experience and intuition, on the closeness to reality of the conceptual modeling. The rest depends only on calculus and responsibility.

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