Proceedings of the XVII ECSMGE-2019
Geotechnical Engineering foundation of the future
ISBN 978-9935-9436-1-3

doi:17ecsmge-2019-Y-XXXX

XVII European Conference
ECSMGE 2019
Reykjavik
on Soil Mechanics
and Geotechnical Engineering

Determination of global stability for a group of geotechnical objects in complicated geological conditions.

Détermination de la stabilité globale pour un groupe d'objets géotechniques dans des conditions géologiques complexes

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ABSTRACT: Slope deformations in Slovakia are one of the most widespread and to some extent one of the most dangerous country geohazards, and represent a significant geobarriers to urbanization planning. A problem of slope deformations is currently very actual. In 2008, were registered 21 190 slope deformations in Slovakia (approximately 5,25% of total land area). In May last year the great landslides caused by storm rainfalls and floods were activated, especially in eastern Slovakia. There were registered a total of 551 newly slope deformations. The article discusses a method of determining global stability, which represents two different views on the calculation, when global stability is provided by a system of geotechnical structures, and when the calculation of global stability is determined for each object separately.

RÉSUMÉ: Les déformations des pentes en Slovaquie sont l’un des géorisques géographiques les plus répandus et, dans une certaine mesure, des plus dangereux, et représentent un obstacle important à la planification de l’urbanisation. Un problème de déformations de la pente est actuellement très actuel. En 2008, 21 190 déformations de talus ont été enregistrées en Slovaquie (environ 5,25% de la superficie totale des terres). En mai dernier, les grands glissements de terrain causés par les pluies d'orage et les inondations ont été déclenchés, en particulier dans l'est de la Slovaquie. Au total, 551 nouvelles déformations de la pente ont été enregistrées. L'article discute d'une méthode de détermination de la stabilité globale, qui représente deux vues différentes sur le calcul, lorsque la stabilité globale est fournie par un système de structures géotechniques et lorsque le calcul de la stabilité globale est déterminé pour chaque objet séparément.

Keywords: Global stability, Slope deformation, Landslides

1 INTRODUCTION

With gradually expanding populations are extensive and demanding technical works built in increasingly complex and less favorable geological conditions. The optimal foundation conditions are not limited only on the territory of the Slovak Republic but also in other countries, leading to an increase in the cost of engineering construction. The complicated geological structure and geomorphology of Slovakia makes the occurrence of several geological failures, the most widespread being the slope deformations.

In Czechoslovakia as the first state in the world, all dangerous landslides in economically significant areas were registered nationwide in 1962-1963. Approximately 62% of the country's surface area was surveyed. All areas that have been damaged or threatened by landslide or other forms of slope deformation have been documented and mapped to a scale of 1:25,000.

The last summary registration of slope deformations in the Slovak Republic was in 2008, where it was recorded 21 190 slopes deformations with a total area of 257 591, 2 ha, it representing approximately 5,25% of the total area of the country. Slope deformations are the cause of road damage, deterioration of agricultural land, woodland and so on. In May last year, high precipitations were recorded in Slovakia resulting in hundreds of landslides being activated (a total of 551 new landslides were registered) (Figure 1).

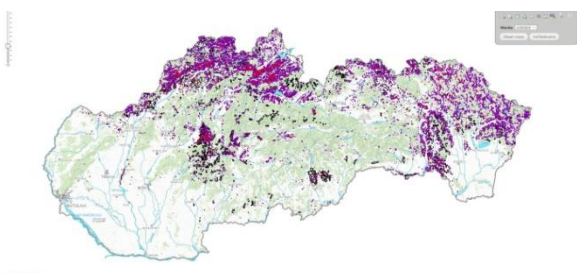

Figure 1. Recorded slope deformationy in Slovakia

Slope deformations in Slovakia that represent one of the most common types of geological faults of the country and represent a significant geobarriers in urban planning. Evaluate the landslide risk is especially useful in areas where it is expected socio-economic and technological development of the region.

In the Figure.2 are presented geological formations in the Slovak part of the Western Carpathians.

The slope deformations are the most disturbed unit of the paleogene and the mesozoic of the limb zone 14.8% and the paleogene of the flysch zone 12.7%. Follow neogene volcanicity 9.3% and intra-Carpathian paleogene 7.2%. The least damaged are Mesozoic rocks 2.4%, neogenic and quaternary sediments 1.5% and crystalline rocks 1.5% (percentages represent the shares of the total area of the formation).

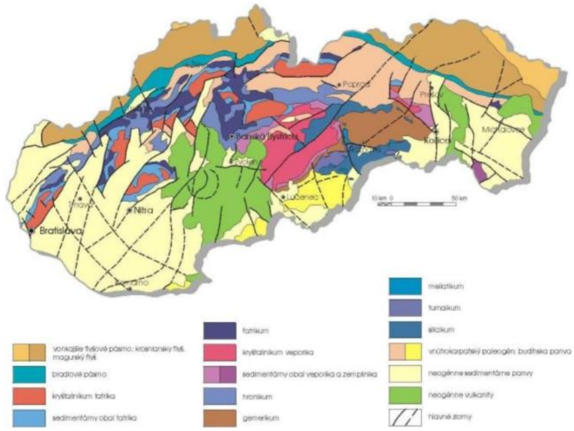

Figure 2. Tectonic scheme of the Slovak Western Carpathians

Regarding the activity of slope deformations, active is 11.6%. These active forms represent just landslides (94.9%) and streams (3.5%).

In one of these areas it is currently underway construction of an important linear structure. This is the highway D3 Čadca, Bukov - Svrčinovec and the bypass of Čadca (Figure 3).

Such extensive construction can have a positive but also a negative impact as it represents a relatively large impact on the environment. First of all, it is a direct relationship of the technical work with the rock environment. One of the main geotechnical problems in the design and construction of technical works in the rangy terrain it is just slope stability. Incorrectly stable assessment of the slope stability, where the technical intervention is to be carried out, can lead to disastrous consequences.

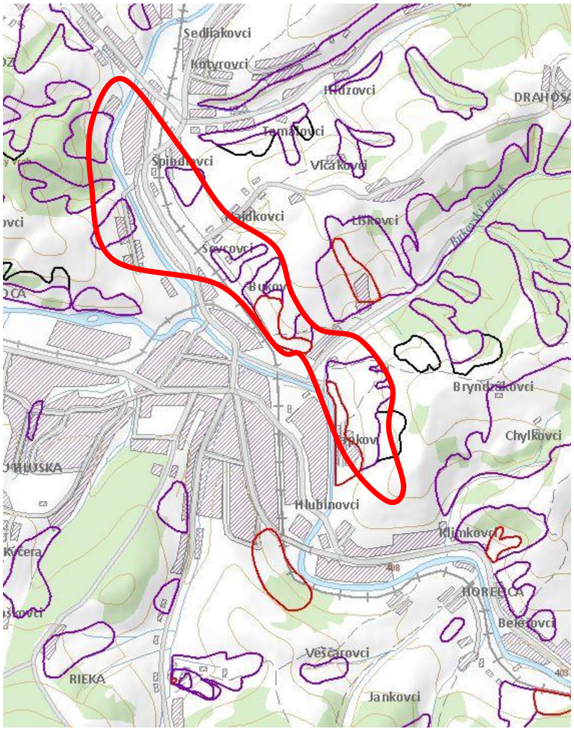

Figure 3. Recorded landslides at the site of the D3 highway (schematically marked)

2 LANDSLIDES VS. LINE CONSTRUCTIONS

Slope deformations generally have a negative impact on planned construction. The greatest interest is mainly focused on landslides threatening the new family houses, it being remembered that many times the owners, who decided to build on the slope without the help of an geologist or geotechnical engineer, they can often themselves for this situation. Linear structures, however, represent a strategic building that has a very wide use for the population and the state.
The biggest problem of Slovakia is the complicated geological structure complex in the interaction with the construction of highways and the related occurrence of slope deformations. Although the atlas map of slope stability, in which the landslides and other slope deformations are registered, is being developed, during construction and especially during it, the responsible geotechnical engineer often encounter unexpected complications.
Project planning counts on what has been documented in the past, and therefore are realized remedial arrangement which resulting from a previous survey. As already mentioned, there are cases when the combination of adverse natural conditions and anthropogenic intervention of construction into the natural environment activate slope deformations. One of the most frequent building interventions in the rock environment during construction is the undercut. Nothing unusual, but from stability side, it is very dangerous. Although the stability ratios are calculated, due to the construction of supporting walls, the slope deformations are often unpredictable and thus annoying and mainly overcharge the actual construction.

3 STABILITY ASSESSMENT OF SLOPE DEFORMATIONS IN HIGHWAY CORRIDOR

The most significant exogenous geodynamic phenomenon for near the newly built highway D3 Čadca, Bukov - Svrčinovec included landslide, which is a response to the geological and tectonic structure of the area and its hydrogeological conditions. Slope deformations, that are in multiple locations combined with a movement of rubble´s layers, cover the bulk of the area slopes engaged motorway route (or a range). We decided to focus on the first section of the highway (Figure 3), which almost represents one potential landing gear that directly threatens the adjacent railway station and, therefore, the direct northern rail link between the Czech Republic, Poland and Slovakia. This section is divided into several homogeneous units.

3.1 Section 1

The route undergoes extensive stabilized slope deformation at the final development stage. First

120 m is applied to potential landslides a frontal planar slip surface in a depth of 7.0 to 8.0 m.

3.2 Section 2

The section of the highway is situated in the accumulation of potential frontal landslide. The rock environment disturbed by sloping movements reaches a depth of 2.1 m - 3.0 m. The depth of the sliding body according to the piezometric borehole is 5.0 m.

3.3 Section 3

This section includes a large sliding area with two staged, stepped slides of 250-300 m in length, interconnected by two smaller flat landslides. The surface layer is damaged to a depth of 4 - 5 m by a potential landslide, where a basic shear surface is assumed to be 9.5-10.5 m deep.

3.4 Section 4

Here is the highway route situated in a compound stabilized slope deformation. The construction sites are situated in the frontal landslide with a thickness deluvial landslide at 7-8 m. The central part of the territory is violated planar and current stabilized landslides, the upper part of the slope deformations are broken by rubbles. The depth of the shear area is 7.0 m below the terrain.

3.5 Section 5

This is a section where the rock environment is damaged by stabilized frontal landslide with a depth of shear area of 2.1 m - 4.1 m.

Already on the basis of this sectional division and a short description of deformations, it is obviously what challenging geological environment. In general, we encounter several, mutually interconnected shear surfaces, either at the basal level (deeper shear areas) or the level of deluvial rubbles movement (shallow shear surfaces).

4 DESIGN OF GETECHNICAL CONSTRUCTIONS FOR LANDSLIDES STABILIZATION

Whole, the above described part of the newly built highway has been divided into six homogeneous units and on the basis of geological survey was proposed set of geotechnical constructions, whose task is to stabilize the slope deformations. Figure 4 approaches one of these variants.

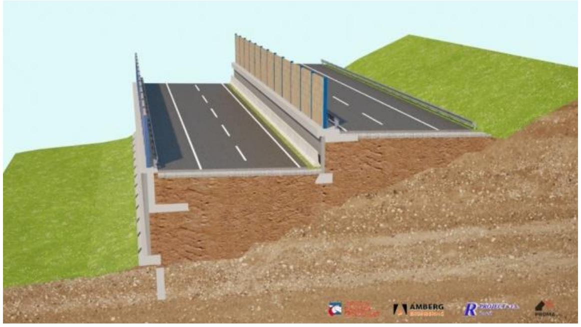

Figure 4. Schematic cross section

Given that the problem is not only shear surface but a number of independent ones, it was necessary to choose the most advantageous construction process that would already have its own built steps created a motion-preventing construction unit.

As an example of a stabilization process, was a homogeneous section 5 selected.

Calculation of stability ration took place on two levels.

1. Calculation of the global stability of the section, account of the construction process and each step has been assessed separately, to avoid accidental triggering of slope movement. If the step result in a decrease of stability to the previous step, was reviewed and selected other process so as to still ensure the continuity of the construction (Fig. 5 - to 8).

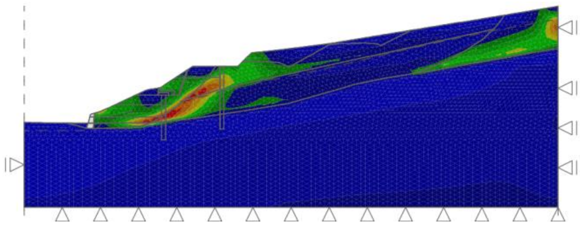

Figure 5. Shape of the shear surfaces for the first construction step (Phase 0 represents the initial stress state)

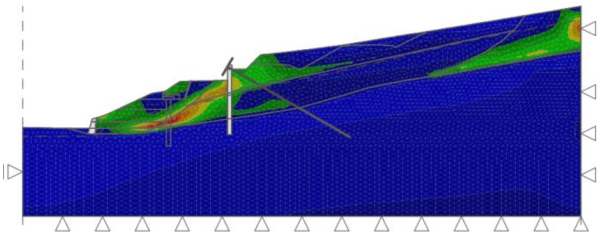

Figure 6. The redistribution of the shear displacements after completion of the first object, which now allowed the start of release the landslide

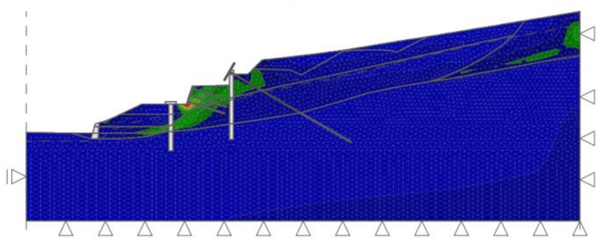

Figure 7. Construction of another pilot wall, the task of which will be primarily to secure the left-hand highway

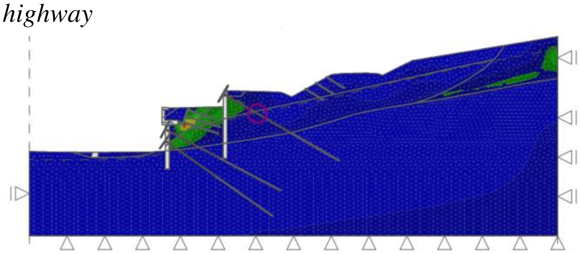

Figure 8. The final stability system of highway

2. Calculation of internal stability of individual structures to determine internal forces and subsequent dimensional evaluation (Fig. 9 and 10)

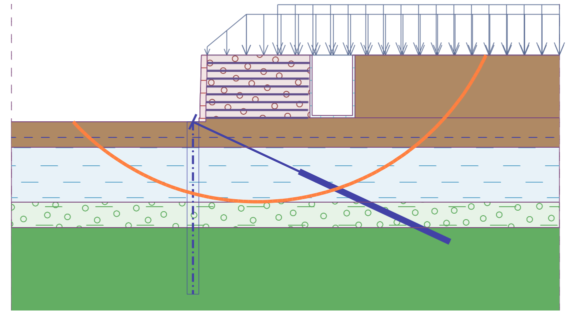

Figure 9. An example of determining global stability for part of a construction with a reinforced structure

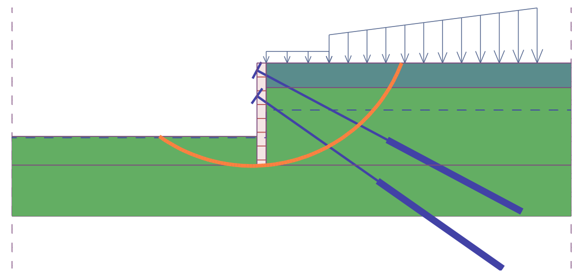

Figure 10. Another part of the same object and determination of global stability for piles and anchors

Many times, there is a requirement for control of project documentation sometime, directly from the contractor, supported global stability assessment for individual objects of the construction system. However, this requirement is often based on a misconception that the system can be divided into parts and they carry a proportion of the total degree of global stability.

5 COMPARISON OF GLOBAL STABILITY FOR THE GEOTECHNICAL SYSTEM AND INDIDUAL PARTS

As has already been mentioned in the previous chapter, the difference is whether the geotechnical engineer to design as a "stabilizing"(multiple geotechnical constructions have a single role) or a "partition" system (each unit fulfills a stabilizing function but does not

affect the stability ratio of the closest construction).
In order for the geotechnical "stabilization" system to function properly, it must have agreed in advance, as is set timetable construction. It is important, because it is necessary to take into account in the construction of individual building components. It is also important, so that the contractor has a fully defined boundary, what can and does not happen in each construction phase. It is not possible to build a retaining wall on the piles, when it was a requirement first excavated material in other part and then begin with new wall.
In determining global stability by „partition“ system are not calculated boundaries so well defined, but on the other side we have for this adequate constructions. They must be automatically designed more massively and, of course, more expensive.

Table 1. Comparison of „stabilizing “ and „ partition" system

Object	Stability ratio [%]	Finaly stability ratio[%]	
		without seismicity	with seismicity
1	71,5	75,36	78,53
2	74,9		
3	79,7		
1-2-3		59,17	65,79

Table 1 clearly shows the effect of a well established construction procedure on the calculation of global stability. This procedure is necessary to have premeditated, because any change must be taken into account in the calculation again and it has a time impact, because numerical model and calculation need time too. On the other hand, adjustments, such as depths of geological layers or shifting of the shear surface, on the basis of the already started realization of construction, are important because it is a status update. This update helps to identify existing anomalies that were not captured in surveys and flexibly respond to them.

6 CONCLUSIONS

With slope movements man does not encounter every day, but it should be noted that this happens, and it happens more often. These movements are influenced only by two factors, namely nature and humans themselves.
In this paper, we have attempted to describe ways of determining global stability, which represent two different views on the calculation, when global stability is provided by a system of geotechnical constructions, and when the calculation of global stability is determined for each object separately.
In complex geological conditions it is mainly about understanding the overall geological environment with the development and effective design of geotechnical structures designed to ensure long-term stability. The term effective design is meant a set of geotechnical construction, which complement each other, so that their final effect has the desired influence. Therefore, the calculation is conditional on precisely the construction process and the time dependence. This is the primary input that geotechnical engineer should identify at the beginning of the design work. This procedure is unalterable and all other work has to come from it. Based on this, it is then possible to simply involve individual suppliers in the building process and effectively manage the overall process.

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