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SLOPE STABILITY ANALYSIS USING GEO 5 SOFTWARE IN BREBU COUNTY CASE STUDY

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Abstract

The purpose of this paper is to analyze the stability of a slope that was subsequently affected by a landslide through several methods of analysis. The well known limit equilibrium methods are conventional ways for the assessment of stability for homogeneous and layered soils. A comparison between the percentages of utilization of these methods has been done according to the norms in force. The following methods had been used: Bishop Method, Fellenius Method and Janbu Method. Landslides are phenomena that occur regularly in our country. They can cause serious damage to the environment and can endanger human lives. This article will present a case from a rural area that has been affected by such a phenomenon and its harmful consequences.

Keywords*: Bishop, Fellenius, Janbu, Landslides, Limit Equilibrium Method, Slope stability.*

INTRODUCTION

The DC4B communal road was affected by a landslide that caused major traffic issues. This road passes through the village of Pietricioaia and belongs to the Brebu County. This county is located in the central eastern part of the country. This area is part of the Subcarpathian arc that consists of sedimentary formations of Cretaceous and Paleogenic age.

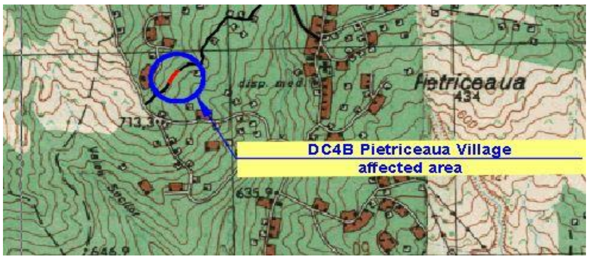

Figure 1. Map Location

From a morphological point of view, the area shows an uneven relief. The slopes are generally varied with an arched structural shape. These slopes consist of silty clay deposits and have the appearance of forested hills, with medium altitudes, their summits having a generally rounded shape on the anticline.

The hydrographic network on the territory of the Brebu commune belongs to the hydrographic system of Ialomita through its tributary river Prahova. Prahova River receives as main tributaries on the left side of the studied area, the Doftana River and the Teleajen River.

To collect the necessary data for the assessment of the slope, 2 drillings were made in the area. The purpose of the drills was to take the necessary samples to be later tested in the laboratory, to identify the terrain stratification, the groundwater level and a possible slip surface. Shear strength tests were carried out to evaluate the shear strength parameters: angle of friction and cohesion. The samples were also weighed to determine the bulk weight.

Figure 2. On site perspective after the landslide occurred

MATERIALS AND METHODS

The slope analysis was conducted using the “Slope Stability” software which is individual program that is part of the GEO 5 software suite. It uses various norms from different countries and continents and it also includes the Eurocode norms that are used throughout Europe. The program uses conventional ways of obtaining circular and polygonal slip surfaces (Gorog and Torok, 2007).
The Design Approach 1 and 3 were used to assess whether the slope was stable or not. The following information regarding the types of soils, their physical parameters and soil stratification can be found within the Geotechnical study.

Table 1. F1 drilling

Drilling	Location	Depth(m)	Description
F1	Placed on the roadway. The P1 sample was taken at a depth of 2m and at the depth of 5m the P2 sample was taken	0-0.10	Asphalt
		0.10-1.10	Gravel
		1.10-1.50	Filling out of boulders
		1.50-3.80	Brown clayey sand with light green interlaces and sandstone fragments
		3.80-8.50	Sandy siltwith sandstone fragments

Table 2. F2 drilling

Drilling	Location	Depth(m)	Description
F2	placed on the slipped ground surface at a distance of 15m from F1. The P1 sample was taken at a depth of 2m and at the 4m depth the P2 sample was taken	0-0.30	Vegetable soil
		0.30-3.50	Yellow brownishsilty sandwith green grey interlaces
		3.50-6	Grey clayey silt with sandstone fragments, with carbonized roots

Two layers were taken into account for analysis. Their geotechnical index parameters and an overview of the model can be seen below. A distributed load of 200 kPa was assigned on the road platform.

Table 3. Soil index parameters for the first layer

Brown clay sand with light green interlaces and sandstone fragments	
Unit Weight γ	17.49 kN/m^3
Angle of internal friction Ø	24.00 °
Cohesion of soil c	23.40 kPa

Table 4. Soil index parameters for the second layer

Grey clayey silt with sandstone fragments, with carbonized roots	
Unit Weight γ	18.88 kN/m^3
Angle of internal friction Ø	17.00 °
Cohesion of soil c	27.30 kPa

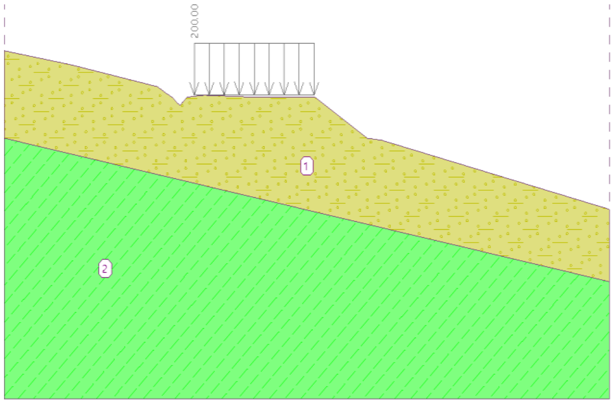

Figure 3. Overview of the model

Three methods were used to evaluate the slope’s stability: Bishop, Fellenius and Janbu.
The characteristic values tabulated above will be affected by partial safety coefficients according to the norms in force for each calculation approach used (Eurocode 7). These coefficients are integrated into the software’s database.
Design Approach 1 (DA1): according to EN 1997 - reduction of actions and soils parameters
C1: A1+M1+R1
C2: A2+M2+R2

Table 5. Partial safety factors for DA1

Design Approach 1			Combination 1			Combination 2		
			A1	M1	R1	A2	M2	R1
Permanent Actions	Unfavorable	γ_G	1.35			1		
	Favorable	$\gamma_{G,fav}$	1			1		
Variable Actions	Unfavorable	γ_Q	1.5			1.3		
	Favorable	$\gamma_{Q.fav}$	0			0		
Partial factor on internal friction		$\gamma_{\varphi'}$		1			1.25	
Partial factor on effective cohesion		$\gamma_{c'}$		1			1.25	
Partial factor on undrained shear strength		γ_{cu}		1			1.4	
Partial factor on unconfined strength		γ_{qu}		1			1.4	

Design Approach 3 (DA3) - according to EN 1997 - reduction of actions (GEO,STR) and soil parameters
A1/A2 + M2+R3

Table 6. Partial safety factors for DA3

Design Approach 3			A1	A2	M2	R3
Permanent Actions	Unfavorable	γ_G	1.35	1		
	Favorable	$\gamma_{G,fav}$	1	1		
Variable Actions	Unfavorable	γ_Q	1.5	1.3		
	Favorable	$\gamma_{Q,fav}$	0	0		
Partial factor on internal friction		$\gamma_{\varphi'}$			1.25	
Partial factor on effective cohesion		$\gamma_{c'}$			1.25	
Partial factor on undrained shear strength		γ_{cu}			1.4	
Partial factor on unconfined strength		γ_{qu}			1.4	

RESULTS AND DISCUSSIONS

Slope stability verification (Bishop) DA1 Combination 1

Utilization: 98.6 %

Slope stability ACCEPTABLE

Slope stability verification (Bishop) DA1 Combination 2

Utilization : 106.1 %

Slope stability NOT ACCEPTABLE

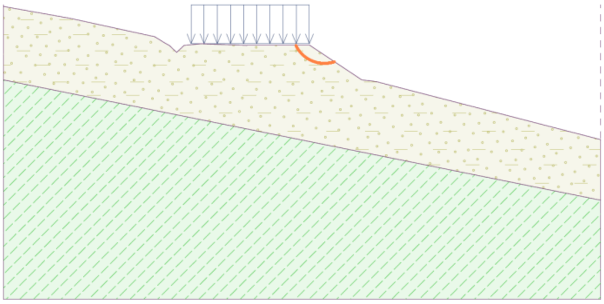

Figure 4. Slip surface Bishop DA1

Slope stability verification (Bishop) DA3

Utilization : 122.8 %

Slope stability NOT ACCEPTABLE

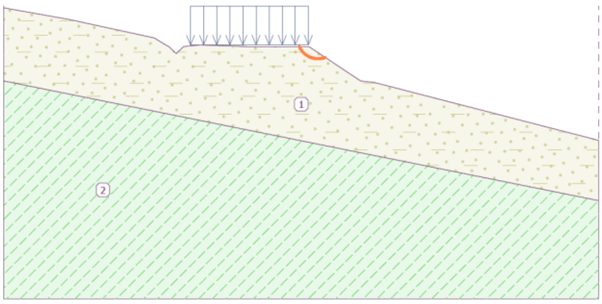

Figure 5. Slip surface Bishop DA3

Slope stability verification (Fellenius / Petterson) DA1 Combination 1

Utilization : 116.2 %

Slope stability NOT ACCEPTABLE

Slope stability verification (Fellenius / Petterson) DA1 Combination 2

Utilization : 122.6 %

Slope stability NOT ACCEPTABLE

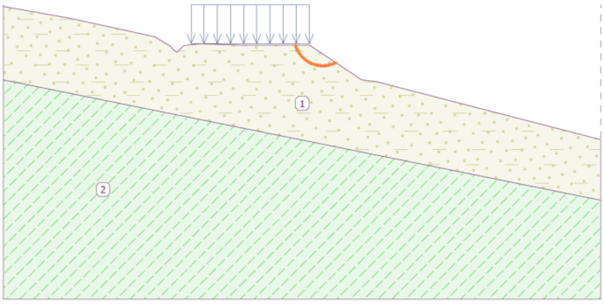

Figure 6. Slip surface Fellenius DA1

Slope stability verification (Fellenius / Petterson) DA3

Utilization : 145.4 %

Slope stability NOT ACCEPTABLE

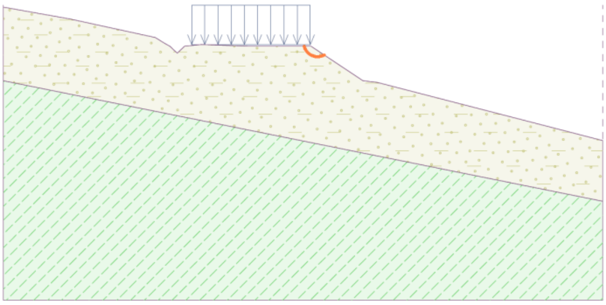

Figure 7. Slip surface Fellenius DA3

Slope stability verification (Janbu) DA1 Combination 1

Utilization: 99.0 %

Slope stability ACCEPTABLE

Slope stability verification (Janbu) DA1 Combination 2

Utilization : 106.8 %

Slope stability NOT ACCEPTABLE

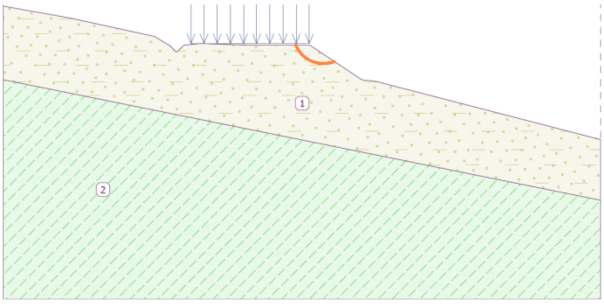

Figure 8. Slip surface Janbu DA1

Slope stability verification (Janbu) DA3

Utilization : 123.4 %
Slope stability NOT ACCEPTABLE

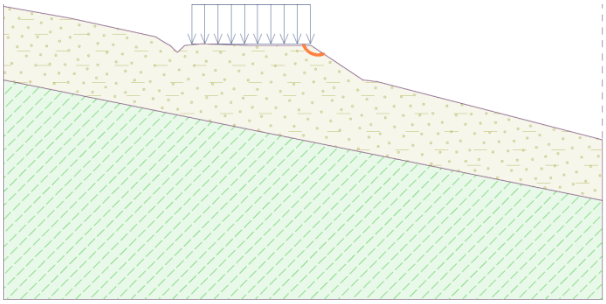

Figure 9. Slip surface Janbu DA3

It can be observed that for each of the methods applied, DA3 proved to be the most unfavorable approach. The Fellenius stability test recorded the highest percentage of utilization: 145.4%.

CONCLUSIONS

Following the evaluation of the results, it turned out that the slope was not subjected to a correct analysis in terms of stability. It is possible that at the time when the road was designed, the civil engineers did not take into account an adequate surcharge that would simulate the passing of vehicles on that road. There is also the possibility that at the time when the construction of the road began the slope stability was calculated according to the old norms, and probably following the old approaches it became apparent that the slope was stable. Landslides like these are dangerous because they can cause damage to the road structure and raise traffic and safety issues.

ACKNOWLEDGEMENTS

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