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STABILITY OF SLOPES APPROACHED AS AN INTEGRATED SYSTEM

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Abstract: *This paper presents a case study designed as an integrated system, unitary figured for ensuring stability in the area. This research paper analyses a horizontal platform and an excavation of about 2 hectares, required by an industrial building. Vertical systematization designed on the site ensures the run off of the rain water, collecting in-depth water, achieving consolidation, and ensuring the stability of the embankments resulted from the excavation.*

Key words: *Stability of slopes, consolidation, soil mechanics.*

1. Introduction

The literature shows that slope stability is a problem of geomechanics. Theories of stability show that the shear set in motion by a certain mass of unstable ground controls it. Stress analysis takes into account the external loads (roads or buildings) and internal loads (the volume of the unstable ground) [1, 2, 3]. Buckling mechanism is specific to each case depending on the following factors: massive rock structure, vegetation, the angle of inclination of the slope, the moisture, content of the system in addition to groundwater levels, and characteristics of constructions [1].

The theme of this paper intends the following goals: achieving the vertical systematization on the total area, achieving the stabilisation of slopes, draining the pluvial and phreatic water in the right conditions from slopes and refurbished platform (Fig. 1) [8].

2. The Description of the Technical Solution

Lithologically, the soil nature determined up to 20 m depth intercepted an almost uniform stratification composed of clays. Thus, the layer composition appears as follows: silty clay up to (3-4)m; next is the yellow clay with a thickness of (3-6)m; then a clay in which the water comes under pressure, with the thickness of (0.5-1)m; next comes clay marl „Table 1". Based on the Normative of the regulatory framework of flexible sizing and semisolid road, these types of soils are in the ''P5'' category of soils.

Seismic area: coef af.=0.12 Corner period: Te=0.7sec

The level of the phreatic cloth is high, the

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water reaching the drilling surface after little drilling.

ln Figure 2 and 3 are presented the first and second plan of sliding surface.

In the tables below are presented: the Meshing land „Table 2" Coefficients pushing and inclinations „Table 3". Thrust and point of application results „Table 4" Thrust and point of application results „Table 5.

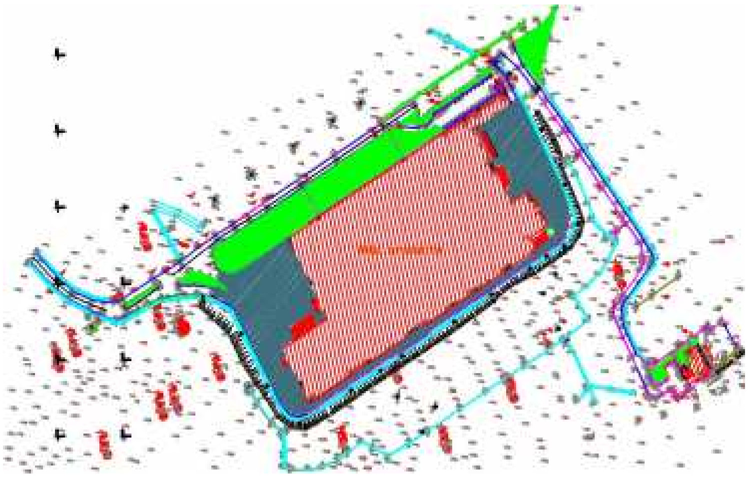

Fig. 1. *Emplacement of the stability system designed to land sliding*

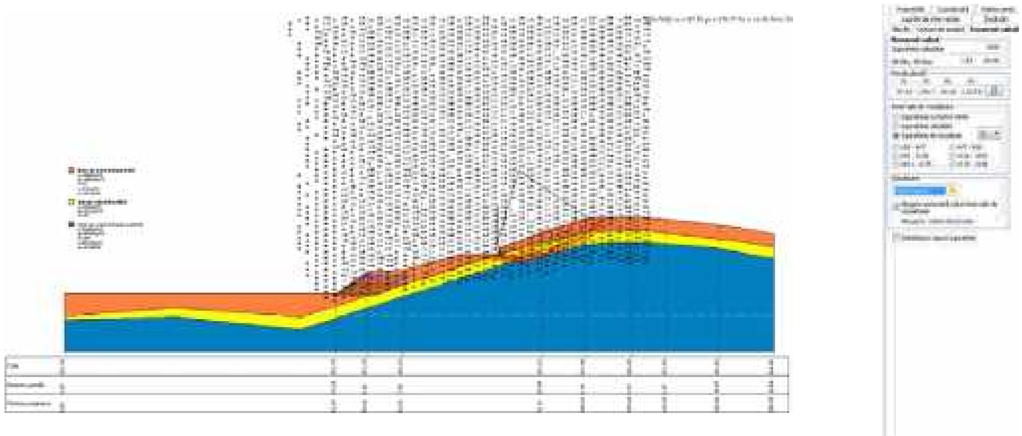

Fig. 2. *First plan of sliding surface*

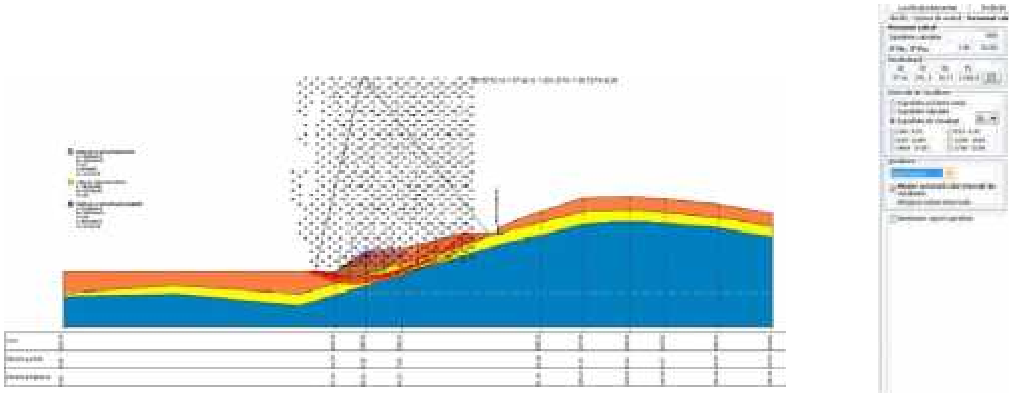

Fig. 3. *Second plan of sliding surface*

Lithology of soil Table 1

Layer	c(kN/m2)	cu(kN/m2)	Fi(°)	G(Kg/m3)	Gs(Kg/m3)	K(Kg/cm3)	Lithology
1	50	50	6	19.00	1950	0.00	Soft clay or silty clay
2	0	0	25	19.5	20.5	0.00	Sand or loose powdery sand
3	20.5	40	30	2100	2300	0.00	Clay or silty clay consistent

Meshing land Table 2

	Qi	Qf	Gamma	Eps	Fi	Delta	c	ß
Meshing land	6.0	6.0	2100.0	0.0	15.0	3.0	20.0	0.0

Qi Share initial layer;
Qf The final share layer
Gamma Volume weight (Kg/m3);
Eps Tilting layer (°);
Fi Angle of internal friction ;
Delta Field wall friction angle (°);
c Cohesion (kN/m2);
β Perpendicular to the upstream side wall angle (°)

Coefficients pushing and inclinations Table 3

	μ	Ka	Kd	Dk
Coefficients pushing and inclinations	87.0	7.57	0.62	0.05

μ Steering angle thrust
Ka Active thrust coefficient
Kd Dynamic thrust coefficient
Dk Dynamic coefficient increment

Thrust and point of application results Table 4

	Fx	Fy	Z(Rpx)
Active push	210.11	11.01	0.0
Seismic push increment	19.9	1.04	0.0
Pushing static overload	0.0	0.0	0.0
Push inc. seismic overload	0.0	0.0	0.0
Wall weight	15.5	258.25	0.0
Stabilization time	1918.39 kNm		
Overturning moment	5.52 kNm		

Fx Force in the x direction (kN);
Fy Forces in the y direction (kN);
Z(Rpy) Ordered resultant point of application of thrust (m).

Thrust and point of application results Table 5

Check to travel	
Amount horizontal forces	245.51 kN
Amount of vertical forces	270.31 kN
Friction	0.36
Adhesion	30.0 kN/m2
Slip plane angle	360.0°
Forte normal to the plane of sliding	270.31 kN
Forte parallel to the sliding	245.51 kN
Coef. CSD for safe travel	**2.25**
Move checked Csd> 0	
Check rollover	
Stabilization time	1918.39 kNm
Overturning moment	55.52 kNm
Coef. The rollover safety Csv	**34.55**
Wall verified rollover Csv> 0	

Movement check	
Amount horizontal forces	245.51 kN
Amount of vertical forces	270.31 kN
Friction	0.36
Adhesion	30.0 N/m2
Slip plane angle	360.0°
Normal forces to the plane of sliding	270.31 kN
Parallel forces to the sliding	245.51 kN
Coef. CSD for safe travel	**2.25**
Move checked Csd> 0	
Rollover check	
Stabilization time	1918.39 kNm
Overturning moment	55.52 kNm
Coef. The rollover safety .csv	**34.55**
Wall verified rollover Csv> 0	

Reinforced Soil (Fig. 4):

To face the stabilisation problem, not only the equilibrium equations but also the constitutive relationships (which describe the soil behaviour) are to be considered.

These are complex equations, for the soils, are multiphase systems which turn down to a monophasic system but only in dry or drained conditions [3,4]. In most of the cases, we are dealing with a material that, when is saturated or at least biphasic, hampers the use of equilibrium equations [5]. It is almost impossible to define a constitutive law with general validity, only based on soil anisotropy and nonlinear behaviour with small deformations depending on the deviatory and normal stresses. Because of these difficulties, simplified assumptions are introduced:

(a) Simplified constitutive laws are used (a rigid-perfectly plastic model).

It is assumed that the material

strength is expressed only by parameters such as cohesion (*c*), angle of internal friction (ϕ), constant for the land and characteristics of the plastic state.

Hence, the Mohr-Coulomb failure criterion is supposed valid [6,7].

(b) In some cases the equilibrium equations are only partially satisfied.

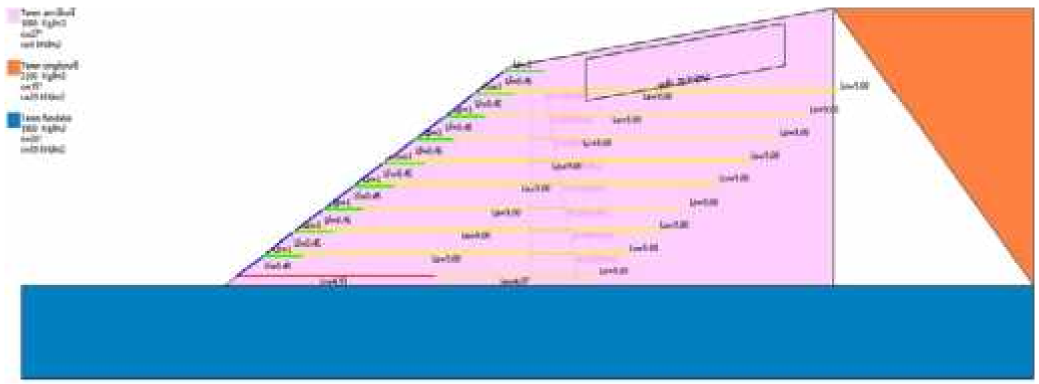

Fig. 4. *Reinforced Soil*

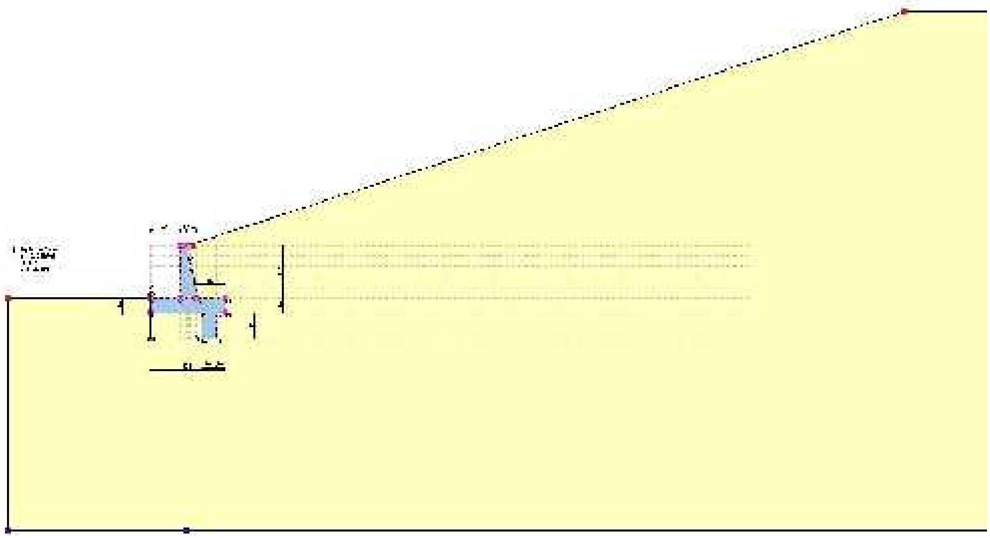

Fig. 5. *Support wall*

The retrofit proposed approached the unified platform around the entire perimeter and acted on several levels as follows:

* On the southern side, upstream was provided to plant sloping stable, which meant creating a retaining wall of "geogrid" reinforced earth with 4.0m height (Fig. 5). The prevention of infiltration of rainwater from upstream was provided by using a reinforced culvert ditch guard role. Also at the base of the

upstream embankment were provided two short drains in the form of a "Y" that unloads water that drains from the base of the wall (Fig. 5). The same base of the slope was provided a reinforced slope with the role of retrieving rainwater from the slopes.

Geotechnical study shoes that the ground waters are flowing and have a buoyancy course in the loamy sand and clay marl are taken by a drain screen deep depth between 3.0 and 6.0m. By cutting groundwater flow at this level prevents sliding creating a potential plan of depth.

The drain and reinforced earth retaining wall in the shape of a horseshoe and is drained more downstream through specific arrangements in the two natural emissaries [8]. Also on ground platforms equipped for future expansion of the plant was expected to achieve drained trenches that are conducted in a drain located on the north side.

Acknowledgements

The main cause of the landslide was the excavation with a big slope that easily activated the instability and the phenomena.

The underground water current had also a major impact in the activation of the landslide.

Some earthworks need more attention from design to build and are not over conservative to look and overlook at the possible problems that could occur on the site. Not fulfilling part of the consolidation project may create serious damage to the whole building. Research done in this situation requires the use of all elements that ensure the stability of the area. Partial realization of the system is serious malfunctioning in other parts operation, which had a unitary thinking. Also degradations caused due to breaching proposals made brain can create serious damage over the entire building and even affect the stability of the area.

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