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FINITE ELEMENT MODELING OF GROUND MOVEMENT ON THE ROAD CW16 SÉRAIDI -CHÉTAIBI (ANNABA, NE ALGERIA)

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ABSTRACT

Grounds movements are considered a natural hazard, some of which have, over time, significant slow movements. Significance of these dynamic effects involves a risk which generates human and material damage. Policymakers must take this issue into account in their permanent security organization program. Some landslides exhibit a function of time, significant slow movements. They are assigned to a behavior of clay materials mechanism caused by the variation of geotechnical properties. The effects of water seepage in wet periods generally linked to the viscous nature of clay materials are causes primarily .They can also be related to the variation modeling parameters. The land slip site is located at the road CW16 Seraidi -Chétaibi, (Annaba, Algeria) area with an annual rainfall of more than 700mm. Analysis of the slope stability is carried out using several methods of deformation calculation of the natural ground state. In our case we use a plastic Mohr Coulomb from supported models. The project proposes to examine the different causes using the example of Cam Clay. The project will examine the different causes using the example of Cam Clay; elasticvisco plastic model with time (SSCM: Soft Soil Creep Model) set in a finite element program Plaxis. This technique can show us how different behavioral assumptions can describe the slow movements of a slope. A comparison will be made with the Mohr Coulomb (MC).

Keywords: Mohr Coulomb, slip, numerical modeling, plaxis, cam clay, elasticvisco plastic model.

INTRODUCTION

Landslides are increasingly common thus causing substantial socioeconomic concerns the authorities of the region and surrounding territories. Predicting these risks in particular as regards landslides is therefore essential. Predicting these risks is therefore essential in particular with respect to landslides Veder (1981). With regard to these movements, traditional analytical and numerical approaches are limited today Lamri (2008). From a mechanical point of view, the stability problems of this field of dynamics has long been studied in connection with the theory of plasticity Doherty *et al*. (2012), Bensmaine (2011), Bartlett (2010), Rice (1976), Mandel (1966) and Hill (1958).

With the creation of geotextiles, the first approaches were the hypothesis of associative behavior of geomaterials, Plessis (2011) and Fernandes (2009) that is to say, the yield strength was supposed confused with the rule flow, which implies that the static and kinematic slip lines are merged Darve and Louafa (2000). In this case, the breaking occurs when the angle of the slope is equal to the friction angle at rest of the material. The slope instability has been described numerically using two approaches: the plasticity theory Duncan (1996) and the localization theory of plastic deformation bifurcation forming shear bands Rice (1976).

The finite element modeling must be relevant and predictive. Geotechnical the objective of the latter is often the search for an answer, solution to a complex problem. Numerical modeling is a powerful tool, it is steadily increasing for over five decades Batista (2011). Over time, some landslides haves low movements of a few tens of centimeters per year. These natural risks remain partially unexplained under conventional methods. This is the case for example landslides appearing in low slope that contradict the traditional stability analyzes (Huynt, 2005).The identification of long movements currently an important issue for the problems in the field of advanced soil mechanics Chelghoum (2006).

Recent technical analyzes are needed for these failure modes. Today, the finite element method intervenes in all areas without exception.

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In order to understand and predict landslides, various other research ideas are essential. It is to look at a specific example and to determine the relative influence of various parameters that control destabilization gravity, by modeling this phenomenon Bachmann (2006). The estimate of this stability compared to the risk of rupture is one of the major problems in geotechnical especially in the area of limited or little known data. The results obtained by Lambe (1973) Al Hussein (2004) are the product of measurement methods for parameters and methods of calculation and it stated that the results must be assessed in the light of these two elements.

The soil characteristics are complex, variable in space and in time. Thereby, the parameters that must be introduced in the geotechnical calculations are often poorly understood. Baheddi *et al*. (2016). Many soil constitutive models exist to represent most of the actual behavior of soils, approached these models can be used with some confidence in the calculations, provided you choose the parameter values Levasseur (2007), Hejazi *et al*. (2007). The equations defining soil behavior are complex and highly nonlinear, in the analysis of geotechnical problems (such as the analysis of slope stability) to solve the equations are often nonlinear Ezaoui and Benedetto (2007). Looking through this work a special focus on understanding and modeling of the phenomena that led to the destabilization of a clay soil and the spread and evolution of the slip over a long period.

MATERIALS AND METHODS

Road slip CW16 (Seraidi Chétaibi)

Share the site geology is characterized by rocky outcrops formed on massive plate gneisses more or less fractured and mica schist altered on the surface formed with sloping colluvial silty with gravelly sediments, gneissic fields.

The slip is generated after the enlargement of the road as part of the development of tourist areas, planned investment program in this area (Fig. 1a). Site visits have allowed us to address the details of the ground motion and deduce the following observation:

- Clear vertical drop by breaking up the slope with circular limits on odds.
- Setback in niche form breakout to the upside of the road (Fig. 1b).
- Sagging at the half floor down side slope.
- Indicator embankment carrying shrubs at the foot of the slope.
- Humidification presence at the beads.
- The field surveys in four three-month periods show the speed of travel on the road more than 50 cm over a length of more than 100m.

a)

b)

Fig. N 1. View of the slip road CW16. Séraidi - Chétaibi.

Role of Plaxis software in the slope

The present research performed by finite element code Plaxis clarifies nonlinear modeling tool in elasto - plasticity not associated with consideration of pore pressures by Chaboche (2002), Haboussa (2013), Géniaut, (2009) and Aubertin *et al*. (2003). Numerically, the software uses high-precision components (triangle 15 knots), and recent resolution steering process (of arc length method). The general algorithm used in solving the code Plaxis is based on the Newton-Raphson remains relatively robust method to solve problems integrating complex behavior patterns (Boulon and Flavigny, 1997).

Graphical representation of the mesh

The making of the mesh is a numerical model presented in Figure 2. This mesh is composed of 403 triangular elements (15 knots, 12 integration points) or 888 knots.

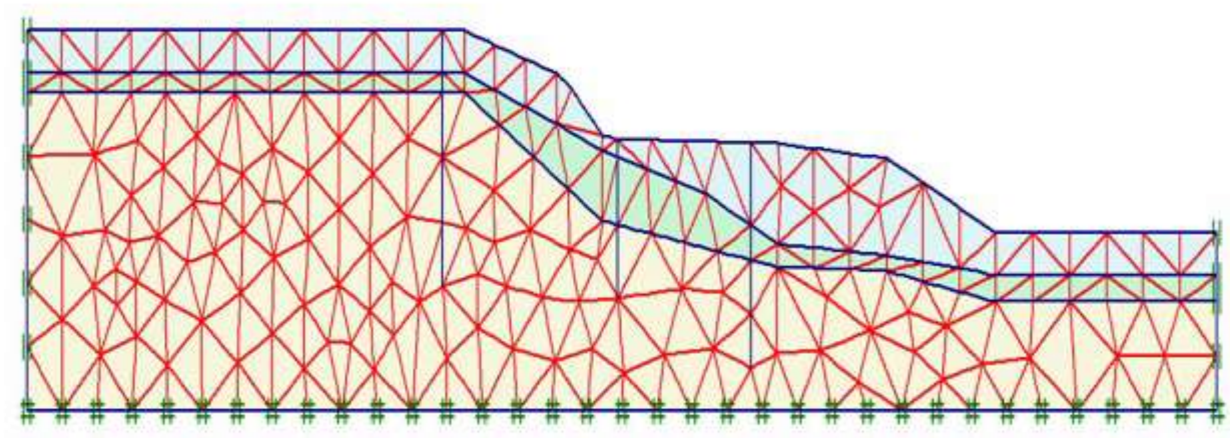


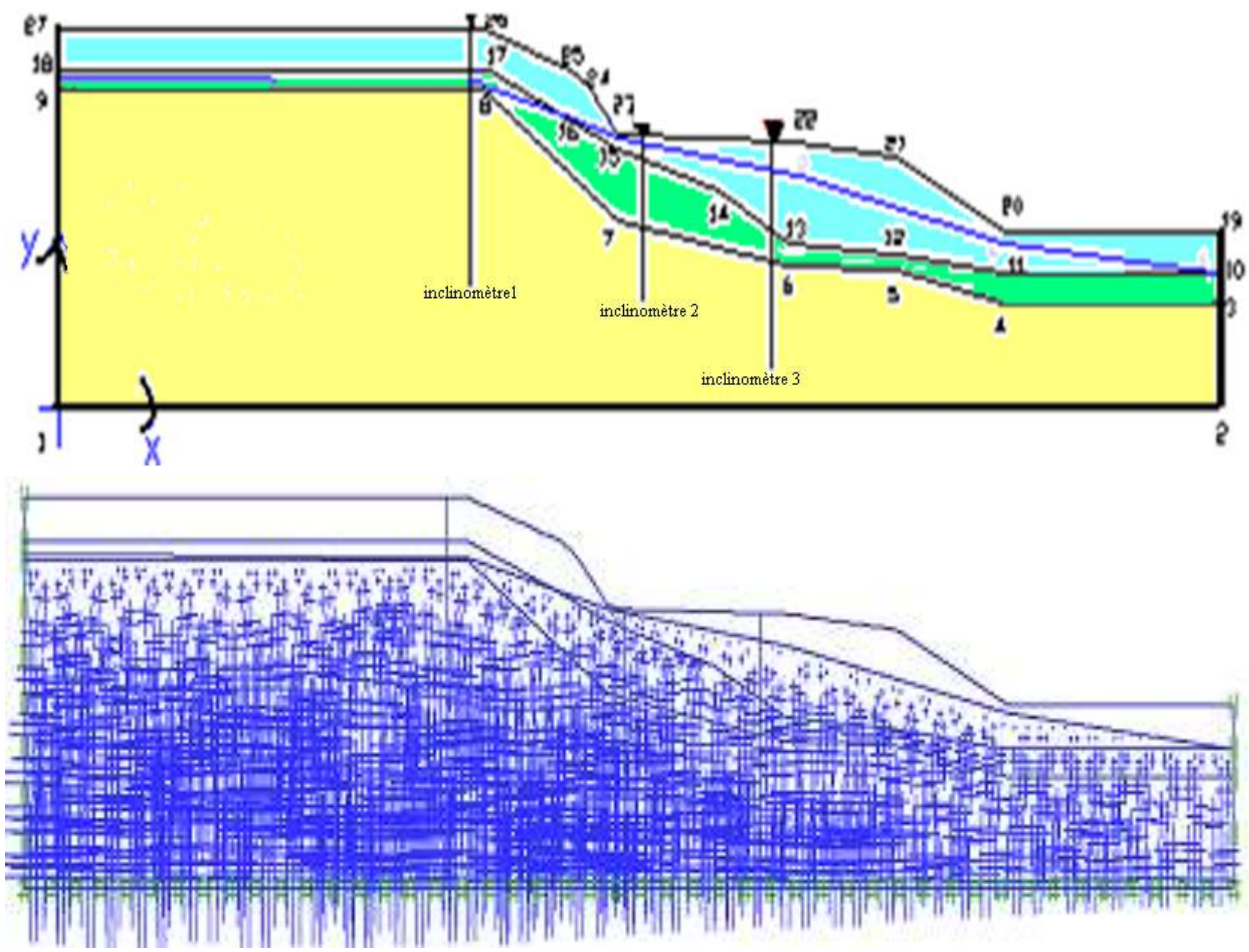
Fig. N2. Geometry, mesh and boundary conditions by finite elements.

Conditions to mechanical limits

The conditions trips are also present in Figure 2. We impose zero horizontal displacements along the X axis on the limits to the left and right of the vertical model and zero along the Y axis on the bottom of the massif.

Conditions to hydraulic limits

Defining levels of the water table is shown in (Figs. 3a,b.).. The pore pressure initially is 414.38 kN / m2.



a)

b)

Fig. N3. Initial level of the water table, initial stresses hydrostatic.

Behavior model and mechanical characteristics

The study conducted only concerns the identification of the component parameters of the Mohr Coulomb model and the SSCM model, inverse analysis, from the results of inclinometer measurements of horizontal movements of the ground Levasseur (2007). To obtain a landslide reference model, we used a direct method of solving the inverse problem (Bartlett, 2010). Values are given to a priori unknown parameters to simulate the direct problem associated with the calculation of finite element code Plaxis. The main parameters of MAS model for three types of materials are summarized in Table 1 Belkeziz (1982).

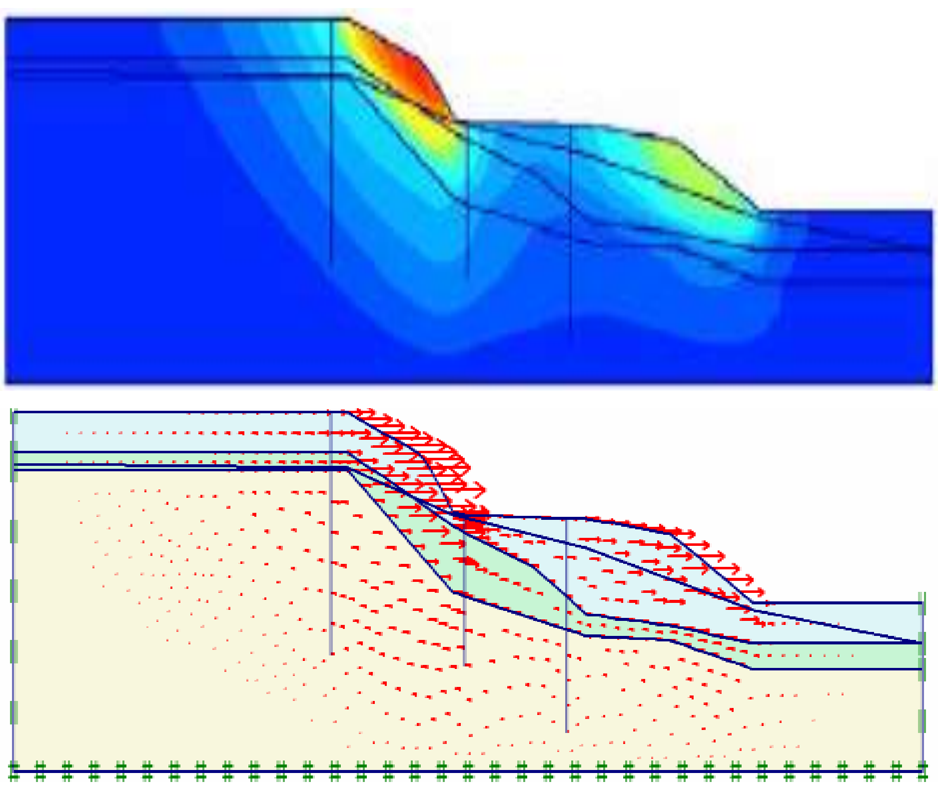
Table. N1. Characteristics physical-mechanical soil.

Layer N°	Type	γ_{unsat} (KN/m3)	γ_{sat}(KN/m3)	*Kx*	*Ky*	λ^*	κ^*	μ^*
01	drained	17,00	19,50	10^{-10}	10^{-10}	0,0120	0,0070	10^{-5}
02	drained	17,00	17,50	10^{-4}	10^{-4}	0,0089	0,0048	10^{-5}
03	drained	18,00	21,50	10^{-12}	10^{-12}	0,0089	0,0038	10^{-5}

Layer N°	Type	K_0^{NC}	*M*	*Cref*	φ	ψ	R_{inter}	ν_{ur}
01	drained	0,815	0,57	13	15	0	1	0,15
02	drained	0,652	0,99	10	25	0	1	0,15
03	drained	0,654	0,99	55	25	0	1	0,15

RESULTS AND DISCUSSION

Figure 4 shows clearly the area where the total deformation is the most important and Figure shows a concentration of the movements along the slope. Displacement has allowed us to detect that the break occurs on a circular surface, so there is a strong commitment to the upstream slope and heads downstream to the foot of the slope. The figure also detects unstable areas in the ground; the red color represents the values of significant displacements (unstable points). These movements are the result of the sum of the elementary deformations created at any point of the massif by changing the initial stress state. Over the maximum displacement of the bank reached 81.76 mm. Note that these movements are calculated relative to the initial configuration.



a)

b)

Fig. N4. Horizontal displacement.

Safety factor

The results shows the existence of the critical values beyond which the calculation diverges, that is to say that the state of equilibrium is not reached.

From the curves shown in Figure 5, over the embankment has undergone a maximum settlement of the order of $54{,}69.10^{-3}$m, and a horizontal displacement Ux of $66{,}19.10^{-3}$m. The average value of the safety factor is ΣM_{sf} = 1,117.

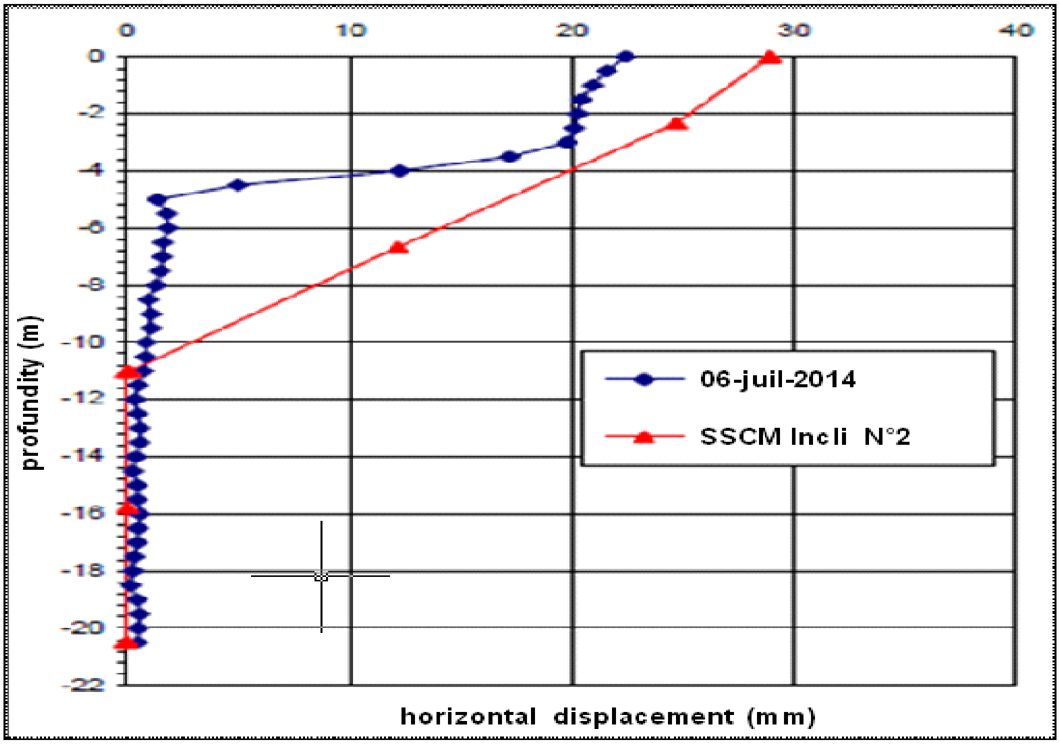


Fig. N5. Ux, depending on the profundity.

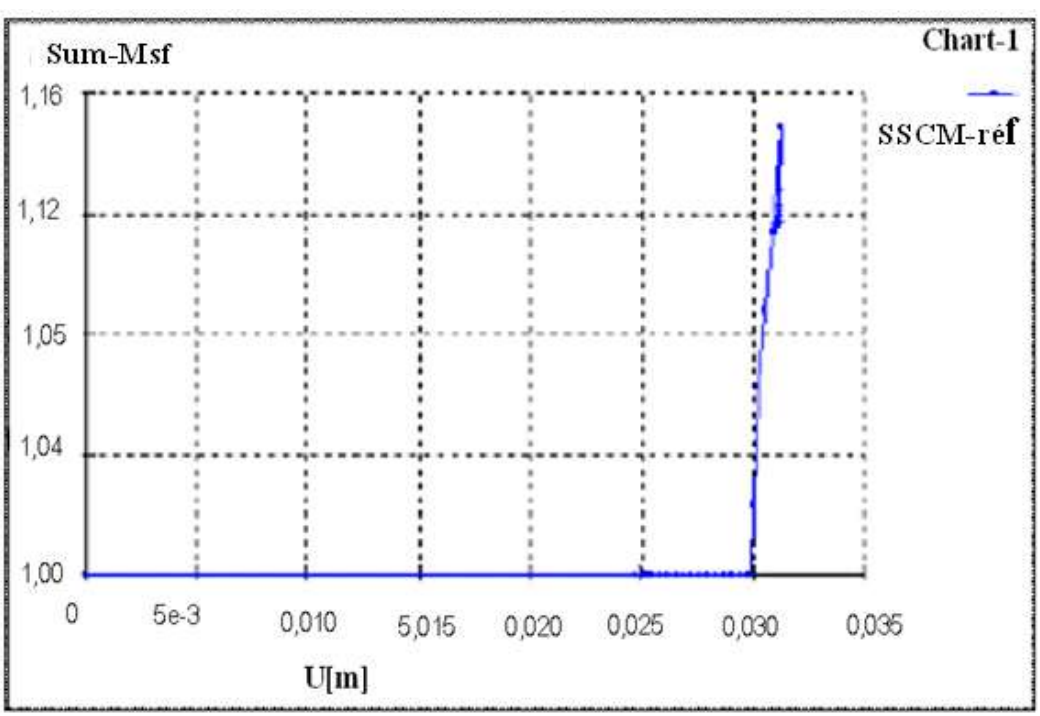


Fig. N6. Safety factor = 1.117 Msf.

Influence of the groundwater fluctuation

This parametric study shows that the gradual rise of the groundwater causes an increase in the effective stress. Will influence the effect of soil compressing, causing a slowdown in surface and large displacements, which appreciates a net decrease of the safety factor see Figures 6, 7,8 and 9 (Rangeard, 2002; Plassart, 2011).

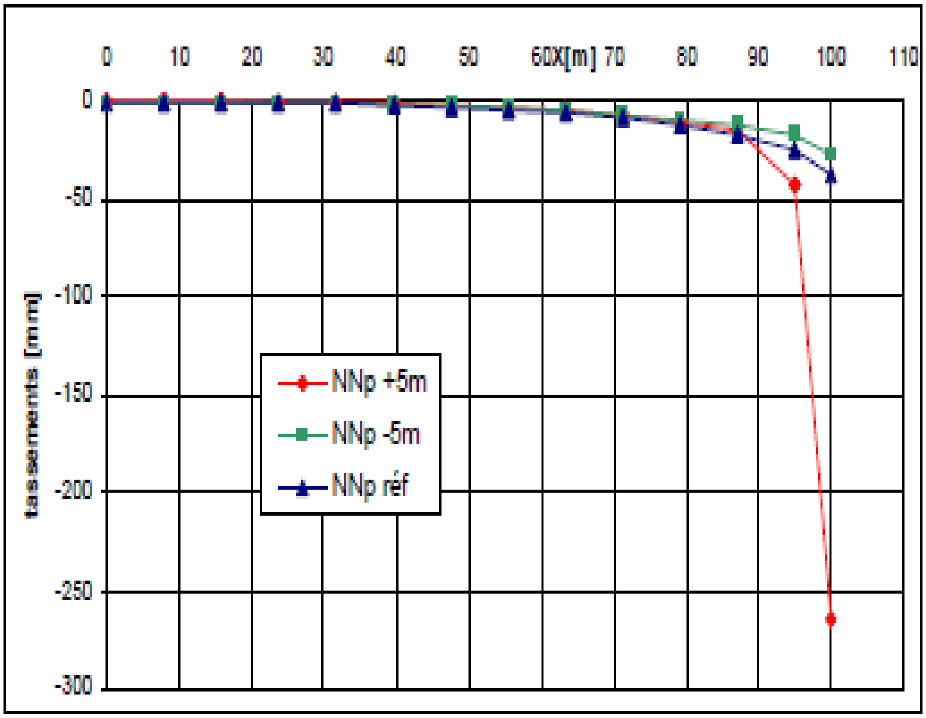


Fig. N7. Influence of fluctuation in the groundwater on settlements.

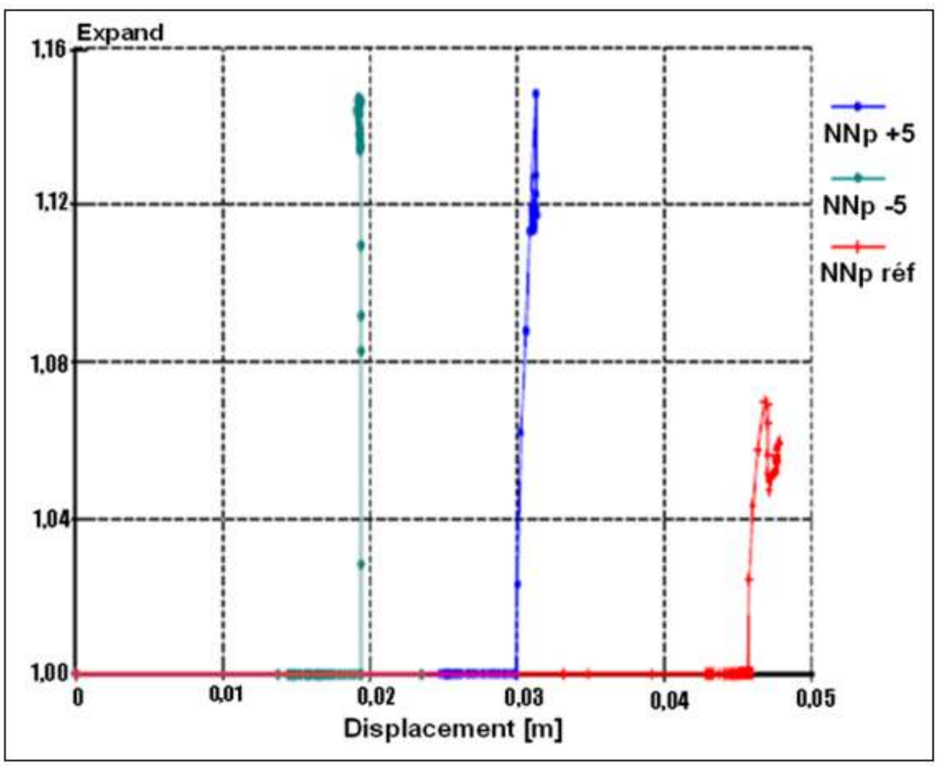


Fig. N8. Influence of fluctuation in the groundwater on the safety factors.

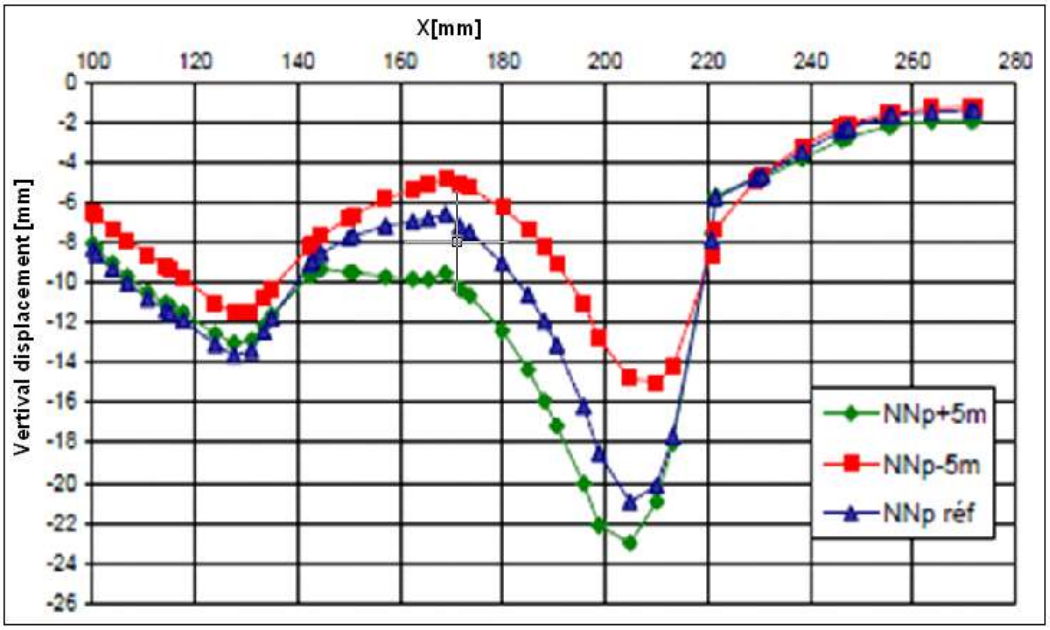


Fig. N9. Influence of the fluctuation of groundwater on the slope displacements.

Effect of behavioral model

To simulate the behavior of soil mass, we choose to model the same problem but with the limits of other behavior patterns Papon (2010) and Bensmaine (2011). A comparison between HSM behavior patterns and Mohr of SSCM reference be made Mestat (2006) and Al Hussein (2004). The Mohr Coulomb module equivalent to the module defined in the model Hardening Soil is calculated by the following formula:

$$E_{50} = E_{50}^{ref} (\sigma'_3 / p_{ref})^m$$

Calculation results obtained are shown in Figures 10,11 and 12.

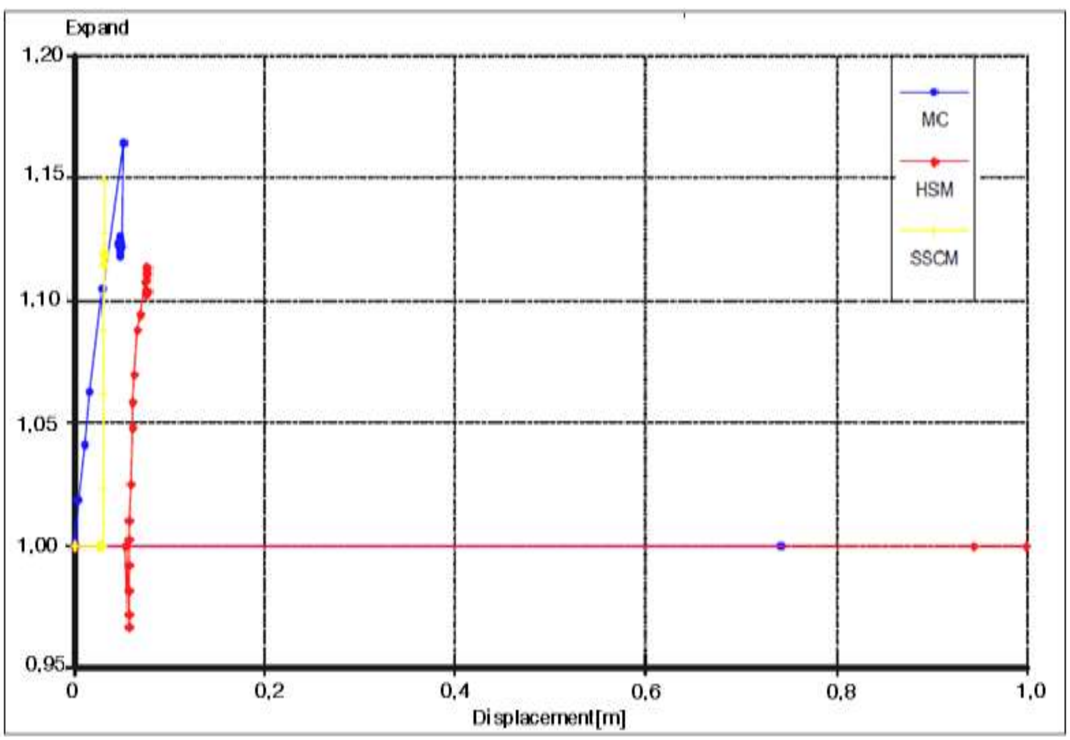


Fig. N10. Behavior model influence on the safety factors.

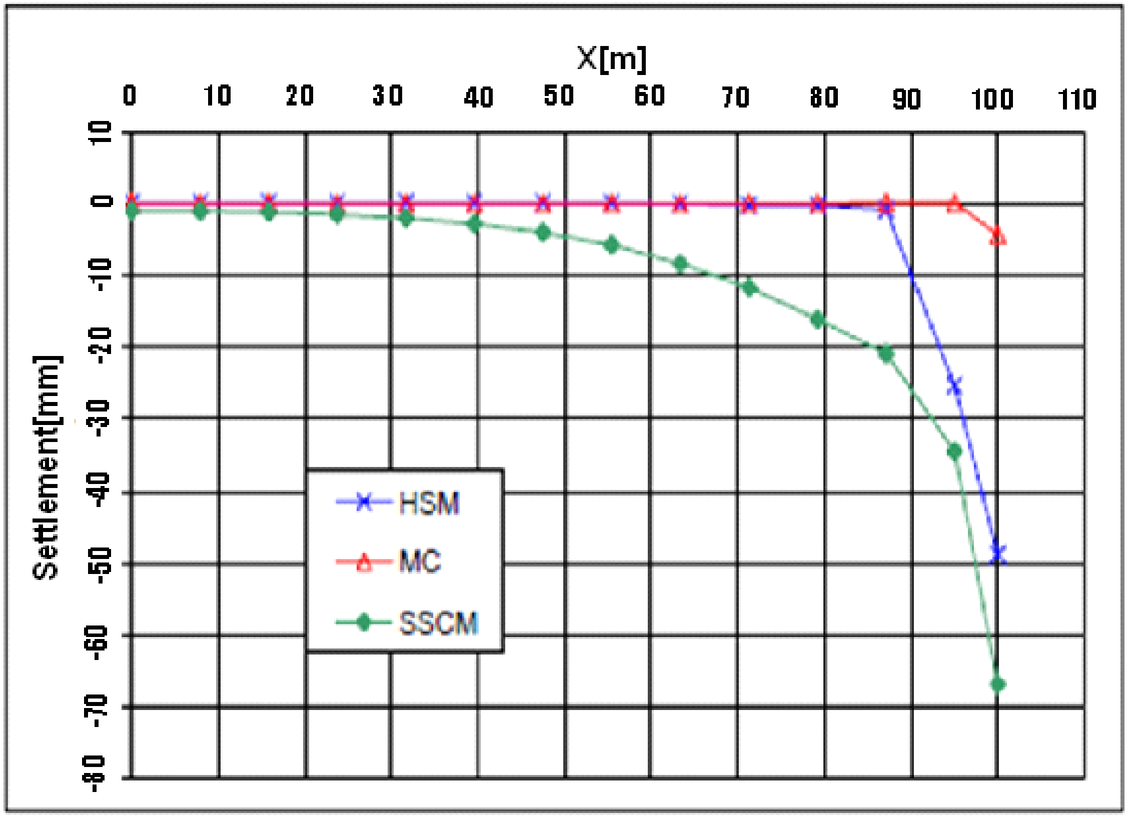


Fig. N11. Behavior model influence on settlement.

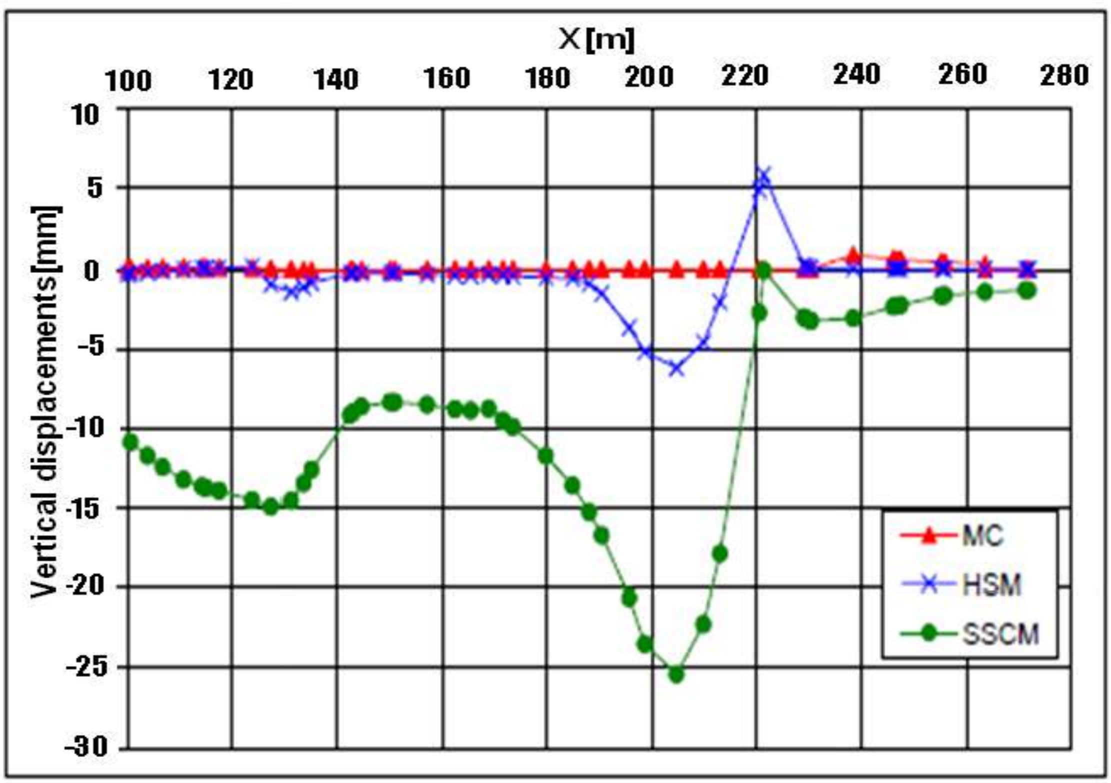


Fig. N12. Behavior model influence on slope displacement.

From these results, it is found that:
- The safety factor Mohr Coulomb model is more important than the SSCM model HSM
- The settlement obtained with MAS model are very important (66.72 mm) in comparison with the settlement obtained with the model HSM (48.74 mm), while the settlement obtained by the Mohr Coulomb are very low (4.39), although, visual parameters (Haboussa, 2013), cohesion, friction angle and dilatancy angle are the same. This is because it incorporates in the soil compaction for the SSCM model, the secondary compaction layers of clay under their own weight.

- The displacement of the SSCM model present significant displacement (25.37 mm), the HSM model has smaller displacement (6.66 mm) with an uprising in nival foot of the slope (5.87 mm).
- The displacements obtained using the model MC are very low (0.08 mm) with a lift at the bottom of the slope (0.088 mm).

CONCLUSION

Various numerical parametric studies were conducted to analyze the influence of the modeling parameters and soil properties on the landslide mechanism developing in the massif. The fluctuation influence of groundwater has also been explored, and the effect of the choice of the behavior model Rangeard (2002) and Ezaoui (2007). This parametric study highlights the major influence of the internal friction angle of the soil on the safety factor and the surface settlements. As the friction angle, as the surface subsidence are low. The increase of cohesion increases the mechanical properties of the soil; the increase of cohesion increases the mechanical properties of the soil; more cohesion is great more settlements are reduced and the rupture then reached for low cohesion Akpila (2013). The dilatancy angle has little influence on the safety factor. However, this parameter has no influence on surface settlements. This parameter controls the intensity of volumetric strains when laminating. The parametric study on the influence of various parameters of SSCM model may possibly shed more light on the divergence of the numerical results Hejazi (2007) and Batista (2011). In behavioral models Mohr Coulomb and HSM Lamri (2008), the comparison of numerical results with reference results (SSCM) shows that digital modeling with the Mohr Coulomb underestimates surface settlements Al Hussein (2004).

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