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Study of soil-retaining wall interaction by the contact finite element method

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ABSTRACT: The increasing use of numerical modelling in works studies confers a significant role on the results of calculations by the finite element method. Their reliability are always attached to the starting assumptions and to the behaviour models used. The aim of this exploratory research is to analyze the contribution of these numerical methods in studying and dimensioning of the retaining walls. In this study, an elastoplastic model was applied on the soil, by using the contact finite element method. Ansys software is used, to simulate the behaviour of the soil and consequently retaining wall in order to determine the principal parameters influencing its stability. The found results were compared with those of the methods of calculation used in the literature.

1 INTRODUCTION

The retaining walls are works used to maintain grounds or all other materials for which stability is not assured naturally (Djeddid AEK). The aim of this exploratory study is to analyze the contribution of the contact finite element method to studying and the dimensioning of the retaining walls.

2 PRESENTATION OF THE MODEL

The use of the Ansys software permitted a choice of a contact element 2D (contac-12), which simulate perfectly soil-wall friction (Dhatt, G. & Touzot). Contac-12 represents an element constituted of two points belonging to two surfaces which may be

- Maintained together and which slides.
- Maintained together without slides.
- Separated from each other.

This element is able to support a compression in the normal direction and a Shearing in the contact plan. It has two degrees of freedom in each node representing a translation in x and y directions (Fig. 1).

The wall as well as the soil is subjected to their actual weights. The materials used are supposed to be homogeneous and isotropic. The characteristics are summarized in table 1.

2.1 *Notice*

The characteristics of soil, concrete and the geometry model are the same used in (Mestat et al. 2000).

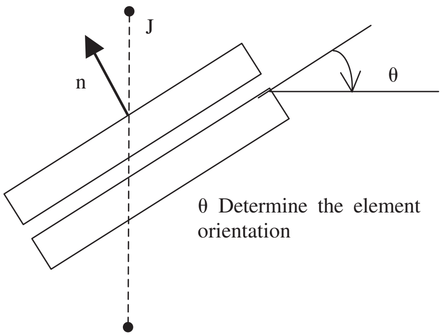

Figure 1. Element contac-12.

Table 1. Properties of soil and concrete.

Volumic weigh	Young modulus E (Mpa)	Poisson coefficient (ν)	Cohesion (Kpa)	φ'°
20	90	0,3	0	30
24	20.000	0,2	–	–

In this model the soil-wall friction has been simulated in the three faces of the pile, at the level of the base and its two side surfaces. The conditions of the interfaces are supposed perfectly stuck. The iterative model chosen is the one of Newton-Raphson (Fig. 2).

An automatic and manual combined grid has been chosen for the general structure with quadratic iso parametric elements at 08 nodes. For contact interfaces a standard elements of contact springs (conatc-12) was used. The grid takes the following form: (Fig. 3).

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The analysis was carried out in two principal stages. The first consists in studying the friction effect of soil-wall and the second studies the effect of the geometry of the wall and in particular the slope of its upstream face on the distribution of the contact stresses. The obtained results were compared with the principal theoriotical methods studying the retaining walls which are Rankine's and Coulomb's method.

3 RESULTS AND INTERPRETATION

Modelling consists to apply the weight of the embankment and to activate the soil-wall contact elements with a friction estimated at 2/3 φ (Ras, A). Under the effect of its actual weight, the embankment packs and involves partly the wall caused by the contact rigidity taken into account in the modelling soil-wall, which is equal to the lowest rigidity of two materials. The wall is thus drawn upstream (Fig. 4). This kinematics also generates tractions in the soil close to the top of the wall and causes the separation of some points. On the other hand, at the bottom of the wall a majority points are sliding.

Plasticity appears in a much localized zone at the bottom of downstream of the wall (Fig. 5). This zone is characterized by a great separation of points what generates an inconsistency between the results obtained numerically and analytically according to the downstream pressure stresses diagram (Fig. 6). This verification shows the complexity of the step when mix the processes of resolutions of the interfaces problems (traction-slip) and plasticity. On the other hand the two methods analytical and numerical were coherent in pressure diagram (Fig. 6) as well as the corresponding forces by posting an error rate of 4.91% compared to the theory of Rankine and 20.31% compared to the theory of Coulomb.

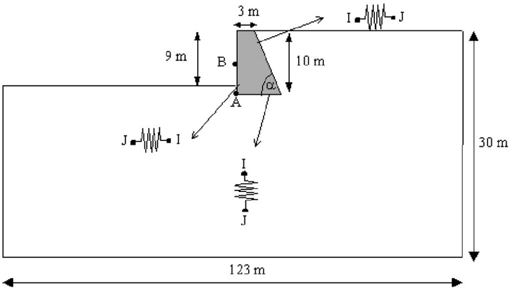

Figure 2. Modelling of soil-wall interaction.

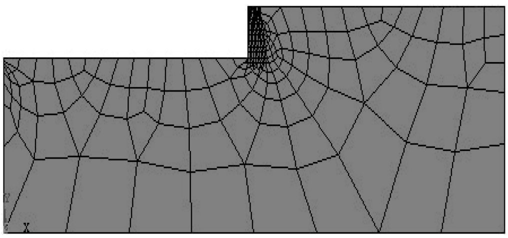

Figure 3. Grid in quadratic Iso parametric elements at 08 nodes and contact-12.

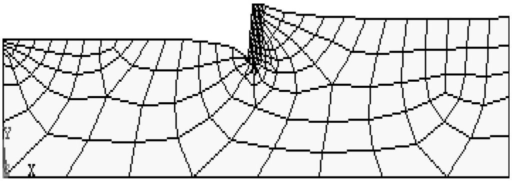

Figure 4. Deformed shape.

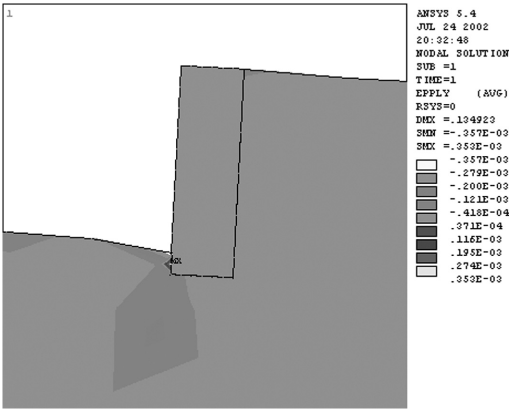

Figure 5. Plastic strain.

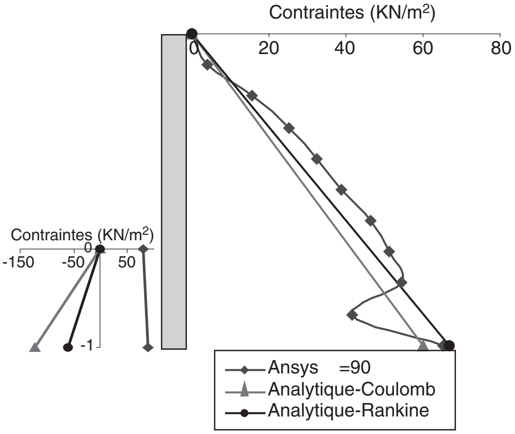

Figure 6. Pressure and stabilization stress diagram.

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The results of this first analysis, tend overall towards those obtained by the Rankine theory what reinforces its assumption to be unaware of friction between the wall and the soil. This remark was confirmed by a second analysis where friction soil-wall was removed. The curve of the pressure stresses obtained was literally superimposed on that found in fig. 6.

If the effect of the downstream stresses pressure and the wall surface, are neglected, only one parameter remains and can influence its stability, it is the slope of the upstream face.

3.1 *Effect of the upstream face slope*

The fig. 7 represents the pressure stresses diagrams for various positions of the face upstream. The curves of pressure are all concentrated in the same zone and post only small differences in their maximum values what is in agreement with the theoretical results theoretical as table 2 shows it.

On the other hand the examination of the forces in contact with this facing revealed a very significant rise of the stabilizing forces (vertical) then that they were multiplied by 8.6 against a rise from approximately 20% of the pressure forces (table 3).

To finish this analysis the distribution of the contact stresses at the bottom of the wall was studied. The results of the fig. 8 show a total inconsistency between the numerical and analytical results since it envisages a triangular distribution meaning that the resultant of the forces of reactions of the soil being apart from the central square (E > B/6), on the other hand, the numerical results shows a trapezoidal distribution. This divergence is due mainly to the mode of instability which envisages analytically an inversion around point A at the base of the downstream face. But, simulation revealed a compressing (Fig. 4) soil involving the wall to the upstream, which supposes an axis of rotation passing by the point B at the middle height of the downstream face. This mind remains very vague because the slip which it is operated under the wall returning the determination of the axis of rotation is very difficult.

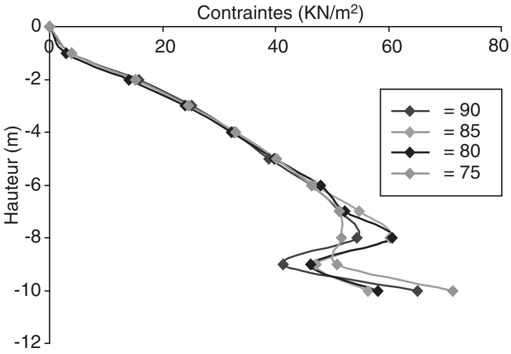

Figure 7. Pressure stresses diagram according to α.

Table 2. Values of the calculated and deduced pressure ratio.

Ka α	90°	85°	80°	75°
Ansys (σ_H/σ_V)	0.34	0.31	0.33	0.37
Coulomb	0.29	0.33	0.37	0.42
Rankine	0.33	0.33	0.33	0.33

4 CONCLUSION

A parametric study on three factors influencing the behaviour of a retaining wall was undertaken by

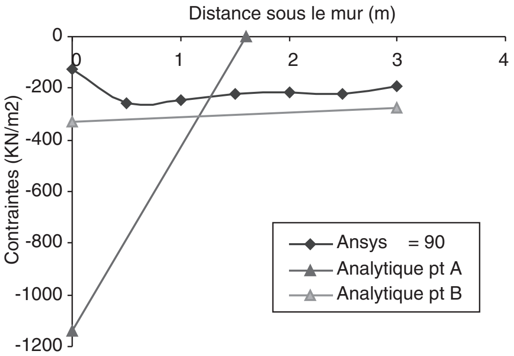

Figure 8. Distribution of the contact stresses at the bottom of the retaining wall.

Table 3. Stabilizing and pressure forces at the upstream of the wall.

α	85°		80°		75°		70°	
Force	F_x	F_y	F_x	F_y	F_x	F_y	F_x	F_y
Ansys	350.58	36.06	382.16	106.83	405.38	173.98	420.56	273.74
Coulomb	279.38	101.68	314.70	114.64	354.17	128.90	398.92	145.19
Rankin	333.33	0	333.33	0	333.33	0	333.33	0

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introducing contact elements between the soil and the structure. The results obtained by this modelling reveal that only one of these parameters is able to ensure more stability, it is the slope of the upstream face which generates a significant growth of the stabilizing forces. On the other hand the results of the two other parameters appeared of very weak influence for friction soil-wall and erroneous for the downstream soil stress pressure. Finally the evaluation of the distribution of the contact stresses at the bottom of the wall was interesting especially on the qualitative level since it indicated a direct relation between the mode of instability and the distribution of these stresses. Néo minus this work highlighted also the limits of the numerical methods to solve the slip problems in the interfaces soil-structures interfaces since this phenomenon generates a rearrangement of the grains of the soil what can not easily be simulated numerically.

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