Contact Effect on the Dam Core Dimensions (Case Study in Algeria: El-Izdihar Dam)

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ABSTRACT

The stability of an earth dam with thin core is ensured by the upstream refills massifs. Earth dams with thin cores are lightened by the contact effect with refills massifs. A study of mechanic behavior taking into account the contact effect was performed for El-Izdihar earth dam without reservoir water effect which permits to predict its behavior and estimate the core thickness beyond which the contact has no effect. The finite element method was chosen as a method for the modeling.

KEYWORDS: Earth dams, Contact effect, Dam core, Algeria.

INTRODUCTION

Contact phenomenon and the corresponding friction coefficient are very important in a variety of engineering problems. In cases where significant differences of material properties between the structure and foundation soil occur, serious problems in theoretical and numerical modeling of interaction between the structure and the adjacent soil exist. These problems are often met for dams (MarcinMazdziarz).

A large literature is available for the treatment of contact phenomenon; for example, Goodman, R.E. et al. in (1968) used the contact elements to treat the contact problems (Goodman et al., 1968).

Hermann, L.R. (1976) did not use contact elements but a combination of normal and tangential springs to model the contact phenomenon and to control both sliding and uplift at contact interfaces.

In the present article, an analysis of the contact effect between the clay core and the refills massif and between the clay core and the foundation was conducted.

Two cases have been compared to understand the contact effect on the static behavior of El-Izdihar dam situated at Sidi El-Abdel, Tlemcen, Algeria.

In the first case, the interfaces core-filter (core-refills) and core-foundation were supposed bounded.

For the second case, these interfaces were modeled by contact elements available in the ANSYS code library. Four friction coefficient values (0%, 10%, 20% and 50%) have been chosen for contact elements to view the effect of the friction coefficient on the mechanical behavior of the dam object of the present study.

FINITE ELEMENT MODELING OF EL-IZDIHAR DAM

This study deals with the earth dam El-Izdihar located in Tlemcen city, in the north-west of Algeria. The capacity of the dam is 110 HM3 and its depth is

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about 71 m. The length of the dam is much more important than its width. For this reason, the problem was studied in 2D. Figure 1 represents the dam foundation system composed of five materials.

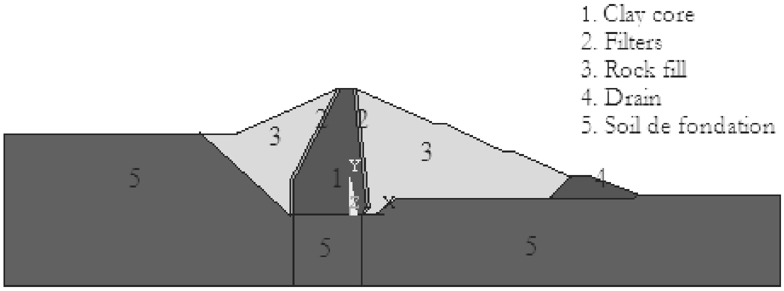

Figure 1: Dam foundation modeling

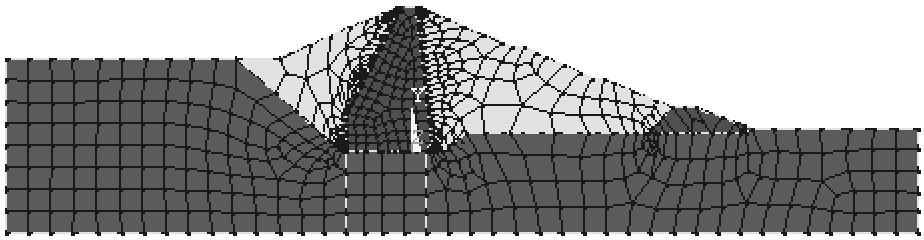

Figure 2: Dam foundation meshing

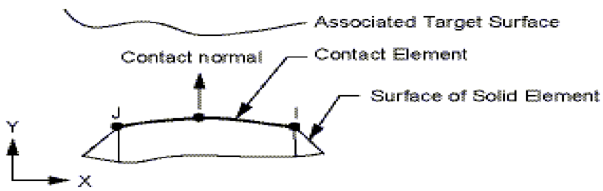

Figure 3: Contact element CONTA 172 (ANSYS)

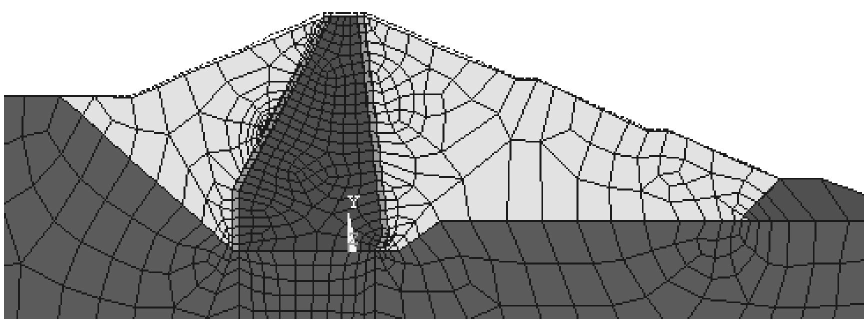

Figure 4.a: Deformed shape of the system dam foundation without contact elements

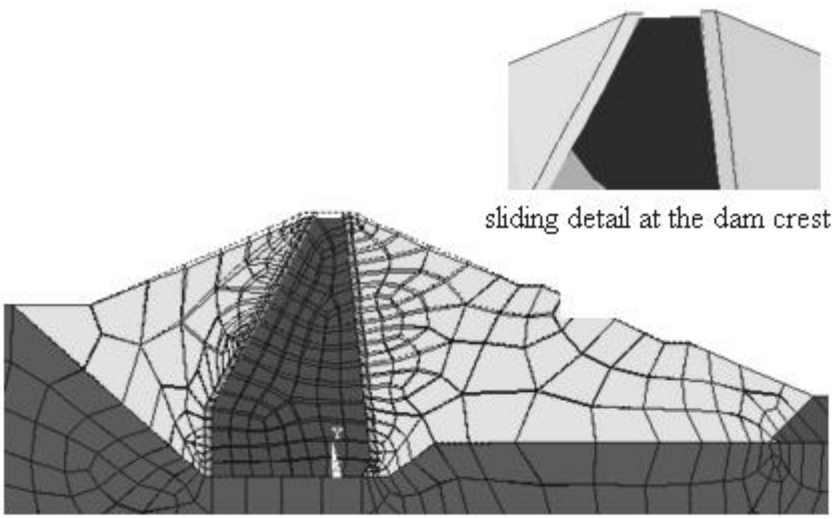

Figure 4.b: Deformed shape of the system dam foundation with contact elements

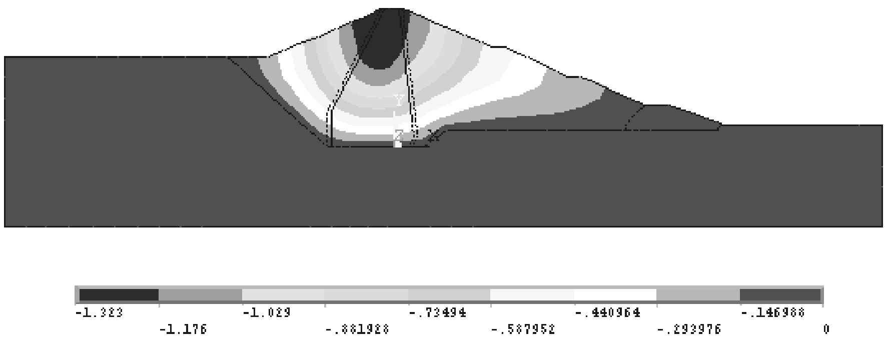

Figure 5.a: Vertical displacement on the earth dam without contact elements

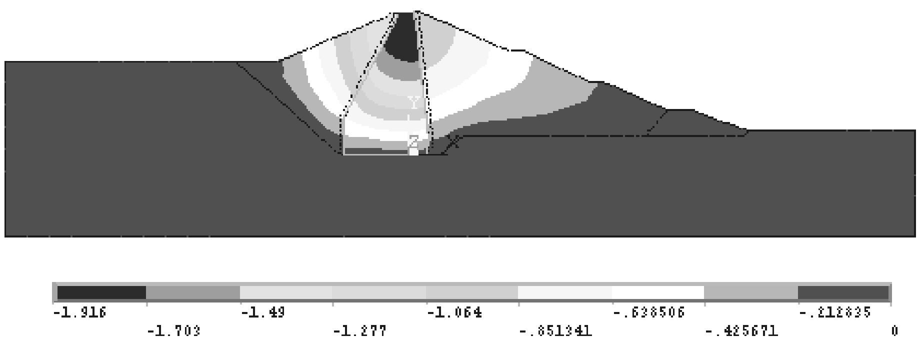

Figure 5.b: Vertical displacement on the earth dam with contact elements

An automatic mesh (Figure 2) was chosen for the general structure with quadratic iso-parametric elements with 4 nodes. The latter presents a good compromise between the run time and the quality of results. The interfaces are modeled by two-dimensional contact element (CONTA 172) with three nodes (Figure 3).

RESULTS AND INTERPRETATIONS

The two deformed shapes corresponding to the two approaches are presented in Figure 4.a and Figure 4.b. The dam is subjected only to its own weight and the refills.

For the first approach, where no contact elements are considered, the core settles taking the refills with it, the crest core settlement is about 1,365 m (Figure 5.a). This mode of deformation is characterized by the absence of sliding of the refills.

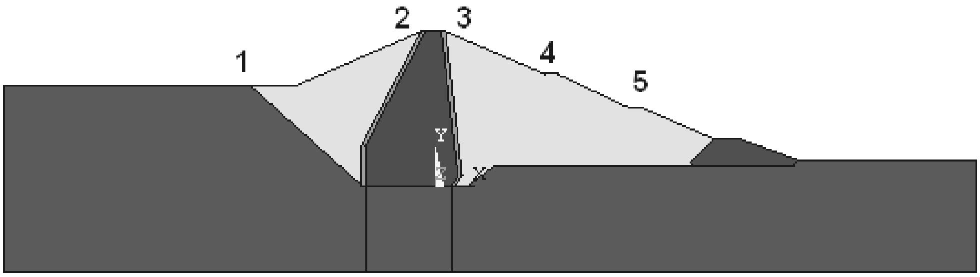

Figure 6: Points where vertical displacements were recorded

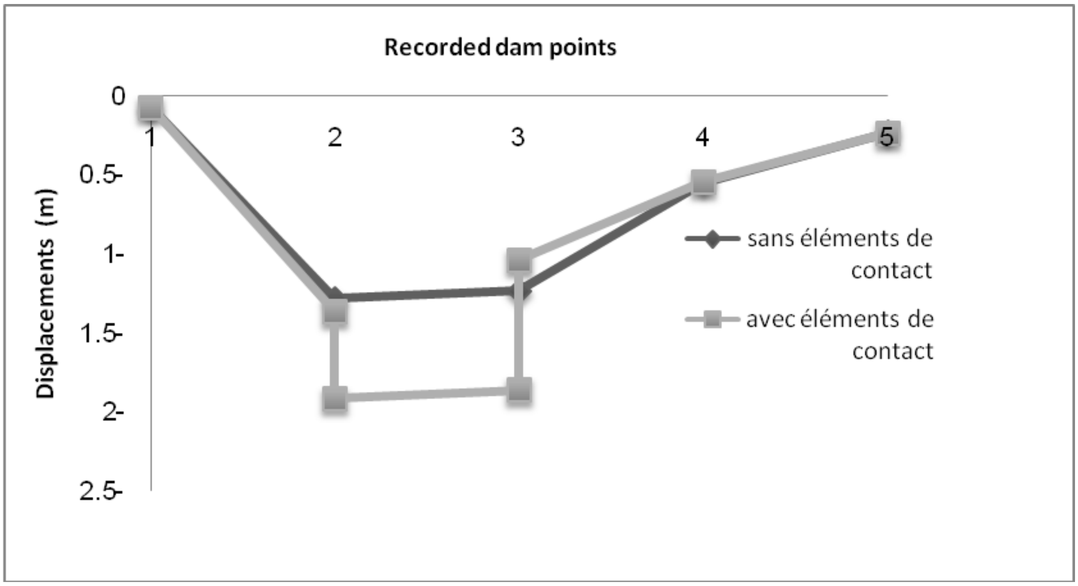

Figure 7: Displacements at recorded dam points

For the second approach, where contact elements are considered, the crest settlement is about 1,921 m (Figure 5.b) with sliding at the interfaces.

Vertical displacements at points recorded in Figure 6 are given in Figure 7, for the two approaches, with and without contact elements. From Figure 7, it is clear that when contact elements are used, sliding phenomenon is observed, this is achieved by two settlement values at the same recorded point. This is observed for the two points (2 and 3) situated at the interface clay core-refills. In the second case, where no contact elements are used, continuity of the displacement is observed at these points. This is obvious because the core is supposed bounded with the refills. The settlement difference between the two approaches (with and without contact elements) is about 61% at point 2 clay-core side and about 16% at the refills side. It is also observed that the settlement difference decreases far from the clay core.

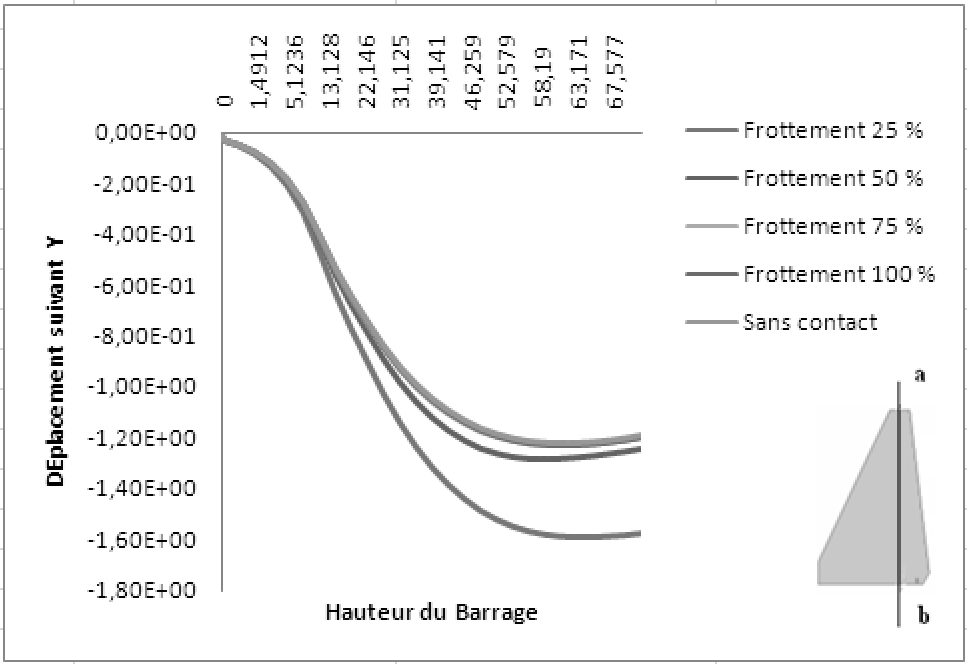

Figure 8: Effect of contact friction coefficient on the vertical displacement along the a-b axis

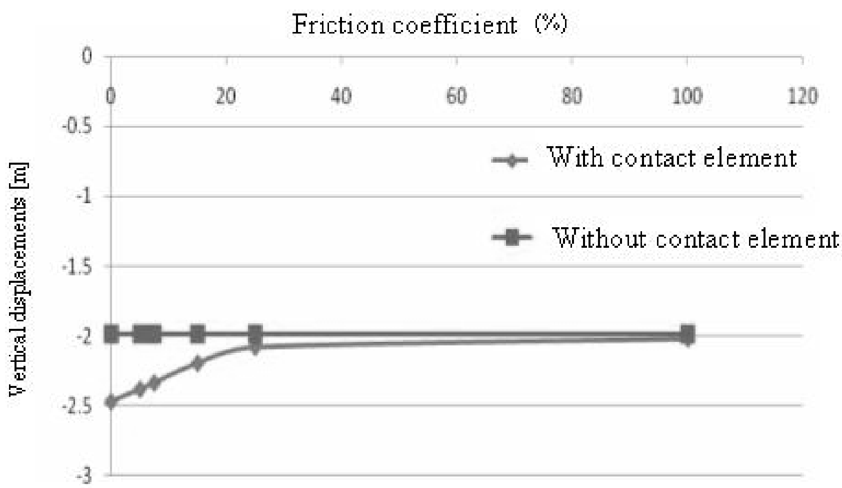

Figure 9: Vertical displacement at the crest for different friction coefficient values

PARAMETRIC STUDY

Friction Coefficient

The contact is characterized by the friction coefficient, therefore a parametric study was performed to view the effect of this coefficient on El-Izdihar dam behavior. Six friction coefficients have been chosen: 5%, 10%, 15%, 20%, 25%, 100% and also the bounded case which means without contact elements. As a result, the vertical displacements along the a-b axis are presented in Figure 8.

Figure 9 sketches the vertical displacement at the crest as a function of the contact friction coefficient for the two approaches with and without contact elements. This figure shows that if the friction coefficient value is between 0% and 25%, a difference of settlement of 14% is estimated between the two cases with and without contact elements. Beyond 25% of friction coefficient, the variation is negligible.

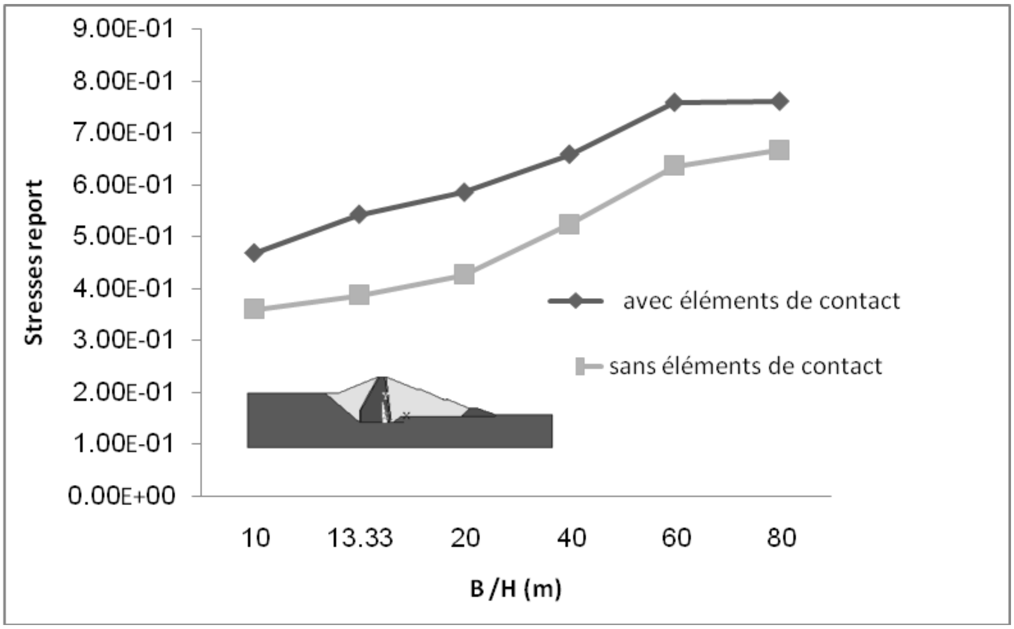

Figure10: Contact effect on the stress decrease at the core bottom

Dam Dimensions

In this part of the present work, the dam width has been discussed with respect to stress and deformation results. Different dam dimensions have been chosen; from B/3 to 2B, where B is the real clay core width estimated as 40 m. The dam depth is about 71 m.

Figure 10 represents the contact effect on the stress decrease at the core bottom for different values of B/H. The stress decrease is represented by the stress difference parameter, which represents the difference between the calculated stress and the analytical one.

It is clear from this figure that the core width affects the dam behavior in stress cases with and without contact elements. The stress decrease changes from 0.5 $\sigma_{analytical}$ for a thin core dam to 0.7 $\sigma_{analytical}$ for a thick core dam. It is also evident that contact elements have no effect for the thick core dam case.

CONCLUSIONS

The effect of contact clay core-refills and clay core-foundation on the static behavior of El-Izdihar dam was studied in the present work. The presence of contact elements at these interfaces gives birth to sliding phenomenon and an amplification of both stresses and displacements with respect to the case where this contact is ignored which means that the interfaces are supposed bounded.

It has been concluded that beyond 25% of friction coefficient, the contact phenomenon has no effect on the static behavior of the dam object of this study.

The dam dimensions depend on the B/H parameter, where B represents the dam bottom width and H represents the dam height. The choice of this parameter is very important to avoid the decrease of stress at the core dam bottom. It was concluded that below B/H=0.5, the calculated stress becomes different from the analytical one, and this is for the different approaches of interface modeling (with and without contact elements).

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