Proceedings of the 16th International Conference on Soil Mechanics and Geotechnical Engineering

doi:10.3233/978-1-61499-656-9-791

Results of the auscultation and the modelling of an earth dam

Résultats de l'auscultation et de la modélisation d'un barrage en terre

Mohamed Ridha El ouni
Department of Rural Engineering, Waters and Forests, Agronomic National Institute of Tunisia
Laboratory of Civil Engineering, National School of Engineers of Tunis -Tunisia

ABSTRACT
The development of research on modelling of the soil behaviour results in the proliferation of rheological models and programs of calculation by finite elements whose verifications are made based on observations on real data. The present work fits in this category of survey. Convenient support of our survey is an earth dam. Monotoring results are considered as a case history for survey and validation of the calculation models.

RESUME
Le développement des recherches sur la modélisation du comportement des sols se traduit par la prolifération de modèles rhéologiques et de programmes de calcul par éléments finis dont les vérifications se font en s'appuyant sur les observations faites sur des ouvrages réels. Le présent travail s'inscrit dans cette catégorie d'étude. L'appui pratique de notre étude est un barrage en terre. Il s'agit d'utiliser les résultats d'auscultation pour faire en quelque sorte un cas d'étude et de validation des modèles de calcul.

1 INTRODUCTION

To ensure the security of dams is a permanent worry of responsible persons to all phases of the project. The setting up of measure instruments during the construction of dams became frequent in all countries (Magnan and Deroy, 1980; Londe, 1990 and Hanna et al, 1992).

This is how the income information of the dam auscultation will have a high value, because they permit to situate devices of control in the future dams to the most delicate points where all danger will be able to be signalled in useful time and hence to bring fast and efficient remedies.

On the other hand, applications of the methods of finite elements to the survey of dam problems know a fast development, due to the efficiency of this method.

It is therefore by the narrow association of the auscultation and the numerical methods that one will be able to predict better the behaviour of dams in embankment.

The present work concerns the modelling of an earth dam by using different types of behaviour rules and parameters of materials selected as well as a confrontation of calculation predictions by finite elements analysis with results of auscultation measures.

2 PRESENTATION OF THE DAM

2.1 *Features of the dam*

The dam, called Lebna, is situated in the Cap - bon region in Tunisia and has for function the supplying of irrigation water.

The main element is a homogeneous earth dam, provided with a filter and internal drain in granular materials (technical Document, 1983). The dam, of 500m length and 22m maximum height over its foundation, allows to keep a capacity of about 25 millions of m³. Limits of material liquidity constituting the body of the dam varies between 30 and 65 (average 43,1) and their plasticity index varies between 15 and 41 (average 25,3). Therefore the 80% constituted materials is fairly plastic clays while the remaining 20% is very plastic clays (Albert et al, 1989 and El ouni, 2001).

2.2 *Nature of soil foundation lands*

The geological longitudinal section of the foundation at the axis of the crest of the dam, is given in Fig. 1. We distinguish the foundation in the zone of over digging close to the right strand, where will be constructed the special profile and the current right foundation of the minor river bed, and on which the current dam profile will be constructed.

2.3 *Devices of auscultation*

The device of auscultation of the dam consists of vibrant rope piezometers and surface topographic reference.

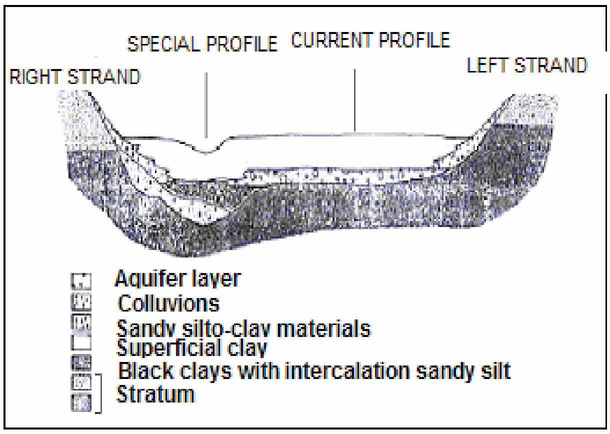

Fig. 1. Geological profile longitudinal section

3 DEFORMATION CALCULATION AND RESULTS COMPARISON

3.1 *The used finite elements models*

The software used for calculation is SOLVIA (1990). The study of the problem concerns, essentially the behaviour of the body and the foundation of the dam. Therefore, we consider modelling is satisfactory for calculations of the whole set (embankment and foundation).

Fig. 2 shows a three – dimensional finite element mesh. This mesh contains for the whole set, after assembly, 2916 elements and 3650 nodes.

For the whole set embankment - foundation, several behaviour laws have been used (Elastic : 2 parameters, Plastic : 5 parameters, Plastic –Multilinear : 6 parameters, Curve Description : 10 parameters). While for the special profile, we have adopted the law of Drucker – Prager : 9 parameters.

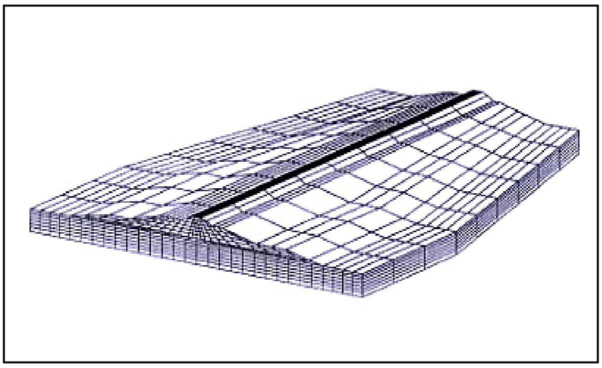

Fig. 2. Three - dimensional mesh of the dam

The studied problem is complex because recognitions had shown that foundation soils were very heterogeneous and layers were not of constant thickness (El ouni, 2001). Considering this heterogeneity, one have tried to represent the set of zones featuring mechanical different put in evidence by polls.

Such analysis will provide the evolution of settlements, lateral displacements, interstitial pressures, and therefore of the effectif vertical stresses at any time chosen during or after the construction (El ouni, 2001).

On the other hand, we have available elements of comparison with measurements data made by means of the disposed measure devices installed in the embankment and the foundation of the dam. Thus, a good determination of model parameters can assure a good agreement between predictions and observations under construction and after the water fill.

3.2 *Settlements*

In the axis of the dam (Fig. 3), the foundation, essentially under vertical efforts, presents considerable settlement. In addition, we underline that zones of soil rupture appeared outside of the most loaded zone. The plastic deformation of soil propagates itself mainly in direction of the outside, i.e, towards the free surface (the less or the unloaded) of the foundation soil. The influence of rupture zones results here to the more in a redistribution of stresses, that can cause an increase of the settlement of soil compression. At the end of construction and after the water fill, analysis of results got by the different behaviour laws, didn't show any meaningful differences between the achieved calculations. These maximal movements are respectively the order of 3,5 and 4,7 cm. At long-term, the elastic and plastic laws Rubber band and Plastic show slightly greater settlements to those of Plastic - Multilinear and Curve Description laws (these movements are respectively the order of 18,5 and 21 cm).

At the uphill foot of the dam, the submissive foundation to efforts, due to the water fill, records some considerable vertical displacements. Uprisings of soils are always recorded to the uphill foot and downstream of the dam (Time 4 and 5).

Fig. 4 shows evolutions of the settlements of the crest. These results have been got by the different behaviour laws, as well as with in-situ measures (El ouni, 2002). Settlement curves agree globally. One notes a gap however between results obtained by the Drucker - Prager laws with those predicted by other laws.

Otherwise, the analysis of these settlement curves recorded on several years has, for its part, confirmed the good representativeness of consolidation laboratory tests with respect to in-situ compacted soil. The goal will be to determine the amplitude of settlements during the life of the dam, in order to foresee the height security in necessary head to eliminate the risk of crest tipping.

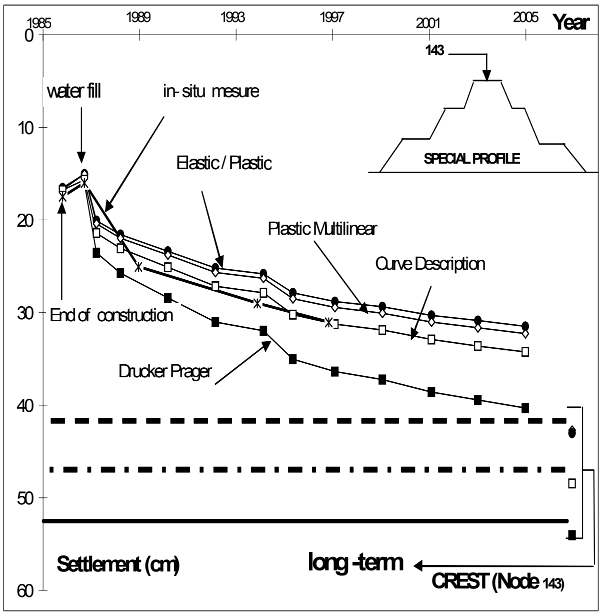

Fig. 3. Vertical displacements of the contact Embankment-Foundation of the current profile of the dam. Behaviour of the dam at the end of construction (Time 4), after water fill (Time 5) and long-term (Time 6).

3.3 *Excess water- pressures*

The numerical modelling allows us to analyze more precisely the behaviour of soil. While taking account of the hydraulic coupling–mechanical, the numerical model foresees the apparition of excess pore water- pressures in dams.

Comparisons of calculation results with in-situ measured values, under the dam foot are given in figure 5. The some anomalies of curves resulting from calculation are owed mainly to the effect of the heterogeneity of layers of the mesh.

Furthermore, figure 5 illustrates the main difficulty of comparisons between calculations and measures that is the high liberty of a good appreciation of experimental when it must join points of measure to define isochrones. In spite of substantial effect during instrumentation, only few in-situ experimental points were recorded. In the present case, the available points don't permit to fix with precision the depth of the interstitial over- pressures maximum.

In general, these results are nevertheless encouraging and show the interest to take into account the incomplete saturation of materials in calculations.

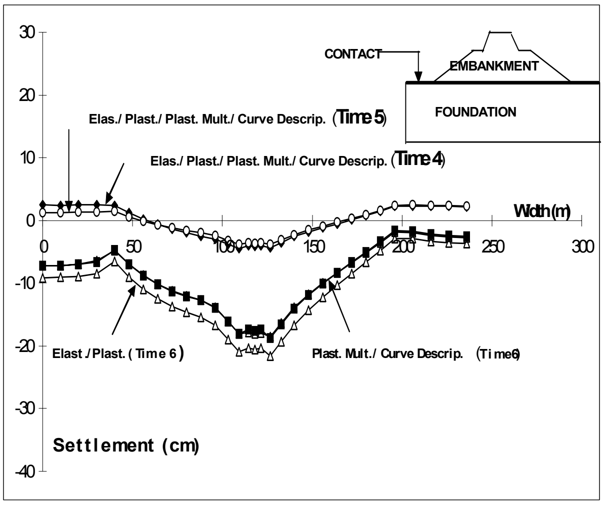

Fig. 4. Settlement of the dam crest (special profile).
Comparison of measured and predicted curves in 2D

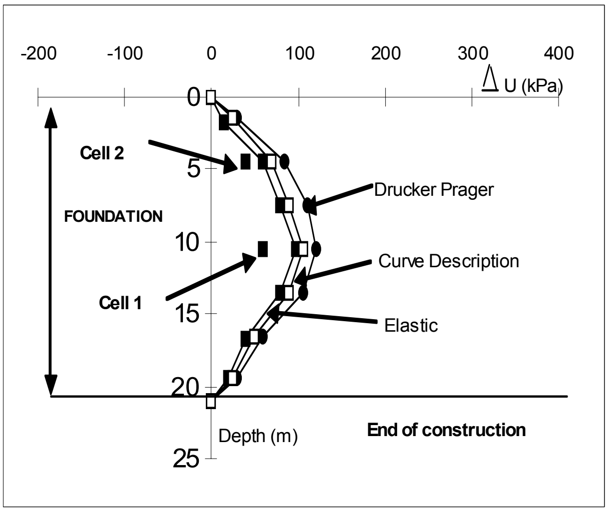

Fig. 5. Excess pore water - pressures as a function of the depth. Measured and calculated results comparison by different behaviour laws. (Foundation of the special profile of the dam * End of construction *)

4 CONCLUSION

To the light of obtained results, we can make the following observations:

* The analysis of obtained calculation results in this survey by different behaviour laws shows, in general, convergences with the real behaviour of the embankment and the foundation of every dam. The light difference between the measured and calculated settlements could result from:

- The hypothesis of the incompressibility of the interstitial fluid that is generally compressible.

- The real fluctuation of the retained water level, whereas, for the numerical modelling, it was assumed that the retained water is located at a constant level.

* The hypothesis of a consolidation at the end of construction is certainly confirmed by the shape of isochrones giving that presents the excess pore water distribution with the depth.

REFERENCES

Albert T., El ouni M. R. et Flavigny E. 1989. Le barrage de Lebna. Propriétés mécaniques de l'argile et stabilité des pentes. Journées d'études Franco - Tunisiennes. Paris, pp. 1-7.

Document technique, 1983. Le barrage de Lebna – Ministère de l'Agriculture - Tunisie , 92p.

El ouni M. R. 2001. Les lois de comportement des sols et leur application à la modélisation de deux barrages en terre. Thèse de Doctorat – FUSAG - Belgique, 313p.

El ouni M. R., 2002. Modélisation du comportement d'un barrage en terre. Colloque International sur l'eau, février Chlef – Algérie, pp. 111-117.

Hanna A., Lum K. Y. and Lou J. K. 1993. Reinstrumentation of an earthfill dam. Can. Geotech. J. 30, pp. 193 – 210.

Londe P. 1990. La sécurité des barrages. Revue Française Géotechnique, n° 51, pp. 41 – 49.

Magnan, J., P. et Deroy J. M.. 1980. Analyse graphique des tassements observés sous les ouvrages. Bull. Liaison Labo. P. et Ch. - 109, pp. 45- 56.

Solvia pre–post, Users manual for stress analysis. Report SE90-1, Solvia Engineering AB, Sweden, 1990.