The Observation and Modeling Contribution to Urban Geotechnical Works Projects : Al Boustane Clinic Extension ,Rabat-Morocco.

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Abstract. Starting each geotechnical work site needs a preparatory study and a pre-design. Both of them requisite an observation intervention before, in particular, those in urban sites. The purpose of this paper is to explain how observation combined with modeling makes it possible to manage the difficulty and complexity of this type of project, based on the observational method. Thus, a safe geotechnical structure requires a modeling based on observation investigation and site survey. In accordance with the site's context, the model will be verified to see if the actual behavior is consistent with the design modeling. On this manner, we will detail this illustrated approach on several concrete geotechnical projects cases. This article will also include a case study of Alboustane clinic's extension, in Morocco, to illustrate this method.

Introduction

The purpose of each approach used at the beginning of each geotechnical project is to optimize the support as well as the cost and structure safety. It is within this framework that the use of the observational method, introduced by Peck in 1969[1] and subsequently included in Eurocode 7 in 2009[2], is deployed. We will start by explaining the principles and limits of this method by applying it to the EL BOUSSTANE clinic's extension in Rabat, capital of Morocco. This method is associated with numerical modeling. The application is mainly based on measurement tools and numerical simulations. It is based on the quality of the soil found in order for us to estimate which method is used and which model will be the best to represent.

In most site studies and following the markup made along the observations and site investigation's results, the reinforcement of the soil or support is oversized, which only increases the structure's cost even if its safety is maintained.

The observational method application brings together two conceptions [1]:

- First one based on the most probable conditions.
- A second based on the most unfavorable conditions.

These two designs will make it possible to control safety, cost and deadlines, without falling into structure oversizing problems.

During the project phase, an inspection system must be defined to ensure the monitoring and the progress of the work. Also, to compare the results of this progress previous results. In 1948, Terzaghi specified that all projects with geotechnical characteristics were based either on a geotechnical study using increased characteristics, hence the oversizing of the structure and therefore a high cost, or on similar studies carried out in areas where the soil has similar characteristics [3]

Apart from this approach, numerical modeling is sometimes ideally done: a perfectly horizontal stratigraphy different from reality, increased characteristics, and a less steep slope than that in the field of study, a piezometric level rarely modeled or taken into consideration.

1. Conditions and procedure for applying the observational method

1.1 Application conditions

The observational method can only be applied if the following conditions are verified. At first, without a survey that allowed having all the information on this land, this method may not give good results. It is also necessary to assess the actual project conditions and classify them as "more likely" and other "more unfavorable" conditions. In a third step, the whole process must be modeled on the basis of the "most unfavorable" conditions. At this point, it is necessary to define a sequence of modifications on the model designed for each hypothesis of change during construction. In other words, it

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is necessary to provide for "just in case" with that being the case. In the project phase, a follow-up of the results obtained is necessary to observe each change and act on it through previously programmed actions [1]. On Eurocode 7, the purpose of the observational method is to allow reaction during work, in the event of an anomaly or presence of risks, thanks to the auscultations and the results of the modeling carried out. In other words, it aims to anticipate the risks envisaged since the alert thresholds and the limit conditions are defined and modeled in advance.
Once site investigation results are obtained, the geotechnical model is designed. It is not only to make stability calculations, for example, but also for planning the construction and execution of the structure, by stages as an instance.
This modeling also takes into account all the risks present in this field, assessing them, in order to reduce these risks as much as possible, whether they are financial, human or technical risks [4].

1.2 Application procedure

To apply this method, a simple and efficient procedure was defined. Obviously, it was necessary to start with a preparatory phase gathering as much information as possible on the study site. This phase includes soil survey studies, hydraulic studies, seismicity studies, etc. [5]
The interpretation and analysis of these results is done in order to create a geotechnical model. Thereafter, construction monitoring during the project phase must be carried out using appropriate testing methods in order to compare the initial results with the actual values and to react if the limit values previously defined as an alert threshold are exceeded.

2. Concrete cases of the observational method application

2.1 Landslide of Guavio

Slope stability remains a classic subject where it is often the case to copy solutions made in other slopes and apply them according to an analogy procedure. These remedies become intuitive with practice. The lack of observation in this case makes the search for a solution more limited.
The case of the Guavio landslide in Colombia is a perfect example of the observational approach. This is a steep slope slide located in a high rainfall area (4000 mm/year), which appeared during the construction of a temporary access track to a hydraulic gallery window during excavation work [6].
The observations made it possible to deduce the existence of a fault delimiting two parts of the substratum. Thus, from the piezometric surveys, it was observed that a slick was present in the bedrock during the dry period and that it rose rapidly during the rainy period. Following these observations, two choices seem obvious; either abandons this track and builds another one. Either stabilizes the slip over a very long length (which only increases the cost of construction).
Indeed, it was planned to set up an auscultation system composed of an inclinometer, a piezometer and a rain gauge, as well as a monitoring of the flow rates of the drains. This allowed them to make the following conclusion: The heavier the rain, the higher the water table level increases, which increases the lower safety factor and accelerates the sliding movement. Based on these conclusions, they defined three levels of risk, a first one called "normal" where pluviometry is not likely to cause slippage and therefore traffic can be maintained without restriction. A second one, called "alert", where traffic on this runway is restricted as movements increase with rainfall. And the last one, called "alarm" level, traffic is prohibited since the movements exceeded the imposed threshold.

2.2 Odeon Tower

This time, the problem arises in an urban environment where defluxion criteria are limited and imposed by the presence of neighbors. This is the case of the construction of the Odeon tower in Monaco, 160 m high and with 10 basement levels [6].
Following preliminary studies carried out on the site, it was concluded that the movements

are limited to 5 mm on the neighboring constructions.

At this level, 3D finite element modeling had ensured proper support while ensuring that an auscultation system composed of motorized theodolites, inclinometers, extensometers and strain gauges was implemented. These had made it possible to detect the uprisings noticed following the support work and to use emergency solutions to bring the whole thing back up to standard.

3. CASE STUDY: ALBOUSTANE CLINIC -RABAT

This is the extension of the Alboustane clinic (fig.1) located in Rabat, the capital of Morocco. The extension has three basement levels adjacent to other buildings. This makes deflexion allowed very limited.

Fig. 1. The extension site location

It is therefore intended to ensure the stability of the walls of this new structure with regard to adjoining buildings by defining the appropriate earthwork method, taking into account the planned supports.

In this sense, a preliminary study was launched including a study of soil recognition (identifications, resistances based on the results of shear and pressure tests), piezometric survey, seismicity, as well as any information (Tab.1)(fig.2) allowing a better understanding of the characteristics of the study site.

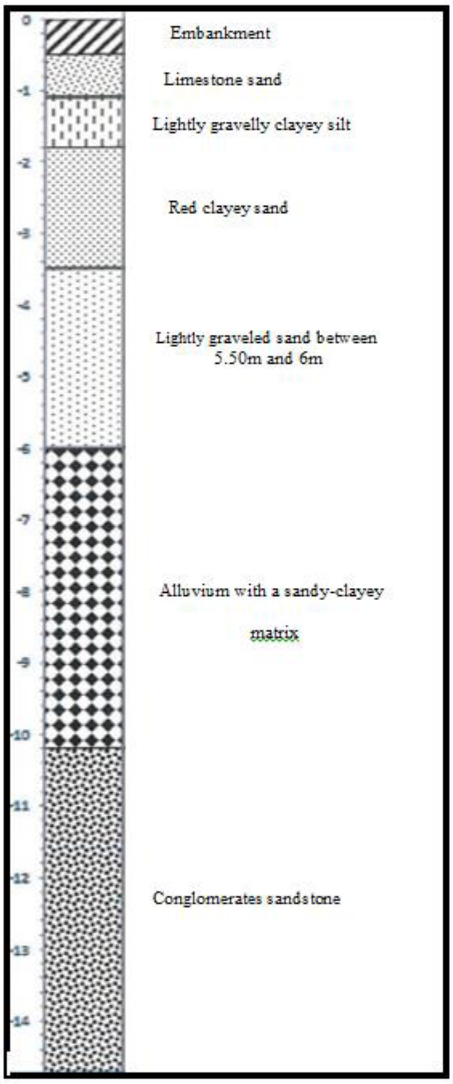

Fig. 2. Geological log corresponding to the study site

Table 1. Mean geotechnical characteristics [7]

Soil Nature	Pl (MPa)	EM (MPa)	α	Z base (m)	γ	C'	Φ'
Red clayey sand	1	14	0,5	5,5	18	0	40
Alluvium with sandy matrix	2,4	40	2/3	10	20	0	45
Conglomeric sandstone	4	100	-	15	Substratum		

Following these observations, it was concluded to design foundations at 10m/NG (since it is planned to build three basements), taking the conglomerate sandstone layer as the foundation layer, with an anchor of at least 0.5m. The settlements, which have been calculated according to the pressure metric method, are of millimeter order.

The main objective now is to ensure the stability of the walls. The layout of the adjoining buildings is receding by 3m compared to the future construction. It was important to know the type and location of the shoreline foundations of the adjoining building overlooking the future construction. For this purpose, the modeling was done assuming a distributed load of 30KPa at 3m from the project excavation.

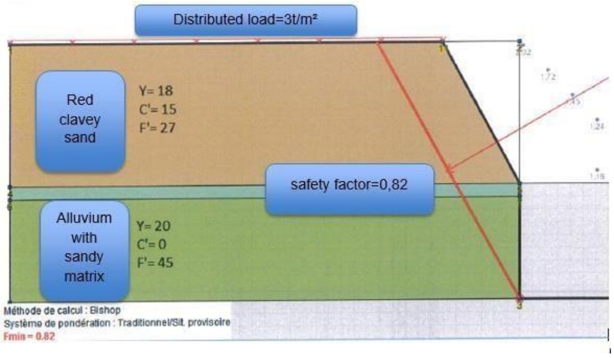

Fig. 3. 2D site modeling on Talren 4 at initial state

Thus, in the provisional phase, the earthworks will be carried out as follows:
-For the stability of the layer of reddish clayey sand:
A slope of 1H/3V will be adopted while protecting the embankment from runoff or rainwater inflows.
-For the stability of the alluvial layer:
It was not easy to observe the matrix and the compactness of the alluvial layer, especially if the latter are located with decametric diameters.
With these circumstances, two cases arise:
-Either the alluvium has a matrix that ensures its cohesion: In this case the earthworks can be done by embankment with a slope depending on the assessment of the cohesion.
-Or the alluvia have a matrix that does not ensure their cohesion: In this case, a support of the walls will be necessary of the Berlin type or molded walls.
In this case modeling will be done in phases. The stability will be checked after every 1m of earthwork (fig.4) from the alluvial layer and then the Berlin wall will be progressively put in place (fig.5 and fig.6) in order to maintain the stability of both the future construction and the walls.
It is therefore planned, at the time of excavation, once the alluvial layer has been reached, to carry out a mechanical shovel survey to determine the exact texture of the alluvial layer and to evaluate the cohesion of its matrix. It remains to be seen whether the right of way will allow it, otherwise all that remain is to proceed with support by Berliners.

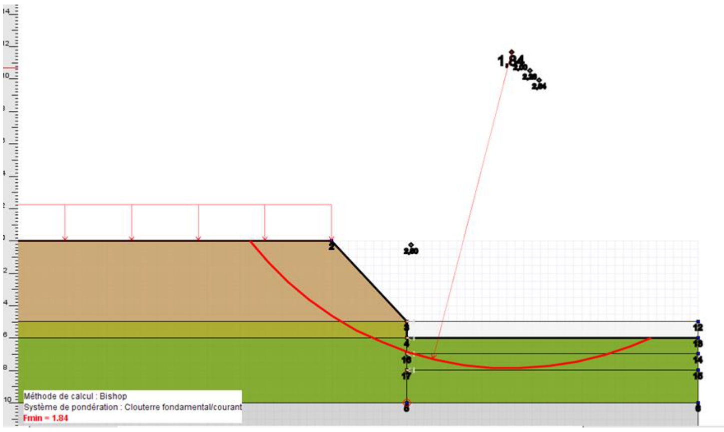

Fig. 4. 2D site modeling on Talren 4 at the first phase of excavation without reinforcement

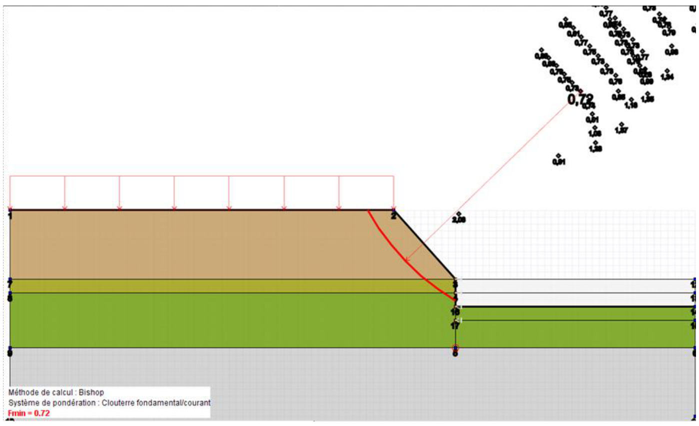

Fig. 5. 2D site modeling on Talren 4 at the second phase of excavation without reinforcement (requires the creation of a stop by a wall to stabilize the walls)

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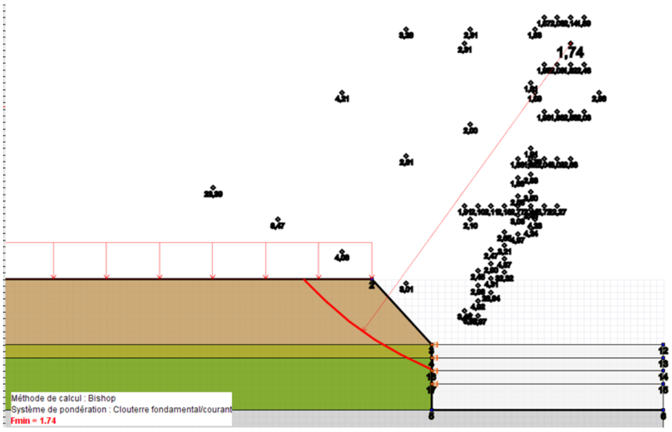

Fig. 6. 2D site modeling on Talren 4 after reinforcement

It is also planned to ensure a drainage system for runoff and rainwater during the work in order to protect the foundation soil from these water inflows.

4. CONCLUSION

It is true that the observational method makes it possible to reduce the cost of construction while ensuring safety and delay. Except that, on the other hand, wouldn't it be more expensive to carry out all of its observational studies, while respecting the duration of each test, compared to a conventional oversized support? since the first method requires access to several data characterizing the soil in its application and therefor the time required for the assumed work must be modified by adding the time it will take to carry out these recognition studies?
The more efficient the modelling system is; the more characteristics it requires on the ground. Therefore, preliminary studies become very costly.
It is therefore necessary to foresee the best case between using a rational and more accurate method by comparing it with other methods based on traditional solutions, approximations and analogies in terms of cost, time and safety.

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