ANALYSE DEFORMATION OF GROUND DURING EXCAVATION PROCESS IN BASEMENT BUILDING CONSTRUCTION – A CASE STUDY IN HO CHI MINH CITY

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Abstract. In modern cities, high-rise buildings were built more and more with limited land area. Therefore, the basement is the way out to increase underground space to solve that above matters. However, the deformation and stabilization of soil around need to be controlled during the excavation process in basement construction. Beside that, decreasing the water table is also the reason to make deformation of underground. The paper is focus to analyse the changing of soil around and find the best way to control the during constuction process in Ho Chi Minh area.

Keywords: Deep excavation, Stabilization, Diaphgarm wall, Deformation of ground.

1 Introduction

In recent years, with the development of high-rise building projects, the underground space of this projects has also developed extremely rapidly. However, during the excavation to build the basement or deep foundation, there is a possibility of affecting and damaging neighboring structures. Therefore, the evaluation of the strength and deformation of the ground is an important part of the foundation design process. Normally, to keep the excavation stable, control displacement, as well as avoid problems for neighboring buildings, the engineers often construct the reinforced concrete diaphragm wall around the perimeter of the building.

When a retaining structure is designed as a diaphragm wall system, safety must be the first priority. Next is the requirement of economic efficiency, which also increasingly requires a reasonable calculation of construction costs, as a result can make the diaphragm wall thinner, as well as increase the risk of damage to the projects and nearby buildings. This leads to the need to more accurately predict the displacement of reinforced concrete diaphragm walls, the settlement of the surrounding ground, and to increase the knowledge of diaphragm wall designing for construction.

Christina Kantartzi (1993) [1] has studied about the diaphragm wall in the condition that the surrounding soil is clay. The author used a centrifuge to measure excess pore pressure that help to assess the effect of ground water level when constructing the wall. In this research, the author only gives the results of changing stress but did not assess the stability and deformation of the ground around the building.
Anders Kullingsjö (2007) [2] described some different methods to assess the movement of ground and to estimate the earth pressure acting on the retaining wall system. In research, some empirical formula to evaluate settlement of ground were also summarized, such as: Peck (1969) [3], O´Rourke (1981) [4], Bowles (1988) [5] and Caspe (1966) [6]. However, the author only gives the measurement results of settlement around the construction but did not simulate or claculate to predict the ground movement.
Z.C.Moh et al. (1984) [7]; Horodecki et al. (2004) [8] study the case of diaphragm wall, a 70cm thick wall placed in silty sand and a 60cm thick wall in very soft clay. In both cases, monitoring instruments at site such as: pressure gauge, inclinometer, stress measurement in soil, settlement plate and strain gauge were installed and calibrated during excavation work. These authors only studied about wall displacement in soil and soil stress with comparison of wall thicknesses placed in different soils. The authors did not analyze the stability of the ground around the work, especially the 70cm thick diaphragm wall is placed in silty sand (soft soil). With such a deep hole, the ground around the building is easily affected.
Dinakar et al. (2014) [9] designed the deep excavation to achieve stability and limit the deformation caused by deep excavation. In this study, Plaxis, a 2D finite element model was developed to describe the diaphragm wall performance and deformation of ground near adjacent structures. Research results show that the diaphragm wall method is stable, help to control the movements of ground under buildings significantly. The results also provide an understanding of the effect of diaphragm wall techniques to reduce ground fluctuations during deep excavation. However, in this research, the variation between simulation results and monitoring data did not mention that make to reduce degree of correlation of study.
In fact, there are some projects in Vietnam that have caused settlement of neighboring structures nearby such as: Pacific Building, Saigon Residences, 102 Cong Quynh Building…Therefore, displacement of the retaining wall, settlement of the surrounding ground are an issue that should be research priority in the detail design and construction.

2 Displacement of retaining wall and movement of ground

2.1 Displacment of retaining wall

Fig.1. shows the calculation of the retaining wall model that were proposed by K. Terzaghi.The soil pressure acting on the retaining wall depends on the direction and displacement of the wall. In both cases, as the displacement of wall moves gradually towards one side or the other then the soil pressure acting on the wall decreases or increases to the limit values and become almost unchanged pressure (limit equilibrium).

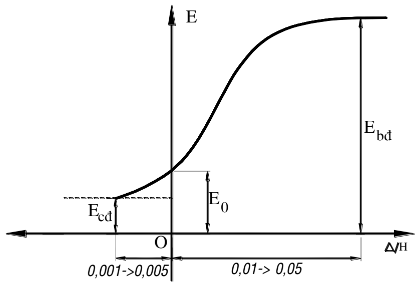

Fig. 1. The relationship between soil pressure and displacment of retaining wall

Based on the monitoring data at site, Sachipana proposed a method to calculate the strut shaft force and moment values in retaining wall. However, in Sachipana method, underground water pressure and soil active pressure below the ground excavated were not mentioned. The researcher from Tongji University has modified some points Sachipana method (Fig.2.)

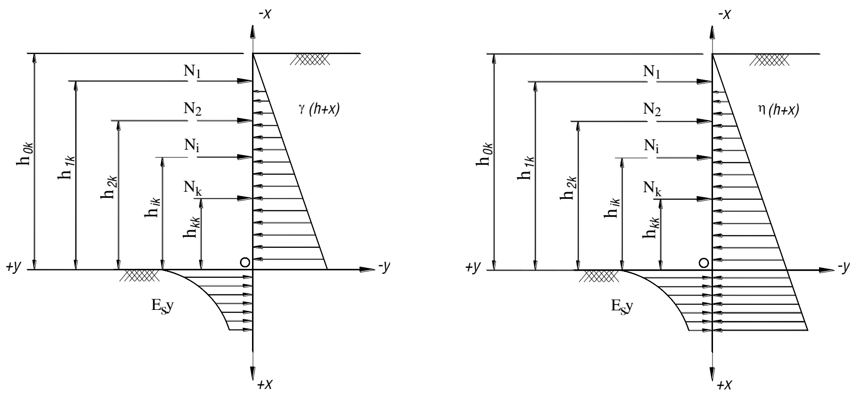

Fig. 2. Sachipana method (left) and Tongji Uni. (right)

2.2 Movement of ground

- Peck's method (1969): It should be noted that in soft and very soft clays, settlement area can be occured at a distance of about 3 to 4 times the foundation pit depth.
- Case's method (1966) and Bowles's method (1988): Case (1966) offers a method for calculating the relationship between the settlement and the deformation of the wall using the following assumptions: there is a variation of the horizontal displacement in the soil between the transformation into the foundation pit and the wall; and at all positions, the vertical displacement is assumed to be related to the horizontal displacement through Poisson's coefficient. After that, Case's method is replaced by Bowles' method which uses the reasonable the calculated settlement data in design.

- Bauer’s method (1984): This method is applicable to foundation pits in sand, showing a reasonable agreement between calculated settlement data and field movements.
- Clough and O’Rourke’ method (1990): Based on calculations of surface settlement, the settlement contours around the deep excavation can follow the Clough and O'Rourke chart.

3 Case study

3.1 Project description

- Project name: Office House.
- Address : 635B Nguyen Trai, District 5, HCMC.
- Project scale : 13-storey office building, including: 02 basements, 1 ground floor, 1 mezzanine, 11 floors.
- Total construction area: 28m x 40m.
- Total height : 48.3m

3.2 Research methodology and results

In this study, the author uses three obtained results to give conclusion analysis are: analytical results, results from actual observations and results from simulation.

- Analytical method: the figure 4 shown the calculation in dangerous case (Phase 4 with H = 9m)

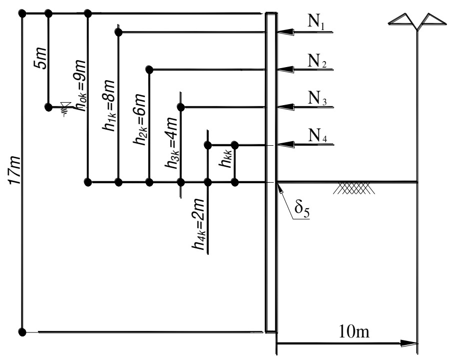

Fig. 3. The theory calculation of retaining wall

- Finite element method – Simulation: The author used Plaxis software to simulate all steps of construction sequence. Figure 5 shown the deformation of construction in this software:

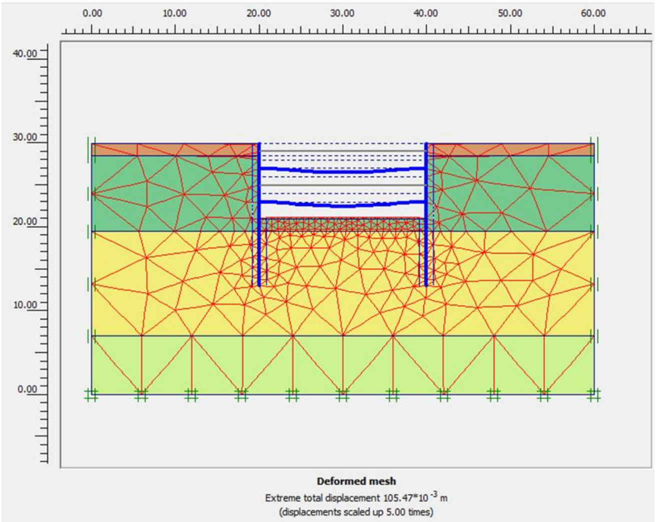

Fig. 4. The simulation results in Plaxis software

- The results comparison: In the figure 6 below, the comparison of settlement between analytical results, monitoring data and simulation rersults were displayed:

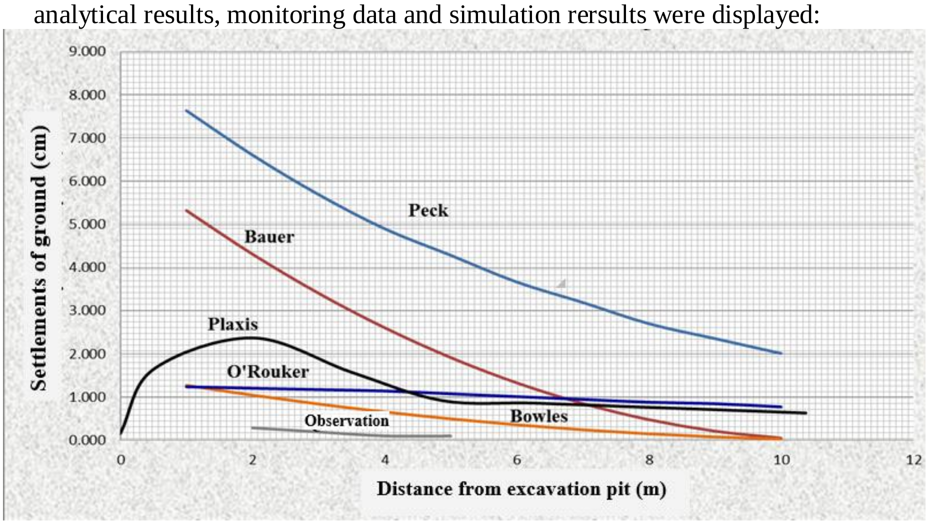

Fig. 5. The results comparison of settlement ground

Discussion:

- ✓ Plaxis, O'Rouker, Bowles have correlation in settlement.
- ✓ Peck and Bauer have large settlement. Peck > Bauer about 1.6 times.
- ✓ Data of monitoring is too small compared to other calculation methods.

4 Conclusion

Based on the empirical and semi-empirical method from Peck, Bauer, Caspe & Bowles, Clough & O'Rourke; the settlement results of ground were calculated in the study. However, the result comparison between analytical method and observation datas have a big deviations. This can be explained as in calculation methods, some factors such as: pore water pressure, groundwater level... were not mentioned.

Finite element method (FEM) has solved the problems mentioned above, in the excavation phase, lowering the groundwater level is completely easy to do, and the construction engineer can control the settlement of the ground around the excavation pit, control the outburst at the bottom of the excavation pit and take timely remedial measures. However, the correct analysis of input parameters in the software must be at the forefront of this design problem.

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