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Influence of complex Foundation Pit excavation on adjacent buildings

Xiaolong Sun^{1,2}, Yan Liu^{1,2,*} and Guangxiang Wang³

¹College of Civil Architecture, University of Jinan, Jinan, Shandong, 250022, China

²Research center of underground construction supporting and risk control technology of Shandong Province, Jinan, Shandong, 250022, China

³Shengli Oilfield Central Hospital, Dongying 257000, China

*Corresponding author's e-mail: liuyan322@163.com

Abstract. In order to deeply study the influence of complex foundation pit group excavation on surrounding buildings, this paper takes concrete engineering as an example, using finite element software MIDAS GTS/NX to set up a three-dimensional deep foundation pit model for a piece of land project in a certain city, and carries out numerical simulation and analysis. This paper introduces the general situation of the project, the process of establishing the model, and the value of the deformation of the building and the supporting structure. The results show that the horizontal displacement of the same point increases gradually with the increase of the excavation depth of the foundation pit. The increase of excavation depth will also result in the maximum horizontal displacement moving gradually from the top of the slope to the middle and lower part of the deep foundation pit. In this paper, the three-dimensional numerical simulation analysis of the engineering is carried out according to the site construction procedure, in order to provide technical reference for the support selection and construction of similar projects.

1. Introduction

Many relevant scholars and engineers at home and abroad have studied the deformation of buildings caused by excavation of foundation pit. ^[1] Ding Kewei made numerical analysis on deep foundation pit excavation of Hefei New Traffic Building by means of Midas/GTS finite element analysis software. The settlement and displacement of deep foundation pit are analyzed, and it is concluded that the displacement of soil is increasing with the increase of excavation depth. The excavation of foundation pit will cause the settlement of the central uplift of the foundation pit and the surrounding of the foundation pit, so it is necessary to pay full attention to the influence caused by the excavation of the deep foundation pit. ^[2~7] Taking concrete engineering as an example, the foundation pit, supporting structure and adjacent buildings are placed in a system. Before excavation, the settlement and deformation of adjacent buildings are numerically simulated according to the designed foundation pit support scheme. Then the settlement deformation of the building monitored in the construction process is compared and analyzed.

Combined with a concrete project in a soft soil area, the deformation characteristics of adjacent buildings after excavation are analyzed by using finite element software MIDAS GTS/NX, which provides a reference for the design and construction of similar projects in the future.



2. General situation of Engineering and surrounding Environment

2.1. Engineering survey

The project was built in the north side of Jinan Road, Xicheng District, Dongying City, and in the center of Shengli Oilfield Central Hospital on the west side of West Second Road. The proposed project is a 24-story internal building and an underground garage. The overall shape of the foundation pit is generally rectangular, with an east-west length of about 107 m, a north-south width of about 70 m, a foundation pit circumference of about 360 m, and a foundation pit excavation depth of about 7 m. Adjacent to the south side of the original medical technology building, the foundation pit is a new medical technology building project. The foundation pit is about 69m long from north to south, about 108.5m long from east to west, and the depth of excavation is about 5.9~6.9m. It is connected with the first pit excavation. The original medical technology building (3~5F) has a foundation embedding depth of about 1.50m, and adopts the brick-concrete structure powder-powder pile composite foundation. The positional relationship between the foundation pit and the building is shown in Figure 1.

2.2 Engineering geological condition

The proposed site landform unit is the Yellow River Delta alluvial plain. Mainly for miscellaneous fill, silty clay and part of silt. (As shown in figure 2)

2.3. Surrounding environment of foundation pit

The relationship between the location of the foundation pit and the adjacent road is shown in figure 3

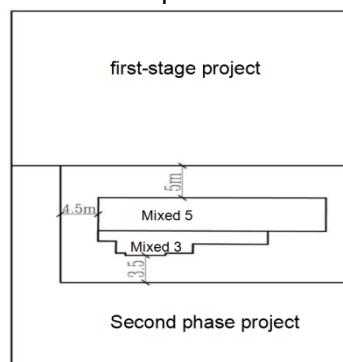


Fig. 1 The position relationship between foundation pit and building

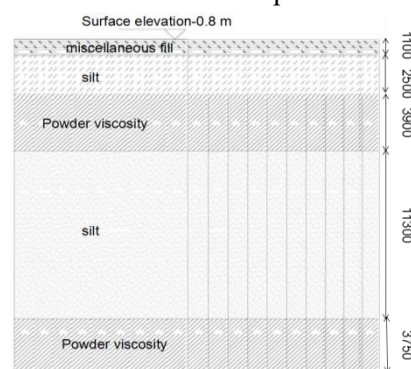


Fig. 2 Geological profile

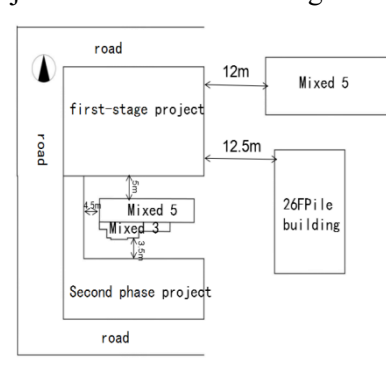


Fig. 3 Foundation pit surrounding environment map

2.4 Foundation pit supporting scheme

In the first stage of the foundation pit, the support scheme of the second stage of the foundation pit is as shown in figure 4, the single row of two bolting sections is shown in figure 5, the single row pile inclined bracing section is shown in fig. 6, and the double row pile supporting section is shown in fig. 7. As shown in Fig 8, the parameters of single row bolting are shown in Table 1.

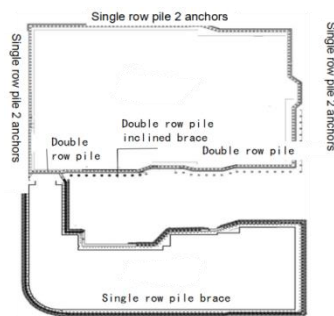


Fig. 4 Support scheme

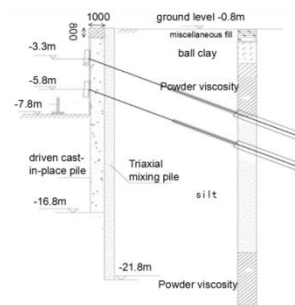


Fig. 5 Single row pile 2 bolting sections

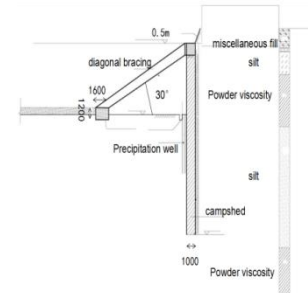


Fig. 6 Single row inclined bracing section

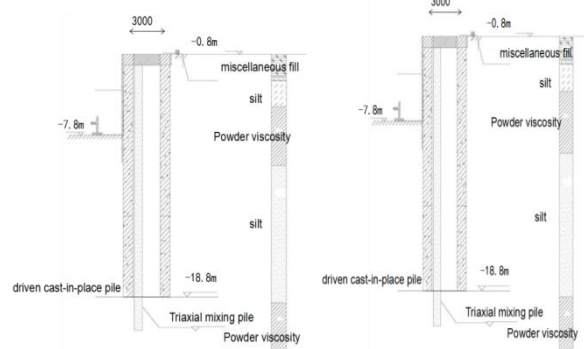


Fig. 7 Double row pile supporting section

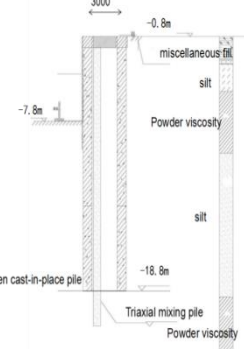


Fig. 8 Single row pile internal bracing section

Table 1 Anchor cable table

Cable number	Anchor cable model	Anchor cable Length	Free segment length	Anchorage length	prestress	Axial force standard value
MG1	32/20anchor arm	22m	8m	14m	160KN	365KN
MG2	32/20anchor arm	19m	6m	13m	120KN	323KN

3. Model establishment

According to the spatial position relationship between excavated foundation pit and existing buildings, a three-dimensional finite element calculation model is established by using MIDAS GTS/NX software. The overall size of the model is $221\text{m} \times 182\text{m} \times 27\text{m}$, and the total size of the model is $221\text{m} \times 182\text{m} \times 27\text{m}$. The excavation depth of 3 ~ 5 times is taken as the distance between the retaining body of foundation pit and the boundary of the calculation model. The computational model is shown in figure 9.

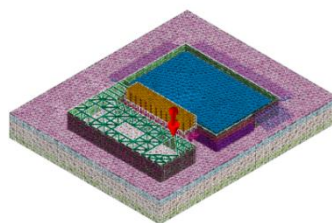


Fig.9 3D numerical model

3.1 Structural models

In this paper, the pile row is equivalent to the underground continuous wall by the principle of equivalent bending stiffness. The diameter of the row pile is expressed by D , the net distance is expressed by t , the length of the underground continuous wall is the net distance of the pile diameter, and the thickness of the ground connecting wall after equivalent is h . Available:

$$E_1 I_1 = \frac{\pi \bullet d^4}{64} \quad E_2 I_2 = \frac{b \bullet h^3}{12} \quad E_1 I_1 = E_2 I_2$$

$$\frac{1}{12} (D + t) h^3 = \frac{1}{64} \pi D^4, \quad h = 0.838 D \sqrt[3]{1 + \frac{t}{D}}$$

3.2 Model calculation parameters

The mechanical parameters of each material are shown in Table 2.

Table 2. Material mechanics parameter list

order number	stratum	Thickness / m	γ (kN/m ³)	E_s (MPa)	ν	c (kPa)	ϕ (°)	unit form
1	plain fill	1.20	17.70	15.11	0.39	7.00	16.00	M-C
2	silt	3.30	19.70	18.73	0.32	8.00	25.30	M-C
3	Silt clay	2.70	19.30	33.53	0.29	17.00	16.80	M-C
4	silt	11.00	19.00	30.00	0.37	4.00	26.10	M-C
5	Silt clay	6.70	18.60	34.00	0.28	19.00	13.10	M-C
6	steel products	--	78.00	6×10^7	0.20#	--	--	Line bomb
7	concrete	--	24.00	6×10^6	0.23#	--	--	Line bomb

3.3 Simulation conditions for excavation of Foundation Pit

By setting up the management of the construction stage in the finite element software, and by activating and passivation of the corresponding soil and supporting structure, the construction conditions are simulated. The simulated construction conditions of specific foundation pit excavation are shown in Table 3.

Table 3 Concrete construction condition of foundation pit

Primary foundation pit	Specific working condition	Construction details
	conditions 1	Initial stress field displacement clearing
	conditions 2	Apply as containment and continuous beams
	conditions 3	Inclined brace excavation
	conditions 4	Excavate the foundation pit to the first anchor cable and apply it as anchor cable
	conditions 5	Excavate the foundation pit to the second anchor cable and apply it as anchor cable
	conditions 6	Dig to the bottom of the pit-7.00m
	conditions 7	Make oblique brace, and excavate inclined brace area to the end.
Secondary foundation pit	conditions 8	Construction of second-stage Foundation Pit Enclosure structure
	conditions 9	Construction of second-stage Foundation Pit completed

4. Building deformation analysis

In the three-dimensional numerical simulation, the deformation characteristics of buildings under different working conditions are obtained. According to the results of three-dimensional calculation, the deformation of buildings under 8 different working conditions can be obtained. According to the influence of different working conditions on building deformation, the building deformation cloud map (see Fig. 10) and the final profile deformation cloud map (see figure 10) are extracted only under the typical working conditions (7/9).

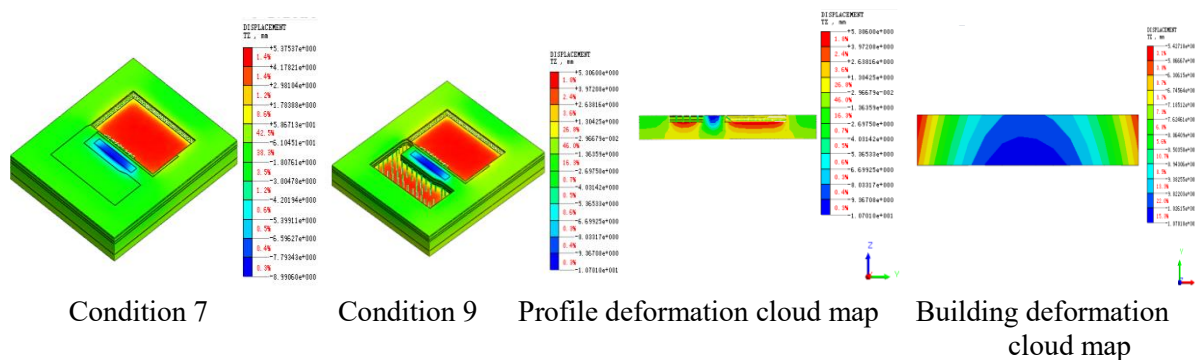


Fig 10 Simulated deformation graph

By extracting the results of numerical analysis, the following conclusions can be obtained:

Building profile position diagram is shown in figure 11, support pile displacement is shown in figure 12

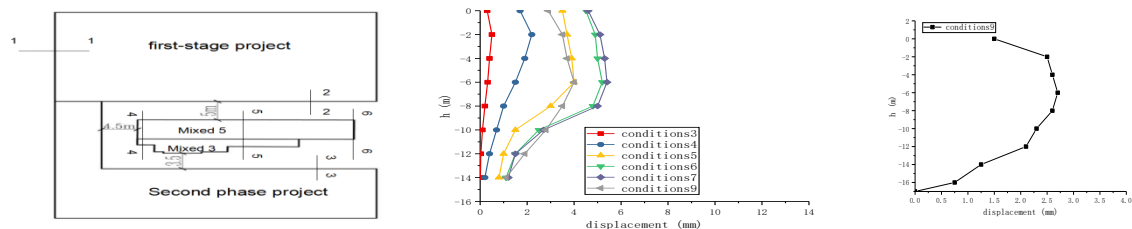


Fig. 11 Location of foundation pit section 2-2 Displacement curve of section guard pile Displacement curve of 3-3 profile retaining pile

Fig.12 Displacement map of supporting pile

For differential deformation of buildings, see figure 13.

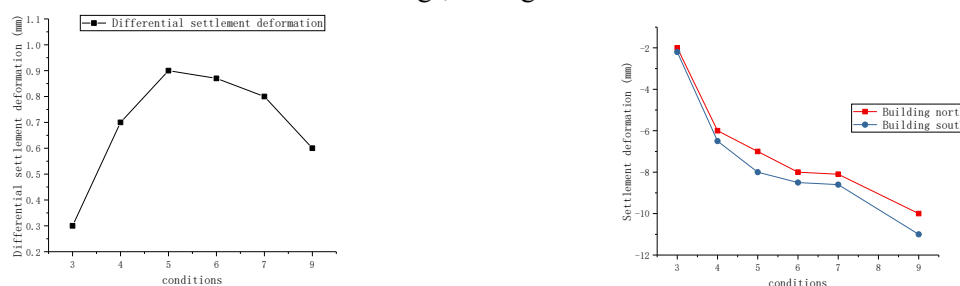


Fig 13 Deformation curve of buildings under different working conditions

5. Conclusion

The analysis of the effect of the foundation pit excavation on the surrounding buildings is an important subject in the foundation pit engineering. The following conclusions are drawn:

1) Due to the wide foundation pit and deep excavation, the effect of soil rebound caused by foundation pit unloading on the foundation pit and its surrounding should be fully taken into account

in the excavation process. At the same time, the central part of foundation pit is most affected by excavation unloading, and the uplift is also the biggest.

2) Because of the stress redistribution caused by excavation, the horizontal displacement of foundation pit increases with the increase of excavation depth, and the horizontal displacement at the same point increases gradually. The increase of excavation depth will also result in the maximum horizontal displacement moving gradually from the top of the slope to the middle and lower part of the deep foundation pit.

3) Through the research of this project, the displacement of the measuring point of the building can be simulated by using the numerical simulation method before construction, and it is more important that the numerical simulation curve can reflect the law of the change of the deformation with the depth of the excavation of the foundation pit, and provide some theoretical guidance for the construction of the foundation pit.

Acknowledgments

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