Numerical Simulation on Top-down Construction Method of Subway Station in Hefei

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Abstract—The top-down construction method has complex construction organization and many courses. Whether on theory or practice, quite a lot of problems need to be solved. In this paper, researchers used the finite element program Midas GTS to simulate THE foundation pit excavation of subway station in Hefei which used top-down construction method. The purpose is to research the regulation of the ground settlement and deformation of retaining structure. According to the theoretical data, researchers can know what time and where the maximum of the horizontal deformation of retaining structure and ground settlement may appear. Researchers may predict the risk and take measures to prevent accidents. All of it will provide the theoretical data to serve engineering practice.

Keywords-Top-down Construction Method; Midas; Ground Settlement; Retaining Structure; Deformation

I. INTRODUCTION

Top-down construction method was first mentioned by Japan in 1935[1]. In the 1950s, it was for the first time to use in building the subway station in Italy. Now it has become home and abroad in the city center with heavy traffic around subway station, a valid suggestion Methods[2]. In Japan, top-down construction method has formed the complete supporting system of steel and flat，which can be used repeatedly[3]. With the development of science and computer technology, outside monitoring and numerical analysis has become the main method to study the top-down construction method[4]. According to numerical analysis, researchers can predict the ground settlement and deformation of retaining structure in order to prevent accidents. At the same time, according to the data of outside monitoring, researchers can put forward practical advices to guide the construction process[5]. In China, the key technology and points of the top-down construction method is still not mature. Many problems such as how to design the joint of the structure and control the uneven settlement need to be solved[6]. Therefore,me scholars simulate the structure of station by Wave equation to analyze the deformation[7]. Therefore,me analyze the stability of retaining structure during the process of construction and optimize the main structure[8]. It is reported that the top-down construction method is first used in the construction of the subway station in Hefei.

II. THE PROCESS OF FINITE ELEMENT SIMULATION

A. *The related parameters*

The related parameters are shown in table 1 and table 2.

B. *Numerical model establishment*

The foundation pit of subway station is 64m length, 23.3m width, 24m depth. According to the impact during the process of excavation, researchers finally establish the numerical model which is 64m length, 100m width, 60m depth. In the numerical model, the size of the grid is 1.5m. Each unit is regular hexahedron. The subway station's main structure is frame structure of three floors underground. Researchers define the beam and column as 1D unit. Researchers define diaphragm wall and floor as 2D unit. Researchers define soil as 3D unit. The size of the component is design value[10]. The detailed structure model is presented in Fig. 1.

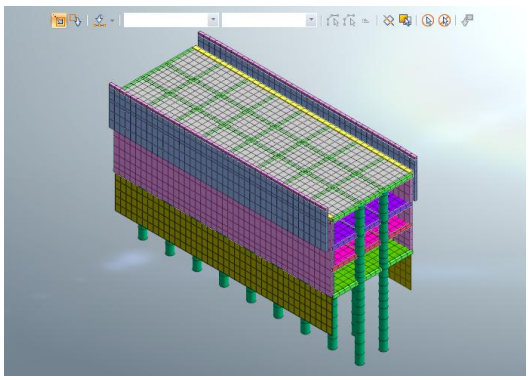

Figure 1. The main structure model.

C. *The numerical simulation process*

(1)Researchers activate all soil unit and exert gravity load. At the same time the authors apply fixed constraint to the model. Then researchers get an initial stress field.

(2)Researchers activate retaining structure and column . Researchers remove the displacement of the soil at the same time. All the component's constrain is fixed except the column. The column's constrain is Rz[11].

(3) Excavating to the first floor underground and activating the first floor's component. Meanwhile researchers should exert construction loads.

(4)Researchers backfill the hollow and restore the traffic.

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(5)Then researchers excavate to the second floor underground and activate the second floors component and exert construction loads.

(6) Repeat the step till the end of the foundation pit. Every step need exert construction load.

From what has been said above, researchers know there are four steps which need excavation. According to the order researchers name them Step 1 to Step 4.

TABLE I. LAYER PARAMETERS

Layer	Elastic Modulus /(pa)	Density /(kN • m^{-3})	Poisson ratio	Cohesion /kPa	Fric /(^{o})	Thickness /m
Miscellaneous fill	2.5×10^6	18.5	0.40	18	14	4.2
Clay	3.0×10^6	19.8	0.40	39	15	7.0
Silt	3.5×10^6	20.5	0.30	10	25	9.0
Mantle rock(1)	1.0×10^7	21.0	0.25	52	30	7.0
Mantle rock(2)	1.7×10^7	22.0	0.31	56	35	32.8

TABLE II. MATERIAL PARAMETERS[9]

Material	Elastic Modulus /(Pa)	Density /(kN • m^{-3})	Poisson ratio
Concrete	3.2×10^4	25	0.2
Steel	2.0×10^5	78	0.3

III. ANALYSIS OF THE RESULTS OF NUMERICAL SIMULATION

A. Ground settlement

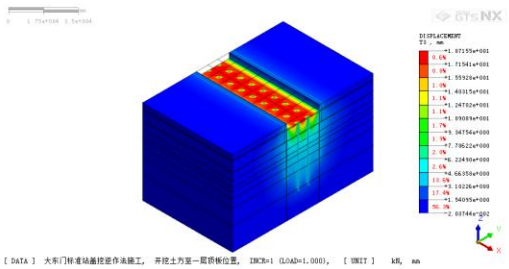

Figure 2. Ground settlement (Step 1)

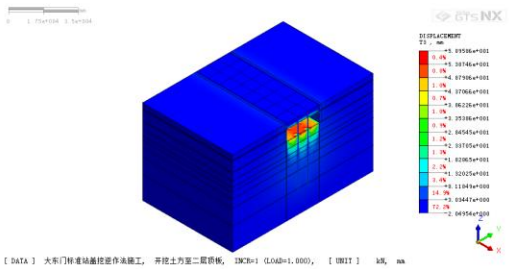

Figure 3. Ground settlement (Step 2)

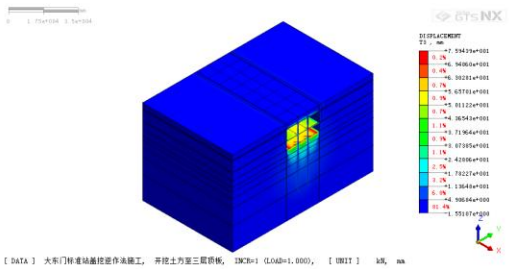

Figure 4. Ground settlement (Step 3)

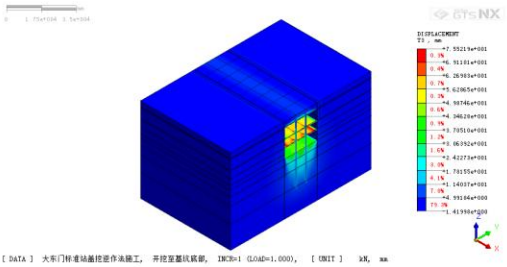

Figure 5. Ground settlement.(Step 4)

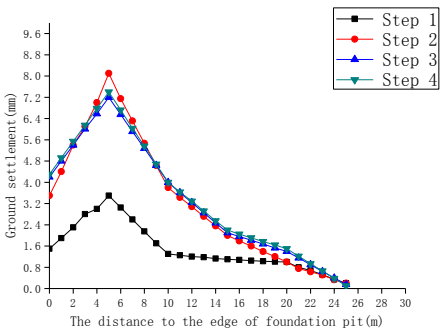

Figure 6. The curve of ground settlement.

From the figures, researchers can find that ground settlement mainly happened in step 1 and step 2.In step 3 and step 4, the ground settlement is nearly unchanged. This trend conforms to top-down construction method. During the construction of Underground structure, this method will reduce the impact on the adjacent buildings and environment[12]. From Fig. 6, researchers can obviously find that the maximum of ground settlement is at the place almost 5 meters away from the edge of foundation pit. Therefore, researchers should focus on

the ground settlement in this range during the period of construction.

B. *Retaining structure*

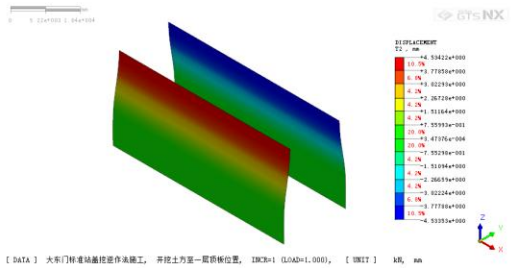

Figure 7. The horizontal deformation of retaining structure (Step 1)

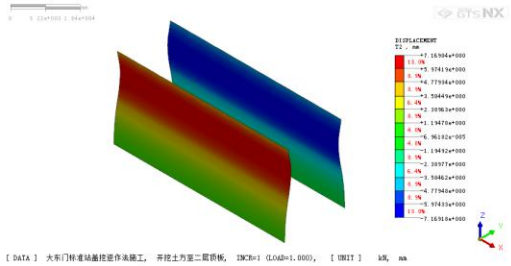

Figure 8. The horizontal deformation of retaining structure (Step 2)

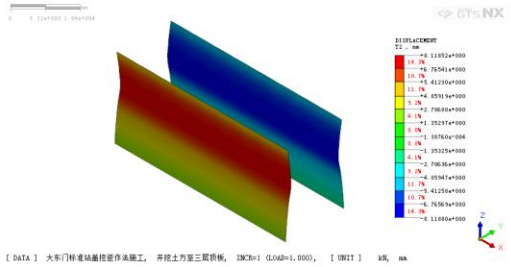

Figure 9. The horizontal deformation of retaining structure (Step 3)

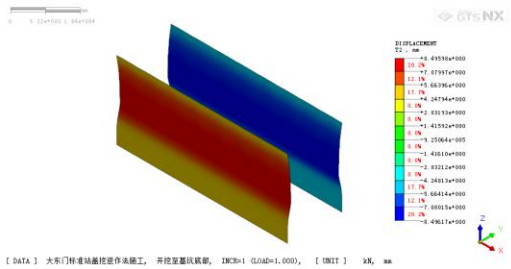

Figure 10. The horizontal deformation of retaining structure (Step 4)

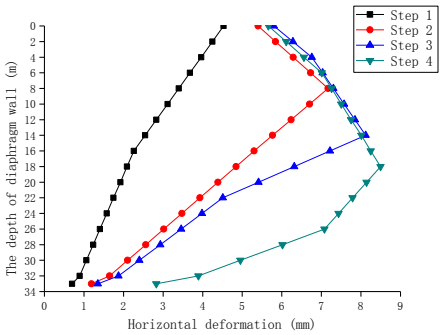

Figure 11. The curve of the horizontal deformation of retaining structure

From Fig. 11, researchers find that the horizontal deformation of retaining structure increased with the excavation[13]. Specially researchers find that the maximum of the horizontal deformation of retaining structure always appear in the surface which is excavated[14]. The horizontal deformation of retaining structure conforms to the time and space effect.

IV. CONCLUSIONS

Based on numerical simulation on top-down construction method of subway station in Hefei, researchers find the regulation of the ground settlement and horizontal deformation of retaining structure. It will provide the theoretical data to serve engineering practice[15]. According to the regulation researchers can draw the following conclusions:

(1) In the early time that the first floor underground is built the foundation pit has very strong stiffness to resistance to earth pressure. Therefore, top-down construction method is safe and reliable[16].

(2) Through the figures, researchers can know what time and where the maximum of the horizontal deformation of retaining structure and ground settlement may appear. Researchers may predict the risk and take measures to prevent accidents.

(3) As the particularity of its excavation method, the relationships of the retaining structure deformation, peripheral surface displacement and the impact of buildings neigh by have become more complex.

(4) This method can shorten the construction period and reduce the cost, because it does not need any redundant retaining structure.

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