

Analysis of Influences Caused by Cantilever Pile-Supported Pit Excavation towards Adjacent Buried Pipe Lines

Wensheng Liu^a, Dinglong Xue^a, Ji Yuan^b

^aSchool of Civil and Resource Engineering, University of Science and Technology
Beijing, Beijing, 100083, China;

^bChina Building Technique Group Co., Ltd, Beijing, 100013, China

E-mail: lwsh1969@163.com

Abstract. Foundation pit excavation adopts a widely used method in real projects—cantilever pile supporting, which has the advantages of easy construction, convenience and low cost, etc. The writers use MIDAS GTS software to build the 3D finite unit model to analyze the influences of such facts as excavation step, pipe diameter, center distance of pile. The conclusion shows: The maximum horizontal and vertical displacement of pipelines in the corner of foundation pit is about 1/2 of its center. The pipeline's diameter increases from 0.6m to 1.2m. The horizontal displacement changes little, but the vertical displacement of pipeline is reduced to half of the original.

1. Introduction

In recent years, urban construction of high-rise building have created a large number of deep foundation pits. The depth and scale increase constantly ^[1]. At present, the main forms of foundation pit supporting have underground continuous wall supporting, pull anchor supporting, soil-nailing wall supporting, inside brace supporting, cantilever pile supporting and so on. The support of the cantilever pile mainly depends on the depth of the buried soil to balance the ground overload and lateral pressure formed by the active soil ^[2]. It has the advantages of simple construction, convenient and low cost.

The influence of pit excavation on adjacent buried pipelines has done a lot of research at home and abroad ^[3-5]. But most of these studies were adopted the underground continuous wall structure or the internal brace supporting form. Research on the influence of Pit excavation supported by cantilever pile on adjacent buried pipelines is rare. The writers use MIDAS GTS software to build the 3D finite unit model and study the underground pipeline influence regulation that caused by excavation step, pipe diameter and center distance of pile. The support of the cantilever pile mainly depends on the depth of the buried soil to balance the ground overload and lateral pressure formed by the active soil.

2. pipeline and Pile soil imitate

The soil material is a kind of granular body material. Mohr-Coulomb yield criterion is applicable for rock body and this paper use Mohr coulomb model as the soil constitutive model. The underground pipeline is made of concrete, using a linear elastic model and a flat panel unit to simulate the concrete tube. The pile is made of concrete with a linear elastic constitutive model. Since pile and soil are two different materials, contact unit is established between pile and soil. The pile is simulated by beam element.



3. Excavation simulation

Firstly, the initial stress field and initial displacement field of soil are calculated before the excavation construction. The produce of the displacement field should be deducted in the subsequent construction phase of the displacement field, because the initial displacement at the end of the practice ahead of time has no effect on the excavation. This means that when we calculate displacement of excavation, the displacement field must be reset.

After the model is established, the concrete supporting pile and the activated pile unit should be added, and the constraint is applied at the bottom of the pile to remove the displacement. The total depth of the excavation is 10m, and the excavation unit of 5 times is set for each excavation. And then the stress field and displacement field are calculated.

4. Example analysis

A foundation pit engineering adopted the form of the cantilever pile support. Model size is about 40m×40m, as shown in figure 1. Excavation depth is 10 meters. The supporting structure is made of concrete circular piles with a depth of 6 meters, as shown in figure 2. Pipeline diameter is 1 meters. According to the engineering experience, the impact width of excavation is 3~4 times of excavation depth, and the influence depth is about 2~4 times^[6]. Since the calculation model is symmetrical, half analysis was performed in the data analysis. The calculation range of the model is 60m×60m × 40m. According to the geological survey report, the soil is divided into three layers. Specific parameters as is shown in table 1. Figure 3 is the grid map of the model.

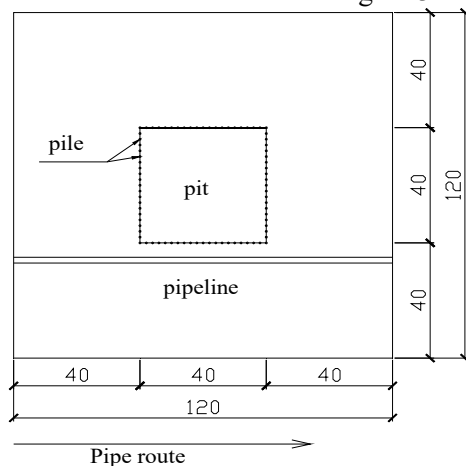


Figure 1. Plan of foundation pit

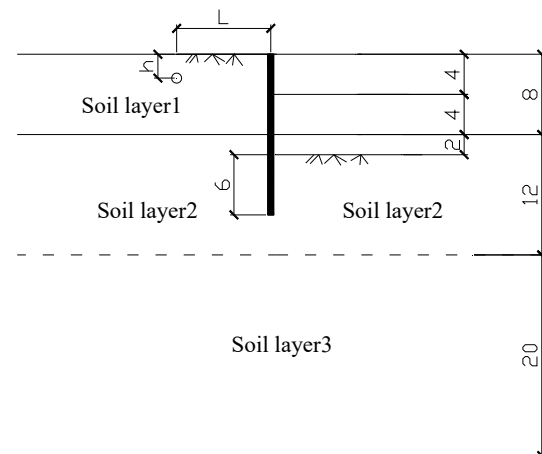


Figure 2. Section of foundation pit

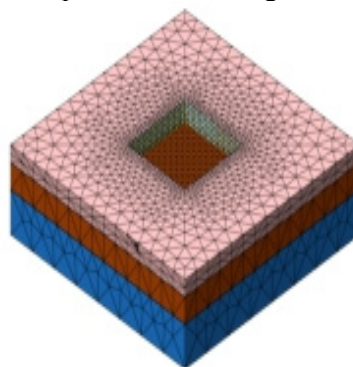


Figure 3. FEM model of foundation

Table 1. The Parameters of soil layer

Soil layer	Thickness (m)	Specific weight (Kg/m ³)	Unit weight (Kg/m ³)	Elastic modulus E/MPa	Poisson ratio μ	Cohesion C/kpa	Friction angle $\varphi/^\circ$
①	8	1800	1850	6	0.45	20	12
②	12	1860	1900	10	0.40	25	10
③	20	1920	1950	100	0.35	4	35

5. The results of calculation and analysis

5.1 The distribution of pipeline's displacement in different excavation step

The horizontal distance between the underground pipeline and the foundation pit is 10 meters, the pipe depth is 1 meter and the pile diameter is 0.6 meters. As we can see from figure 2 and 3, with the increase of excavation depth, the horizontal displacement and vertical displacement of the pipeline are gradually increasing. When cutting depth is not deep, the central position displacement of the pipeline has up uplift trend. As the excavation depth increases, the downward displacement begins to increase. Figure 4 and 5 can reflect the pipeline displacement began to mutation in the coordinates is about 40 meters. This is because this is the corner of the foundation pit. The foundation pit is extruded by the vertical pile of the pipe and the support stiffness is large, so there is a mutation. Thus it can be seen, the risk of excavation in the central part and angle point. So in the excavation process, we must take measures to protection the two place.

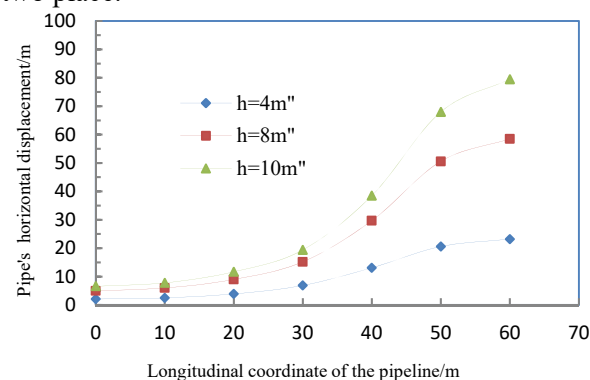


Figure 4. The horizontal displacements of pipeline

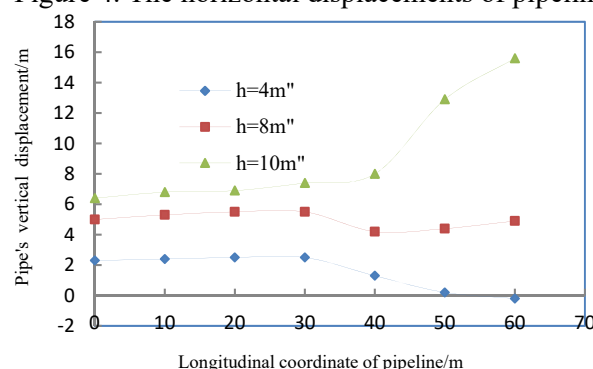


Figure 5. The vertical displacements of pipeline

5.2 Pipeline displacement contrast in different pile diameter

The horizontal distance between underground pipeline and the edge of foundation pit is 6 meters. The pipeline's depth is 1 meters and the cutting depth is 10 meters. The maximum horizontal and vertical

displacement of pipelines in the corner of foundation pit is about 1/2 of its center. Figure 6 shows that with the increase of the supporting pile diameter, the underground pipeline horizontal displacement change is not obvious. Figure 7 shows that the diameter of the supporting pile is changed, and the vertical displacement of the pipe decreases as the pile diameter increases. When the diameter of pipeline increases from 0.6m to 1.2m, the horizontal displacement changes little, but the vertical displacement of pipeline reduce to half of original. To a certain extent, increasing support pile diameter can prevent underground pipeline downward settlement.

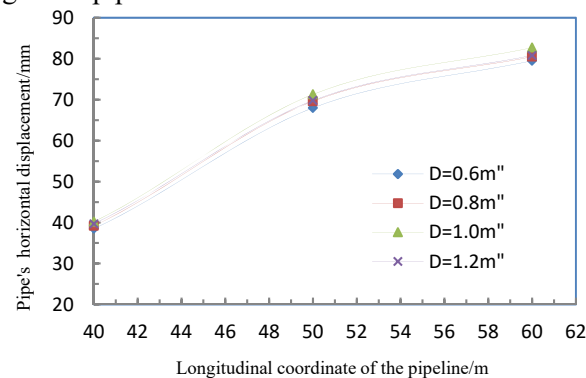


Figure 6. The horizontal displacements of pipeline

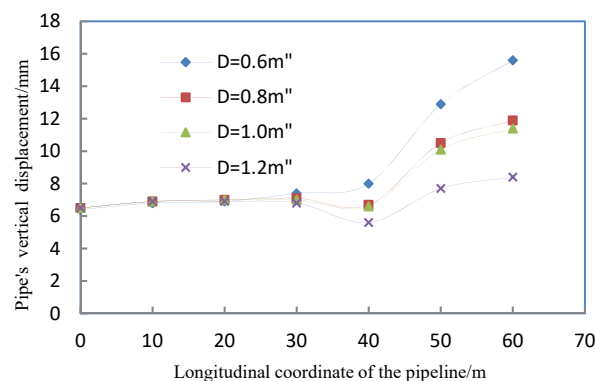


Figure 7. The vertical displacements of pipeline

5.3 Pipeline displacement contrast in the different of the centre distance of pile

The horizontal distance between underground pipeline and the edge of foundation pit is 6 meters. The depth of pipeline is 1 meters and the diameter of pile is 0.6 meters. Cutting depth is 10 meters. We can see from figure 8 and 9 that the horizontal and vertical displacement of pipelines in the corner of foundation pit are about 1/2 of its center. Figure 8 shows that along with the centre distance of pile increases, horizontal displacement reduce. When the centre distance of pile increases to 1.8m, the pipeline horizontal displacement should not change any more. Figure 9 shows that along with the centre distance of pile increases, the vertical displacement reduces. This is because the closer the middle distance is, the stronger the supporting rigidity is and the stronger the ability of the pipe to move, so the pipeline displacement is smaller.

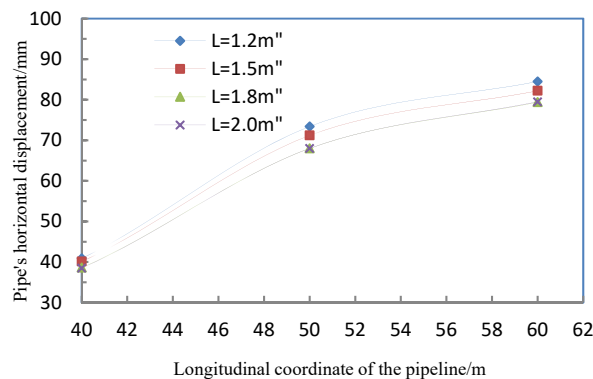


Figure 8. The horizontal displacements of pipeline

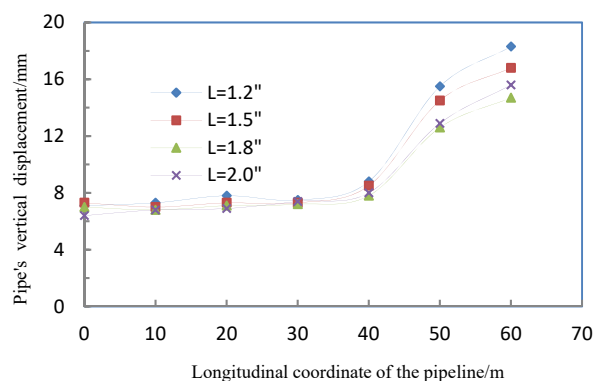


Figure 9. The vertical displacements of pipeline

6. Conclusions

With the increase of excavation depth, the underground pipeline's horizontal displacement and vertical displacement are increasing. Horizontal displacement is more larger than vertical displacement, so increasing the diameter of supporting pile can prevent underground pipeline from moving. The influence of the vertical displacement is more obvious than the horizontal displacement. When the diameter of pipeline increases from 0.6m to 1.2m, the horizontal displacement changes little, but the vertical displacement of pipeline reduce to half of original. Increasing the centre distance of pile, the horizontal displacement and vertical bar displacement of pipeline are all reduced, but changes are little.

Acknowledgments

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References

- [1] Mengxi Zhang, Jin Huang, Chinese Journal of Rock Mechanics and Engineering, 2006, 28 (11) : 1350
- [2] Jianhang Liu. Pit engineering manual[M]. Beijing: China Architecture and Building Press, 1977. (in chinese)
- [3] Shaowei Duan, Pusheng Shen. Engineering Mechanics, 2005, 22 (4): 79- 83. (in Chinese)
- [4] Jinglong Du, Min Yang. Chinese Journal of Rock Mechanics and Engineering, 2009, 28 (Suppl) : 3015
- [5] Dayong Li, Xiaonan Gong. Architecture Technology, 2003, 34 (2): 94- 96. (in Chinese)

- [6] Hu Dong. Finite element analysis of deformation of nearby underground pipelines affected by deep excavation [Dissertation]. Nanjing: Nanjing University of Aeronautics and Astronautics, 2008.