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Study on Foundation Treatment Technology of Comprehensive Pipe Gallery in Collapsible Loess Area

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Abstract. With the large-scale application of urban comprehensive pipe gallery in China, it is an urgent engineering problem that how to adopt appropriate technical schemes for the foundation of comprehensive pipe gallery under different geological conditions. First of all, this paper starts from the unique stress condition of the comprehensive pipe gallery, through the analysis of the change of the stress on the foundation soil, it comes to the conclusion that the stress on the foundation soil becomes smaller after the completion of the comprehensive pipe gallery structure, and further analyses the influence of the buried depth and section size on the stress change of the foundation soil. Then, according to the foundation treatment scheme of the comprehensive pipe gallery in the collapsible loess area, some optimized suggestions and ideas are put forward, in order to provide more economical and simple foundation treatment measures for the construction of the comprehensive pipe gallery in the future.

1. Introduction

At present, in the construction of urban comprehensive pipe gallery in major cities of China, how to study different technical schemes according to the foundation conditions of the comprehensive pipe gallery under different geological conditions, and then choose an economic and reasonable foundation treatment construction technology is an urgent engineering application problem to ensure the construction quality of urban comprehensive pipe gallery and the normal operation in the later period.

Based on the investigation of the comprehensive pipe gallery project of Lintong Renmin Road in Xi'an and the second Weishui road project in the International Port Area in the early stage, it is found that at present, the foundation treatment methods commonly used in the general pipe gallery project are almost same to the common engineering building structure, and the cushion method of 37 lime earth is mainly adopted, which lacks the foundation treatment method combining the actual stress of the comprehensive pipe gallery. Therefore, this paper first studies the soil stress change characteristics of the comprehensive pipe gallery base, and then analyses the foundation treatment of collapsible loess geology which is widely distributed in Shaanxi Province.

2. Factors influencing the change of basement stress

In order to study the influence of the cross-section size and the thickness of the overlying soil layer on the stress variation of the foundation soil, several standard cross-sections with different sizes were



selected from the "Cast in Situ Concrete Comprehensive Pipe Gallery" (17GL201) drawing. The calculation diagram is shown in Figure 1.

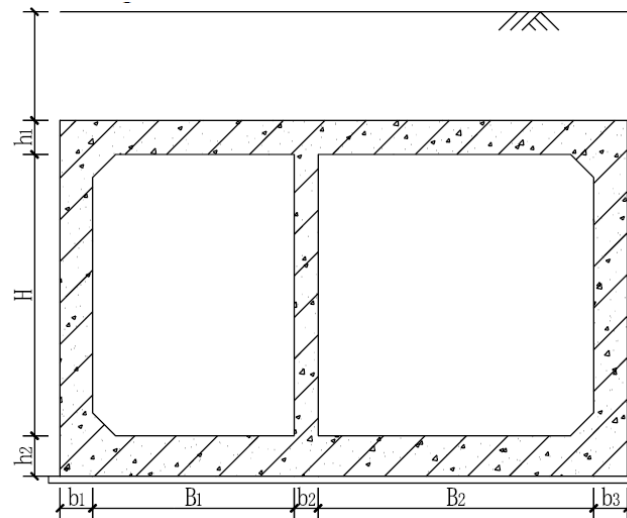


Figure 1 Calculation diagram of double cabin section

2.1. The influence of pipe gallery section size

In this calculation, it is assumed that the bottom slab of the pipe gallery is above the underground water level, the covering weight is 18kN/m^3 , the thickness is 2.5m , the volume weight of reinforced concrete is 25kN/m^3 , and the bottom concrete cushion is 100mm . According to the calculation method of the whole soil column theory, the stress change range of different sections is shown in Table 1.

Table 1 Change of base stress under different section sizes

Section No	B_1 (m)	B_2 (m)	H (m)	b_1 (m)	b_2 (m)	b_3 (m)	h_1 (m)	h_2 (m)	A (m^2)	σ_0 (kPa)	σ' (kPa)	$\frac{\sigma'}{\sigma_0}$
1	1.6	3.6	3	0.35	0.25	0.35	0.35	0.40	23.7	114	79.0	0.69
2	2.4	4.2	3	0.4	0.25	0.40	0.40	0.45	30.2	116	80.0	0.69
3	2.4	4.8	3	0.40	0.25	0.40	0.40	0.45	33.8	118	82.4	0.70
4	3	5.6	3	0.45	0.25	0.45	0.50	0.50	40.0	119	82.1	0.69

Note: σ_0 is the foundation soil stress before the pipe gallery construction, σ' is the foundation soil stress during the pipe gallery operation period.

It can be seen from table 1 that under the condition of constant external load, the stress of the foundation soil decreases after the construction of the comprehensive pipe gallery structure, and it is in the state of over consolidation. With the change of the cross-section size of the comprehensive pipe gallery, the stress of the foundation soil in the operation period of the pipe gallery is obviously reduced compared with that before the construction, but the stress proportion before and after the construction changes little, and the stress in the operation period is about 0.7 times of the stress of the foundation soil before the construction. The main reason is that on the premise of determining the buried depth of the pipe gallery, the stress of the foundation soil is affected by the structure self-weight, the internal space of the pipe gallery and the area of the foundation, but the self-weight of the pipe gallery is small. Therefore, under the comprehensive action, the change of the cross-section size of the comprehensive pipe gallery has little influence on the change of the stress of the foundation soil.

2.2. The influence of the thickness of pipe gallery soil

In this part, Section 1 in Table 1 is selected for calculation. Assuming that the bottom of the comprehensive pipe gallery is above the groundwater level, the influence of the buried depth of the pipe gallery on the change range of the basement stress is studied by changing the cover thickness of the pipe gallery. According to the calculation, the change range of stress under different cover thickness is shown in Fig 2.

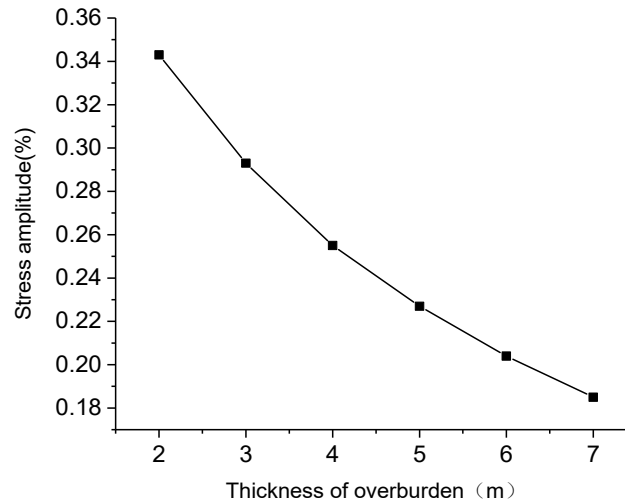


Figure 2 Relationship between thickness of overburden and stress amplitude

It can be seen from Fig 2 that when the buried depth of the comprehensive pipe gallery changes, the conclusion that the stress of the foundation soil is smaller in the operation period of the comprehensive pipe gallery structure than before the construction is still true. However, with the increase of the thickness of the overburden layer of the comprehensive pipe gallery, the stress of the foundation soil is significantly smaller before and after the construction, that is, the greater the thickness of the overburden, the smaller the stress of the foundation soil. The closer the stress is to its initial stress state.

3. Foundation treatment in collapsible loess area

The common treatment methods of collapsible loess foundation are cushion method, dynamic compaction method, compaction method and pre soaking method. Because the comprehensive pipe gallery is mostly located at the lower part or both sides of the road, in order to avoid affecting the foundation of surrounding buildings, the pre soaking method should not be used. The dynamic compaction method is of high noise and vibration, which is not conducive to urban construction and should be avoided as far as possible. In the foundation treatment of the comprehensive pipe gallery, two methods can be used: compaction method and cushion method. Among them, compaction method can be used for the treatment of deep collapsible loess layer and cushion method can be used for the treatment of shallow collapsible loess layer.

Through the study of the mechanical characteristics of the foundation soil of the comprehensive pipe gallery in the previous paper, it can be concluded that for the comprehensive pipe gallery structure with no surcharge, pedestrian load or vehicle load on the upper part, the treatment of collapsible loess foundation should focus on avoiding uneven settlement, while the requirements for the bearing capacity of the foundation are relatively low. In conclusion, the optimization idea of foundation treatment in collapsible loess area is as follows:

(1) Optimization of self-weight collapsible loess foundation treatment

Firstly, the initial collapse pressure of the soil is analyzed to determine whether the load generated by the comprehensive pipe gallery structure reaches its initial collapse pressure. When the initial collapse pressure is reached, it can be compared and selected according to the foundation treatment scheme in the building code of collapsible loess area. The two factors of foundation bearing capacity

and uneven settlement should be considered at the same time, but the requirements and treatment grade of foundation bearing capacity can be reduced properly according to the actual stress situation. If the initial collapse pressure cannot be reached, the insufficient bearing capacity and uneven settlement of the foundation caused by the collapse of the foundation may not be considered. The foundation may not be treated or treated in the same way as the general foundation.

(2) Optimization of non self weight collapsible loess foundation treatment

The non self-weight collapsible loess will produce collapsibility only under the joint action of external additional stress and self weight stress of soil mass. Because the stress of the base soil mass in the comprehensive pipe gallery structure is always less than the self weight stress of the upper soil mass, the base soil mass will not collapse after the completion of the comprehensive pipe gallery structure construction, which ensures that the bearing capacity and settlement of the base soil mass meet the comprehensive requirements for pipe gallery structure. Therefore, the foundation of the comprehensive pipe gallery structure in the non self-weight collapsible loess area can not be treated, or it can be treated in the same way as the general foundation.

4. Conclusion

In this paper, the stress change of the foundation soil after the construction of the pipe gallery structure is studied, and the influence of the cross-section size and the thickness of the covering soil on the stress change range of the foundation soil is analyzed. Then, the paper makes a brief analysis of several common foundation treatment methods in collapsible loess area combined with the stress change characteristics of pipe gallery, and draws the following conclusions.

When the local foundation soil is self-weight collapsible loess, the initial collapsible pressure of the soil should be analyzed first. When the load of the comprehensive pipe gallery structure reaches its initial collapse pressure, the foundation treatment method is the same as that of the buildings in the collapsible loess area, but the requirements and grades of foundation treatment can be appropriately reduced according to the actual situation. If the initial collapse pressure can not be reached, it can not be treated under the premise of ensuring the safety of the structure. When the local foundation soil is non self-weight collapsible loess, it can be treated or not treated in the same way as the general foundation.

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