

Design of Deep Foundation Pit Support Scheme Based on Fuzzy Grey Correlation Projection Method

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Abstract. In order to make full use of the limited land resources, it is an inevitable trend of architectural development to develop underground. With the rapid development of urban construction and the rise of subway, underground spaces are constantly being developed, such as underground parking lots, underground shopping malls, underground warehouses, underground substations and a variety of underground civil and industrial facilities, resulting in a large number of deep foundation pit projects. The construction of deep foundation pit has the characteristics of high risk coefficient, high technical requirements and many influencing factors. If the design of supporting structure is unreasonable or the construction process is not strictly controlled, it will cause hidden dangers of quality and safety, which is not conducive to the smooth implementation of the project. In order to avoid possible uncertainties, it is necessary to adopt a more efficient and safe construction design scheme to provide effective guarantee for smooth construction. This paper expounds the problems encountered in the design and construction of deep foundation pit support, and puts forward the design strategy of deep foundation pit support scheme based on fuzzy grey correlation projection method.

Keywords: Construction of deep foundation pit, Support scheme, Structural design.

1. Introduction

In recent years, due to the rapid development of urbanization in China, the urban population density is getting higher and higher, and the supply of urban land resources is becoming increasingly tight [1]. In order to make full use of the limited land resources, it is an inevitable trend of architectural development to develop underground. In the process of foundation pit construction, in order to ensure that the main structure and surrounding environment are not damaged, the supporting structure, dewatering, earthwork excavation and backfilling are adopted, which is called foundation pit engineering [2]. With the rapid development of urban construction and the rise of subway, underground spaces are constantly being developed, such as underground parking lots, underground shopping malls, underground warehouses, underground substations and various underground civil and industrial facilities, etc., resulting in a large number of deep foundation pit projects, whose scale and depth are constantly increasing [3]. In the system composed of all feasible supporting schemes, there are both known white information and undiscovered black information, and more generally qualitative gray information, so it is a gray system [4]. The factors and indexes in the decision-making of deep foundation pit support scheme influence and restrict each other, and have grey correlation. For such a foundation pit with complicated surrounding conditions, it is necessary to create conditions to facilitate earthwork excavation, and to protect the environment in the densely built areas [5]. Therefore, how to select the supporting structure safely and reasonably and design scientifically according to the characteristics of deep foundation pit engineering is the main content to be solved in deep foundation pit engineering.

In some areas with complicated soil structure, complicated soil geology, diverse soil characteristics, deep excavation depth, narrow construction scope, proximity to surrounding buildings, especially high-rise buildings, and sensitive to deformation, the construction of deep foundation pit projects is increasing, which leads to the complexity in the supporting process, and the supporting construction period is long, the process is complicated and the cost is high [6]. Many deep foundation pits of high-rise buildings are constructed in dense buildings, and there are built buildings, traffic roads and

underground pipelines around the foundation pits. For such a foundation pit with complex surrounding environmental conditions, it is necessary to create conditions to facilitate the earthwork excavation of the foundation pit, and to protect the environment in the densely built areas [7]. In order to avoid possible uncertainties, it is necessary to adopt a more efficient and safe construction design scheme to provide an effective guarantee for smooth construction [8]. At present, most of the methods for optimizing deep foundation pit support schemes are based on investigation, analysis and estimation, listing the technical and economic indexes of the schemes to be selected, and then choosing them by the experience of designers [9]. This method is greatly influenced by subjective factors, the evaluation process is complicated, and the recognition degree of optimization results is poor. This paper expounds the problems encountered in the design and construction of deep foundation pit support, and puts forward the design strategy of deep foundation pit support scheme based on fuzzy grey correlation projection method.

2. Technical characteristics of deep foundation pit support under complex environmental conditions

2.1. Highly complex construction conditions

Construction conditions are highly complex. The construction conditions of deep foundation pit support are highly complex. Typical representatives, such as civil air defense projects, not only meet the needs of exhibition, but also consider urban construction and economic development. Before construction, it is necessary to relocate the old pipelines in the area, and there are many factors to consider. If the construction area is full of dense buildings with shallow foundations, it is very easy to control the deformation. In the past, sheet pile support or sheet pile anchor technology was often used in foundation pit construction. Although this kind of construction system can recycle materials, when the sheet pile is pulled out, the deformation of the foundation pit will be caused by the deformation of the load, and its application is greatly limited because of its small rigidity [10]. Generally, large-scale civil air defense projects are located in the city center. Therefore, during the construction process, it should be noted that the production and life of surrounding buildings are not affected, and pollution such as noise and dust must be controlled. In terms of geological conditions, the soil is divided into four layers according to the physical properties of rock and soil: the main components are miscellaneous fill consisting of gravel soil, sandy soil and cohesive soil, round gravel consisting of granite, feldspar and a small amount of mica, and strongly weathered argillaceous siltstone and moderately weathered argillaceous siltstone. The lower the layer, the greater the cohesion of rock and soil (see Figure 1).

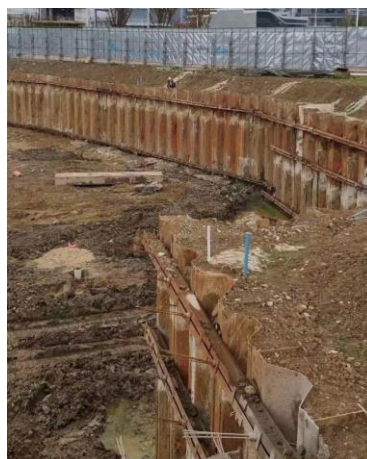


Figure 1. Deep foundation pit construction

The principle of diaphragm wall is to build a guide wall to protect the upper mouth of diaphragm wall foundation groove, and then use machinery to excavate the groove in sections. Make use of the

pressure of the mud to ensure the stability of the groove wall, at the same time bring out the muck, put the reinforcing cage under the groove and pour concrete to replace the mud, thus forming a section of reinforced concrete wall. Due to the different composition and physical characteristics of each soil layer, the mechanical properties and parameters are different, which aggravates the complexity of construction. For example, site stability should be considered during construction, including liquefaction, earthquake subsidence, equivalent shear wave velocity of soil and other factors. In addition, the deep foundation pit construction is also affected by local climatic conditions, hydrogeological conditions, topography and other factors.

2.2. The requirement of support security level is high

According to the engineering objectives of the foundation pit supporting scheme, project managers need to collect various information and data. Including the design of underground structure of foundation pit engineering, engineering geological and hydrological data, surrounding environmental data, and the construction period and cost requirements of the project. Before construction, the engineering geological conditions, geotechnical mechanical properties and surrounding environment should be thoroughly investigated, and the parameters such as the natural weight of each soil layer, the internal friction angle and the friction resistance of anchor body should be specifically calculated to fully understand the engineering geological conditions. In order to ensure the accuracy and reliability of geotechnical parameters, soil samples and in-situ tests should be used. If the results are basically the same, the geotechnical parameters are reliable.

In the dangerous construction industry, the safety requirements of foundation pit support are the most important. Safety is the precondition for foundation pit supporting engineering to achieve its economic and quality goals. Because of its complexity in all aspects, the engineering risk of foundation pit support project is particularly prominent, especially when problems occur in ultra-deep foundation pit, the losses will be disastrous, and the requirements for foundation pit safety are even more stringent. Before construction, we should first do a good job of drainage to ensure the stability of the foundation, and at the same time, we should avoid surface water leaking into the structure, and take effective measures to deal with the problems such as precipitation in time. Construction personnel must work according to the safety technical disclosure. With the deepening of the foundation pit, reliable supports should be added around it. At the same time, a special protection plan around the deep foundation pit should be prepared to ensure that safety measures are put in place.

3. Selection of deep foundation pit support scheme based on fuzzy grey relational projection method

3.1. Grey relational projection method

According to the specific conditions of the surrounding environment of deep foundation pit, the more complex the environment, the more multiple combined support methods should be adopted. If the slope-setting conditions are not met, the slope-setting method cannot be used for construction, and the economy of the continuous wall method should be considered in the construction. Therefore, a combination of pile-anchor support and other methods should be adopted in the construction. The deep foundation pit bracing technology is adopted, which combines pile anchor, pile bracing and diaphragm wall with internal bracing. Considering the complex construction environment, different hydrogeological conditions and poor soil quality of deep foundation pit, the stress can be transferred to other components through temporary bracing by combining two walls.

Different evaluation indexes have different physical meanings and dimensions. In order to eliminate the incommensurability caused by inconsistent dimensions, the evaluation indexes should be dimensionless before making decisions. For benefit indicators, there are:

$$b_{ij} = \frac{a_{ij} - a_j^{\min}}{a_j^{\max} - a_j^{\min}} \quad (1)$$

Where: a_j^{\max} and a_j^{\min} are the maximum and minimum values of j indicators in all schemes, respectively. For cost-based indicators, there are:

$$b_{ij} = \frac{a_j^{\max} - a_{ij}}{a_j^{\max} - a_j^{\min}} \quad (2)$$

For fixed indicators, there are:

$$b_{ij} = 1 - \frac{|a_{ij} - a_j^*|}{\max_i |a_{ij} - a_j^*|} \quad (3)$$

Where: a_j^* is the best stable value of j index. For interval indicators, there are:

$$b_{ij} = \begin{cases} 1 - \frac{a_{1j} - a_{ij}}{\max\{q_{1j} - a_j^{\min}, a_j^{\max} - q_{2j}\}}, & a_{ij} < q_{1j} \\ 1, & a_{ij} \in [q_{1j}, q_{2j}] \\ 1 - \frac{a_{ij} - q_{2j}}{\max\{q_{1j} - a_j^{\min}, a_j^{\max} - q_{2j}\}}, & a_{ij} > q_{2j} \end{cases} \quad (4)$$

Where: $[q_{1j}, q_{2j}]$ is the best stable interval of j index. Remember that the decision matrix after dimensionless processing is the standard decision matrix:

$$B = (b_{ij})_{n \times m} \quad (5)$$

The elements in the B matrix have the same measurement standard and can be treated uniformly.

Some project owners pay more attention to the project cost target because they have a good grasp of the local external relations and have a high tolerance for the deformation of foundation pit and surrounding environment. Therefore, it has low requirements for safety risks of the project, and high requirements for cost risks and time limit risks. However, some project parties attach great importance to the environmental impact, and require that the impact on the surrounding environment be as small as possible, and they can accept slightly higher project cost, so they have high requirements for project safety risks. During the construction, support is first followed by excavation, and the construction of each main structure is gradually completed from bottom to top, until the roof is poured. Construction focuses include slope dewatering and support, earthwork excavation and drainage, structural construction, etc. In order to prevent settlement and deformation, special attention should be paid to the application of slope support technology.

3.2. Optimization strategy of construction support scheme

Mechanical excavation scheme shall be adopted, and backhoe shall be used for layered relay excavation. When the excavation depth is deeper than the surrounding building foundation, to keep a certain slope and distance, retaining walls or supports at the foot of the slope should be adopted to improve the stability of the slope. During excavation, pay attention to whether there are caves, cracks and faults at the bottom of the pit. If any signs are found, they should be dealt with in time. In the past, the goal of foundation pit engineering was simply to ensure that the foundation pit would not collapse in terms of safety, and the requirements for deformation of foundation pit and its influence on surrounding ground buildings were relatively ignored. In the foundation pit shape selection project of ultra-deep foundation pit engineering, in addition to the most basic safety objectives, the impact on the surrounding environment should be analyzed. The engineering geological conditions of deep foundation pit are complex, there are many surrounding buildings, and the material properties, stress structure and many environments are affected. Therefore, simply relying on calculation can't meet the actual engineering needs, and can't accurately reflect the engineering changes and unknown conditions. For example, heavy precipitation, underground pipeline leakage, and sharp increase of

external load all easily lead to large displacement. In order to avoid the instability of the foundation pit, it is necessary to strengthen the monitoring work so as to adjust the construction scheme in time. In the construction stage, the horizontal and vertical displacement of the top, the deep displacement of the supporting structure, the internal force of the anchor and the vertical displacement of the surrounding buildings should be detected. Monitor the total amount of overall change, and adjust the plan in time once it exceeds the alarm value.

4. Conclusions

Once the foundation pit is unstable, the accident will cause great harm, which will cause huge loss of life and property. Therefore, in the construction, it is necessary to strengthen the preparation before construction, improve the safety level of support, and improve the construction process of foundation pit support. This paper expounds the problems encountered in the design and construction of deep foundation pit support, and puts forward the design strategy of deep foundation pit support scheme based on fuzzy grey correlation projection method. The lowering of underground water level has certain influence on surrounding buildings, therefore, corresponding measures should be taken according to the degree of its influence on buildings during foundation pit excavation. During the construction, support is first followed by excavation, and the construction of each main structure is gradually completed from bottom to top, until the roof is poured. In order to avoid the instability of the foundation pit, it is necessary to strengthen the monitoring work so as to adjust the construction scheme in time. In the construction stage, the horizontal and vertical displacement of the top, the deep displacement of the supporting structure, the internal force of the anchor and the vertical displacement of the surrounding buildings should be detected. All-round monitoring of supporting structure and surrounding environment, real-time adjustment of construction technology, to ensure the safety of foundation pit or even local instability, can also minimize the loss.

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