Research on Simulation Optimization and Construction of Deep Foundation Pit Earthwork Excavation Based on BP Nerve Network

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Abstract. Deep foundation pit excavation not only faces complex hydro-geological and engineering geological conditions, but also meets many unknown engineering risks. Deep foundation pit excavation not only faces complex hydro-geological and engineering geological conditions, but also needs to make full use of BP nerve network. Based on this, this paper first analyzes the connotation and function of BP nerve network, then studies the simulation of deep foundation pit construction earthwork excavation, and finally gives the BP nerve network simulation and optimization method of deep foundation pit construction earthwork excavation.

Keywords: Simulation Optimization, Deep Foundation Pit, Earthwork Excavation, BP Nerve Network

1. Introduction
With the iterative progress and maturity of computer tech, it has been widely popularized and studied in many fields, especially in the field of construction infrastructure, which greatly promotes the progress and development of construction engineering represented by deep foundation pit building earthwork excavation simulation. On the other hand, the iterative progress and growth of social economy, as well as the continuous improvement of urbanization level, make a large number of construction infrastructure works emerge one after another [1]. However, in the process of urbanization, limited by the limited urban space, the available land area of buildings is decreasing, which conflicts with people's pursuit of building space and building comfort. In this context, only in the limited construction land area, make full use of ground resources, can better solve the contradiction of land use progress. Therefore, the continuous development of underground construction has become an important trend of construction engineering.

Under the background of the continuous expansion of construction engineering towards underground space, higher requirements are put forward for deep foundation pit construction earthwork excavation tech, especially for deep foundation pit support and earthwork excavation simulation tech. For high-rise buildings, deep foundation pit excavation not only faces complex hydro-geological and engineering geological conditions, but also meets many unknown engineering risks, so the cost and difficulty of construction are greatly improved. The earth excavation of deep foundation pit will be affected by several factors as shown in Figure 1, which makes the excavation simulation of
deep foundation pit have strong stochastic, fuzziness and complexity. In the process of deep foundation pit excavation, complex rock mass with high nonlinearity will be encountered. Conventional experience and finite element analysis methods cannot be used for scientific and professional simulation and analysis. The iterative maturity of intelligent tech represented by AI and nerve network can effectively simulate the complex rock mass in deep foundation pit excavation construction and lay the technical premise for construction optimization.

Figure 1. Influencing factors of earthwork excavation in deep foundation pit construction

In addition, with the help of BP nerve network can accurately simulate the complex parameters of rock and soil, so as to build an accurate numerical model for further computational and analysis, and provide decision-making basis for the rationality of earthwork excavation construction scheme. BP nerve network is not only helpful to optimize the construction design scheme of foundation pit engineering, but also can dynamically track the construction process and improve the rationality and economy of construction [2]. With the help of BP nerve network, the reasonable use of construction feedback information and the construction of efficient numerical simulation analysis model are the technical premise and guarantee for the safe construction of earthwork excavation in building foundation pit engineering.

In short, the excavation of deep foundation pit often encounters complex geotechnical media, and often involves a large number of parameters with complex relationships. It is difficult to build a deep foundation pit excavation model in line with the actual construction engineering by traditional means, resulting in poor precision of simulation results [3]. The application of intelligent tech represented by BP nerve network in the simulation of deep foundation pit construction earthwork excavation can quantitatively evaluate the mathematical model of highly nonlinear geotechnical engineering, provide technical support for deep foundation pit construction Earthwork excavation, and make the construction scheme better and the construction process more controllable. Therefore, the study of BP nerve network simulation optimization and construction of deep foundation pit construction earthwork excavation has important engineering practice value.

2. Connotation and function of BP nerve network

2.1. Connotation and characteristics of BP nerve network
As a kind of nerve network with three or more layers of nerve cells, BP nerve network includes three levels of influx, hiding and outlet layer, in the light of the direction of reducing the error between the target outlet and the actual outlet, it reverses from the outlet layer to the influx layer through each intermediate layer, so as to modify each link weight layer by layer [4]. BP nerve network has two propagation stages: the forward propagation stage of state updating layer by layer and the back propagation stage of error.

For influx mode: if the anticipated outlet of the kth nerve cell in the outlet layer is $d_{pk}$, the actual outlet is $y_{pk}$. The outlet variance of the outlet layer is as follows:

$$E_p = \frac{1}{2} \sum_k (d_{pk} - y_{pk})^2$$  \hspace{1cm} (1)

If N modes are influx, the system mean square error of the network is:
In the outlet layer, the error of nerve cell outlet is back propagated to the previous layers, and the weights between the layers are corrected [5].

2.2. Learning algorithm of BP nerve network
First of all, the network is initialized, each link weight is assigned a stochastic number in the interval, the error function is set, and the computational precision and the peak learning frequency are given. Secondly, an influx prototype and the corresponding anticipated outlet are stochastically selected, and then the I/O of each nerve cell in the hiding-layer is computed. In addition, the partial derivatives of the error function to the nerve cells in the outlet layer are computed by using the anticipated outlet and the actual outlet of the network [6]. The partial derivatives of the error function to the nerve cells in the hiding-layer are computed by using the link weights from the hiding-layer to the outlet layer, the partial derivatives of the outlets of the outlet layer and the outlet of the hiding-layer. Then, the partial derivative of each nerve cell in the outlet layer and the outlet of each nerve cell in the hiding-layer are used to modify the link weights [7]. The partial derivative of each nerve cell in the hiding-layer and the influx of each nerve cell in the influx layer are used to modify the link weight.

2.3. Visual explanation and function of BP algorithm
When the partial derivative of the error to the weight is greater than zero, the weight tune-up is negative, the actual outlet is greater than the anticipated outlet, and the weight is adjusted to decrease the difference between the actual outlet and the anticipated outlet. When the partial derivative of the error to the weight is less than zero, the weight tune-up is positive, the actual outlet is less than the anticipated outlet, and the weight is adjusted to increase, so that the difference between the actual outlet and the anticipated outlet is decreased [8]. BP algorithm has strong nonlinear mapping ability, and can learn and store a large number of influx-outlet pattern mapping relations without knowing the mathematical equations describing the mapping relations in advance. In addition, BP algorithm has strong generalization ability and fault tolerance.

3. Simulation of earthwork excavation of deep foundation pit

3.1. Influencing factors of earthwork excavation in deep foundation pit construction
The influencing factors of earthwork excavation of deep foundation pit mainly include the construction of retaining wall, dewatering before excavation, geometry and size of foundation pit, performance of retaining wall and support, stiffness and insertion depth of retaining wall, horizontal and vertical spacing of support, etc [9]. Among them, at the construction level of retaining wall, the dewatering before foundation pit excavation has a significant impact on the displacement of diaphragm wall. The dewatering before excavation has a significant impact on the displacement of diaphragm wall. Secondly, the influence of the geometric shape of the foundation pit is mainly reflected in the spatial effect of the foundation pit. The excavation depth of the foundation pit directly affects the stress change of the undisturbed soil. In addition, the performance of retaining wall and support has a great influence on the deformation of foundation pit.

3.2. Selection of constitutive relation and model parameters
For hard clay, sand, rock and reinforcement, the Mohr Coulomb elastic-plastic model can be used; for supporting structure, the linear elastic model can be used. The special stress path of foundation soil in foundation pit engineering should be considered reasonably. The computational parameters of the model are very important, so it is necessary to simplify and simulate the construction process reasonably [10]. In the numerical analysis, it is necessary to reasonably simulate the link relationship between the retaining structure and the support, and between the support and the column. The
simulation of plane strain state can greatly decrease the amount of computational and meet the needs of computational. When there is significant asymmetry in the foundation pit, 3D numerical analysis can be used to simulate the model accurately.

4. Simulation and optimization of deep foundation excavation based on BP nerve network

4.1. Dynamic prediction of deep foundation pit construction based on BP nerve network

The results of numerical simulation of deep foundation excavation are easily affected by the selection of soil parameters, especially the elastic modulus. Generally, the elastic modulus can only be estimated, but cannot obtain accurate values, which leads to the poor precision of numerical simulation. Therefore, it is necessary to inverse the elastic modulus of soil. In the numerical simulation, the compression modulus of shallow soil is about 4 frequencies, and that of deep soil is about 8 frequencies. The normalized horizontal displacement value is taken as the influx of the learning prototype, and the outlet of the learning prototype is respectively influx into the BP nerve network. After training, the consistency between the target prototype and the training result is compared, as shown in Figure 2. It can be seen from the figure that the result of coarse fitting is good, which indicates that the network can be used to invert the elastic modulus of soil.

![Figure 2. Consistency between target prototypes and training results](image)

4.2. Deformation prediction of deep foundation pit construction

In the light of the BP nerve network deep foundation pit support deformation analysis system, firstly, the prototype data information is collected in the deep foundation pit construction site. Secondly, carry out the scientific computational of the weight value, and test the effectiveness of the overall consistency of the target layer [10]. In addition, the scientific evaluation index system is established to collect and analyze the effectiveness of prototype data information, and the results of BP nerve network prediction and analysis are compared with the measured results, so as to improve the quality and level of prediction and analysis.

5. Conclusion

In summary, with the help of BP nerve network, the reasonable use of construction feedback information and the construction of efficient numerical simulation analysis model are the technical premise and guarantee for the safe construction of earthwork excavation in building foundation pit engineering. This paper analyzes the learning algorithm of BP nerve network by studying the connotation and function of BP nerve network. Through the analysis of deep foundation pit building earthwork excavation simulation, the selection of constitutive relationship and model computational
parameters are studied. Based on the study of the simulation and optimization of deep foundation pit construction earthwork excavation based on BP nerve network, the dynamic prediction method of deep foundation pit construction based on BP nerve network is analyzed.

References
[1] An Guanfeng, Wo Tuo. Monitoring and analysis of comprehensive support for deep foundation pit of underground space in front of Guangzhou Metro Park [J]. Journal of geotechnical engineering, 2017, 29 (6): 872-879.
[2] He Juntao, Zhang Jie, Huang Hongwei, et al. Back analysis of foundation pit displacement based on multiple response surface method [J]. Geotechnical mechanics, 2012, 33 (12): 3810-3817.
[3] Hu Wusheng. Application examples of Nerve Network tech for deformation analysis [J]. Surveying and mapping engineering, 2018, 17 (3): 37-42.
[4] Li Lei, Duan Baofu. Monitoring measurement and numerical simulation of deep foundation pit engineering of subway station [J]. Journal of rock mechanics and engineering, 2013, 32:2684-2691.
[5] Liu Yong, Feng Zhi, Huang Guochao, Feng Xudong. Study on deformation of retaining structure of deep foundation pit of Beijing Metro Engineering [J]. Journal of underground space and engineering, 2019,5 (2): 329-335.
[6] Meng Fanli, Zheng Qi, Li Yan, Lu Chengyuan. Deformation prediction of deep foundation pit support based on BP Nerve Network [J]. Journal of Zhejiang University of tech, 2014 (4): 367-372.
[7] Ren Jianxi, Gao Lixin, Liu Jie, et al. Study on site monitoring of deformation law of deep foundation pit [J]. Journal of Xi'an University of science and tech. 2018, 28 (3): 445-449.
[8] Ren Lifang, Yuan Baoyuan, Wang Jiang. Application of grey Nerve Network combination model to predict deformation of deep foundation pit [J]. Subgrade engineering, 2007, 134 (5): 22-24.
[9] Zhang Shihao, Zhu Dehua. Deformation prediction of deep foundation pit based on BP Nerve Network [J]. Journal of Nanjing Institute of Engineering (NATURAL SCIENCE EDITION), 2016 (3): 17-22.
[10] Zhou Qiujuan, Chen Xiaoping, Xu Guangming. Centrifugal model test and numerical simulation of soft soil foundation pit [J]. Journal of rock mechanics and engineering, 2013, 32 (11): 2342-2348.