

## *Retraction*

# **Retracted: Deformation Detection Model of High-Rise Building Foundation Pit Support Structure Based on Neural Network and Wireless Communication**

### **Security and Communication Networks**

Received 26 December 2023; Accepted 26 December 2023; Published 29 December 2023

Copyright © 2023 Security and Communication Networks. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

### **References**

- [1] D. Ding, "Deformation Detection Model of High-Rise Building Foundation Pit Support Structure Based on Neural Network and Wireless Communication," *Security and Communication Networks*, vol. 2021, Article ID 5525616, 10 pages, 2021.

## Research Article

# Deformation Detection Model of High-Rise Building Foundation Pit Support Structure Based on Neural Network and Wireless Communication

Diandian Ding 

*School of Resources and Civil Engineering, Suzhou University, Suzhou 234000, China*

Correspondence should be addressed to Diandian Ding; [szxyding@ahszu.edu.cn](mailto:szxyding@ahszu.edu.cn)

Received 19 February 2021; Revised 18 March 2021; Accepted 29 April 2021; Published 7 May 2021

Academic Editor: Chi-Hua Chen

Copyright © 2021 Diandian Ding. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The reasonable selection and optimized design of the deep foundation pit support scheme is directly related to the safety, construction period, and cost of the entire project. Here, based on a large number of theoretical results in many related fields, relevant influencing factors are systematically analyzed, and advanced mathematical algorithms such as neural networks are introduced according to the relevant characteristics of building deep foundation pit support construction. First of all, this paper designs and implements deep foundation pit construction safety risk technology based on wireless communication and BIM technology and analyzes and describes the framework and function of the foundation pit construction safety risk identification system. Secondly, we use neural network algorithms to study the deformation prediction of the foundation pit supporting structure, which can describe the expression method of the above safety knowledge. Finally, the differences and benefits of this method and traditional methods are compared through experiments, which show that this technology can pave the way for the construction of deep foundation pit construction safety risk knowledge.

## 1. Introduction

With the rapid development of economic construction, the process of urbanization continues to accelerate, and the space for urban construction is becoming increasingly tight. In order to use urban land more effectively, a large number of high-rise buildings have emerged in various cities [1, 2]. The excavation and utilization of underground space have also been continuously developed in the city, and the scale and depth have been increasing. Whether it is the construction of deep foundations of high-rise buildings or the construction of underground spaces, large-scale underground excavation is inevitable, which is accompanied by a large number of deep foundation pit engineering problems [3]. It is worth noting that the compact construction site and complex surrounding environment of deep foundation pit projects have led to frequent construction safety accidents, causing huge economic losses to the country and society and even casualties, resulting in very bad society influences [4].

Mobile cloud computing provides powerful data processing functions for the perception network and builds mobile group perception applications based on the perception reports of a large number of mobile devices, serving multiple complex social perception and analysis tasks, such as building monitoring, real-time road conditions, and social networking network recommendation. This article is dedicated to integrating advanced security and network communication technology in the construction of high-rise building foundation pits.

High-rise structures in major cities and towns have emerged one after another along with the healthy and rapid growth of the state's financial economy [5]. The construction sites are clustered, and the scale and size are in a double-large mode. The projects are close together and the excavation depth is large. For the groundbreaking of large-scale or high-rise structures, deep foundation pit engineering is a particularly important link. Obviously, the key to the smooth progress of deep foundation pit construction lies in the level

of support structure technology [6]. As we all know, the construction of a deep foundation pit project is a highly integrated and systematic project, which is susceptible to various factors, such as geotechnical structure and construction technology, but there are some related theories that need to be further developed and improved [7, 8]. Due to the various complicated conditions in the actual construction of deep foundation pits and the lack of relevant theories and lack of experience, engineering accidents occur frequently [9]. The BIM model can store all the information needed in the whole life cycle of the building, including the attribute information of the engineering object and the construction information of the personnel and equipment at each stage of the construction, if the information is summarized and integrated and retrieved related information is used to guide the safety risk identification work, can make the result of safety risk identification more scientific and accurate, and ultimately guide the safe construction of deep foundation pit projects [10–12]. In this paper, BIM technology is fully applied to the safety risk management process of deep foundation pit engineering. By creating a BIM model of deep foundation pit engineering, the geometric and nongeometric information of engineering objects are extracted for safety risk identification, which can not only help managers in real time; an intuitive and accurate grasp of the safety status of the construction site can also fundamentally reduce the risk of deep foundation pit construction, which has certain significance in actual engineering projects [13].

The supporting structure of deep foundation pits of high-rise buildings is very important to the entire project. The reasonable selection and optimal design of deep foundation pit supporting schemes are directly related to the safety, construction period, and cost of the entire project [14]. Based on a large number of theoretical results in related fields at home and abroad, this paper systematically analyzes related influencing factors and introduces advanced mathematical algorithms such as neural networks into related research from the relevant characteristics of building deep foundation pit support construction. For the structural part of this article, the second part of the article introduces network security communication and the structure of high-rise building foundation pits. The third part introduces the deformation detection of foundation pit supporting structure based on neural network. The fourth part describes the deformation detection verification of the foundation pit supporting structure. We introduced the article summary and future prospects in the fifth part.

## 2. Related Technology Overviews

*2.1. Security and Communication Network.* With the development of the Internet of Things and sensor functions, mobile terminal devices have the ability to perceive environmental information and converge into a perceptual network [15]. Mobile cloud computing provides powerful data processing capabilities for the perception network and builds a mobile swarm perception application based on the perception reports of a large number of mobile devices, serving multiple complex social perception and analysis

tasks, such as building monitoring, real-time road conditions, and social networking recommendation. This paper is dedicated to the integration of advanced security and network communication technologies in the construction of high-rise building foundation pits [16].

In the development of next-generation mobile networks, nonorthogonal multiple access technologies provide efficient spectrum resource utilization for wireless communication systems. The mobile smart perception application combines mobile cloud computing and Internet of Things technology to provide real-time services for air quality monitoring, road condition monitoring, and other social works [17]. Research on the security defense mechanism of wireless networks can effectively guarantee the reliability of communication transmission under malicious attacks. In the research on physical layer security of NOMA wireless network, defense schemes against eavesdropping attacks and electronic fraud attacks have been proposed in recent years. Tariq and Mahmoud [18] analyzed the secure communication capacity of downlink users in the single-antenna NOMA communication system, that is, the reliable communication rate in the presence of eavesdroppers, and gave the system security through static numerical calculations when the parameters are fully known. The optimal power allocation strategy for communication capacity is determined by the intelligent network. Liao [19] proposed the NOMA wireless transmission technology combined with multicast, which uses cooperative signals to interfere with potential eavesdroppers and improve the capacity of secure communication. However, due to the open nature of wireless networks and the development of intelligent network attacks, the reliability of wireless communication systems based on nonorthogonal multiple access and mobile swarm intelligence application networks has become an important challenge in the security research of next-generation mobile networks [20].

*2.2. High-Rise Building Foundation Pit Supporting Structure.* Foundation pit engineering is an ancient and characteristic geotechnical project in the foundation and underground engineering construction. At the same time, it is a comprehensive geotechnical engineering problem, involving not only the typical strength problems in soil mechanics, including deformation problems, but also the joint effect of soil and supporting structure. The understanding of these problems and the study of their countermeasures are gradually improved with the progress of soil mechanics theory, calculation technology, testing instruments, construction machinery, and construction technology. The selection of the foundation pit support form is determined by the main content and safety of the foundation pit design. Errors or errors in the analysis of various conditions of the foundation pit often led to fundamental errors in the design of the foundation pit. It will directly cause engineering accidents during the construction process, and such cases are not uncommon. The city is undergoing large-scale development. Various buildings are constantly appearing [21, 22]. There are really many mid-high and high-rise buildings in today's cities, and the construction of these

buildings will inevitably be accompanied by the emergence of foundation pit projects. Therefore, the issue of foundation pits has become a topic that our engineering community likes to discuss.

*2.3. Construction of the Spatial Topological Relationship of Deep Foundation Pits Based on BIM.* Foundation pit engineering is related to many factors, such as engineering geology, hydrogeology, some physical parameters of soil, design, construction, and surrounding environment [23, 24]. Nowadays, buildings are getting taller and taller, and higher buildings will lead to deeper and greater development of the foundation pit project. The larger and deeper the foundation pit project, the more difficult it will be for the support structure of the foundation pit project [25]. The current city gives people a new look every year because of the construction of new buildings and the demolition of old villages in the city.

During this process, foundation pit engineering often occurs in some buildings under construction or already constructed. These places are often crowded and there are more buildings, so more economical slope excavation methods can be carried out, and it will have a great impact on the foundation pits of surrounding buildings, and the stability and deformation of the foundation pits are required strictly so as not to affect the safety of surrounding buildings [26, 27]. The building information model is a digital and information tool applied to the entire life cycle of a project. The parametric model created integrates the necessary information at each stage of the life cycle of the project. It is the basis for the construction unit and contractors to work together. The use of BIM technology for construction projects is conducive to improving management, reducing production costs, and improving the quality and efficiency of project construction.

*2.4. Foundation Pit Data Acquisition Module.* The technological change of digital information technology has brought many new development opportunities in other industries (such as electronic equipment manufacturing and automobile industry), which has greatly improved production efficiency. Similarly, the future direction of the industrial revolution for deep foundation pit projects also needs to integrate digital information production methods and to build construction processes to realize the digital information construction of deep foundation pit projects [28]. In the deep foundation pit project, in order to achieve the integration of various related information, it is necessary to link various construction information in the site environment model, drainage model, mechanical equipment model, and other models to the building information model and update, create, and modify in time information model [29]. The data acquisition module circuit designed in this article includes two parts: the sensor part and the signal conditioning and conversion part. The design scheme of the detection node of the foundation pit supporting structure is shown in Figure 1.

Then use the advantages of BIM technology such as simulation and collision inspection to optimize and adjust the professional models to achieve coordination between the majors. As far as deep foundation pit engineering is concerned, we must consider not only the synergy among different disciplines such as earth excavation plan, supporting structure design plan, and drainage construction plan, but also the surrounding environment of deep foundation pit such as existing buildings [30].

### 3. Deformation Detection of Foundation Pit Supporting Structure Based on Neural Network

The RBF neural network is a three-layer feedforward neural network with a single hidden layer proposed by Moody in the late 1980s. Liu et al. proved that when the hidden layer has enough neurons, the RBF neural network can be that the accuracy is close to any continuous function [31, 32]. Because of its simple topology, it can be widely used in classification and time series prediction. The main advantage of the RBF neural network is its strong enough nonlinear fitting ability, and its robustness and memory ability are very good. The disadvantage is that there is no clear mathematical derivation process, and the realization principle of its own algorithm cannot be proved. On the other hand, it cannot normally work when the number of datasets is insufficient [33].

This paper uses a three-layer multi-input single-output RBF network with a hidden layer to establish a prediction model. Although the more hidden layer neurons, the more accurate the results obtained, too many hidden layer neurons will increase the number of network calculations and easily cause overfitting problems, while too few neurons will cause affect the network performance and fail to achieve the expected results, so the determination of the number of hidden layer neurons is very important [34]. The number of hidden layer neurons in the network is directly related to the complexity of the actual problem, the number of neurons in the input and output layers, and the setting of expected errors. This article refers to the following empirical formula on the selection of the number of hidden layer neurons [35]:

$$l = \sqrt{(n+m)} + a. \quad (1)$$

Among them,  $n$  is the number of neurons in the input layer,  $m$  is the number of neurons in the output layer, and  $a$  is a constant between [1, 10]. According to the above formula, the number of neurons can be calculated to be between 3 and 12 because of the application of Gaussian function to function transfer between hidden layer neurons.

$$\varphi_i(x) = -e^{-\frac{\|x - c_i\|^2}{r_i^2}}. \quad (2)$$

Among them,  $c_i \in R^m$  is the data core of the  $i$ -th hidden layer neuron,  $x \in R^m$  is the radial basis network input, and  $r_i$  is a constant. The weight of each neuron layer in the hidden

layer is the transposed value of the input vector, and its threshold is as follows:

$$b = \frac{[1 - \log(0.5)]^{0.5}}{\text{spread}} = \frac{0.833}{\text{spread}}. \quad (3)$$

Among them, the spread is the expansion coefficient. The input vector of the Gaussian function is as follows:

$$k_i^q = \sqrt{\sum_j (\omega_{1ji} - x_j^q)} \times b_{1i}. \quad (4)$$

Among them,  $x_j^q$  is the input vector,  $\omega_1$  is the weight vector, and  $b_1$  is the threshold.

The output of this function must be two values representing two categories, respectively, so the sigmoid function is used, and the function form is as follows:

$$g(z) = \frac{1}{1 + e^{-z}}. \quad (5)$$

The corresponding function image is an S-shaped curve with a value between 0 and 1.

Determine the boundary type of the data division; for the linear boundary; the boundary form is as follows:

$$a = \frac{\sum y_i / \sigma_i^2 e^{b(x_{1i} + x_{2i})}}{\sum 1 / \sigma_i^2 e^{2b(x_{1i} + x_{2i})}}, \quad (9)$$

$$\sum \frac{y_i}{\sigma_i^2} e^{b(x_{1i} + x_{2i})} = \frac{\sum 1 / \sigma_i^2 e^{2b(x_{1i} + x_{2i})}}{\sum (x_{1i} + x_{2i}) / \sigma_i^2 e^{2b(x_{1i} + x_{2i})}} \cdot \sum \frac{(x_{1i} + x_{2i}) y_i}{\sigma_i^2} e^{b(x_{1i} + x_{2i})}.$$

Once the output obtained by the output layer does not meet expectations, the error change value of the output layer is calculated, and then it is broadcast in the reverse direction. During backpropagation, the weights of neurons in each layer will be modified, and this process will be repeated until the desired goal is reached. That is, the neural network is a global approximation network. For each pair of input and output values, all network parameters must be adjusted accordingly.

#### 4. Deformation Detection Verification of Foundation Pit Supporting Structure

In order to verify the high-precision reconstruction performance of the RBF neural network algorithm, this chapter verifies and analyzes the deformation monitoring of the foundation pit supporting structure. At present, the common geotechnical calculation software in the market mainly consists of ANSYS, PLAXIS, FLAG, MIDAS, SOIL, and other software. Among them, general geotechnical engineers and researchers often use PLAXIS, FLAG, MIDAS software, and for studying the stress and deformation relationship between the two-dimensional and three-dimensional soil and supporting system of foundation pits, everyone is used to using IVIDAS series software. The main reason is that,

$$\theta_0 + \theta_1 t_1 + \dots + \theta_n t_n = \sum_{i=0}^n \theta_i t_i = \theta^T t. \quad (6)$$

Construct prediction function:

$$h_\theta(t) = g(\theta^T t) = \frac{1}{1 + e^{-\theta^T t}}. \quad (7)$$

The value of the  $h_\theta(x)$  function has a special meaning, and it represents the probability that the result is 1, so the probabilities that the input  $x$  classification result is category 1 and category 0 are

$$P(y = 1|t; \theta) = h_\theta(t), \quad (8)$$

$$P(y = 0|t; \theta) = 1 - h_\theta(t).$$

The neural network is mainly composed of an input layer, several hidden layers, and an output layer. Its algorithm is mainly divided into two parts: forward transmission of information and backpropagation error. In the forward propagation, the information is calculated layer by layer from the input layer, passes through the hidden layer, and then passes to the output layer.

on the one hand, it has developed a foundation pit support design platform specifically for foundation pit support, which is more targeted; on the other hand, the software interface is good, and the geological and stratigraphic parameters are easy for users to interactively input, which is conducive to getting started. The internal structure diagram of the sensor for detecting the deformation of the foundation pit supporting structure is shown in Figure 2.

The modified Mohr–Coulomb constitutive model is adopted for each soil layer in the test case, and the plane strain problem under the two-dimensional situation is considered. The modified Mohr–Coulomb constitutive model is an improved constitutive model based on the Mohr–Coulomb constitutive model. The Mohr–Coulomb constitutive model is ideally elastoplastic. It only considers the change of strength with confining pressure but does not consider elasticity. The mold changes under confining pressure, and stress levels are not fixed. This is not in line with the actual characteristics of geological materials, and the modified Mohr–Coulomb constitutive can better reflect the ground deformation of foundation pit excavation. The isotropic-elastic constitutive model is adopted for piles, anchors, and soil nails, which can better reflect the force and deformation of piles, anchors, and soil nails. Among them, the attributes of the piles are pile/beam 1 D attributes, and

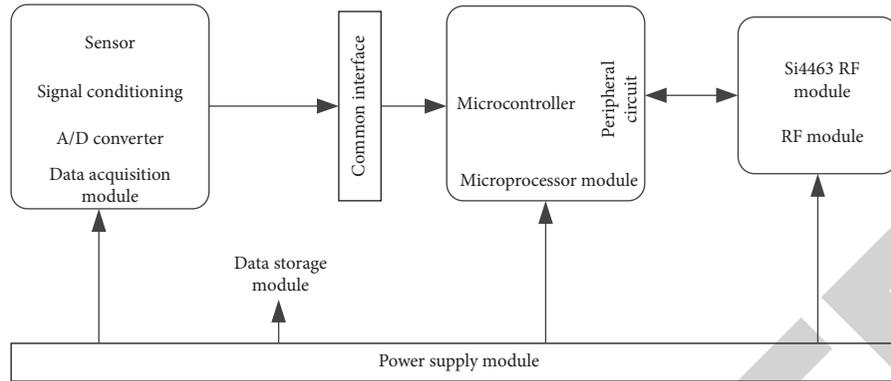


FIGURE 1: The design scheme of the detection node of the foundation pit supporting structure.

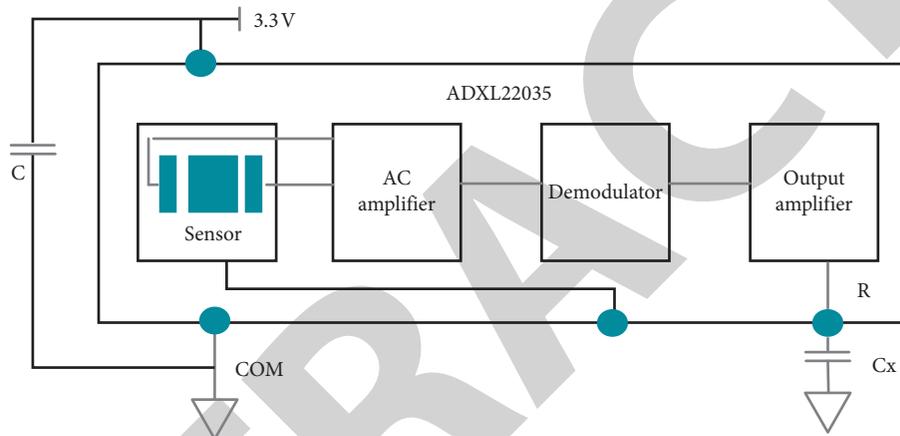


FIGURE 2: The internal structure diagram of the sensor of the foundation pit supporting structure.

the anchors and soil nails are all embedded frame analysis properties. MIDAS GTS NX has a good grid generation function. In this case, each soil layer and piles, anchors, and soil nails are all used in a seeding method of size 2 to mesh each soil layer and piles, anchors, and soil nails.

**4.1. Technical Performance Test.** This finite element analysis selection is calculated by 1-1 section, 2-2 section, and 4-4 section. The axial force of the above three sections will be dynamically tracked, adjusted, and compared with the concept and model of dynamic design. Analyze the corresponding ground deformation and pile deformation. Figure 3 shows the comparison of the axial force loss when the profile deformation is stable. Figure 4 shows the comparison results of pile displacement under the dynamic compensation state of the axial force of the section deformation.

After comparative analysis, whether it is in the case of axial force loss or in the state of axial force compensation, the calculation of the maximum ground subsidence and the actual monitoring value is analyzed, and the maximum ground subsidence calculated from the finite element analysis is analyzed. The maximum deformation under the condition of force compensation is much smaller than that under the condition of axial force loss, about 40%. For the

calculation results and monitoring results under the state of axial force loss, the calculated value of finite element is larger than the monitored value, and the size of the monitored value is about 50% of the calculated value. For the calculation results and monitoring results under the state of axial force compensation, the calculated value of the finite element is also larger than the monitored value. The size of the monitored value is about 80% to 95% of the calculated value. Generally speaking, in this state, the calculated value of finite elements is of great significance to the design.

**4.2. Simulation of Profile Deformation of Foundation Pit.** According to previous engineering experience and finite element calculation results, the width of the foundation pit excavation is about 3-4 times the depth of the excavation, and the depth of influence is about 2-4 times the depth of the excavation. The symmetry between the foundation pit and the calculation domain is used, and the half section of the calculation domain is taken for analysis. The calculation range taken in the analysis is  $100 \times 50$  m. It is equivalent to extending the excavation depth 3 times to the bottom of the wall and 7 times the excavation depth outside the wall. The finite element model is divided into 19920 elements. Among them, the underground continuous wall has 180 units, and

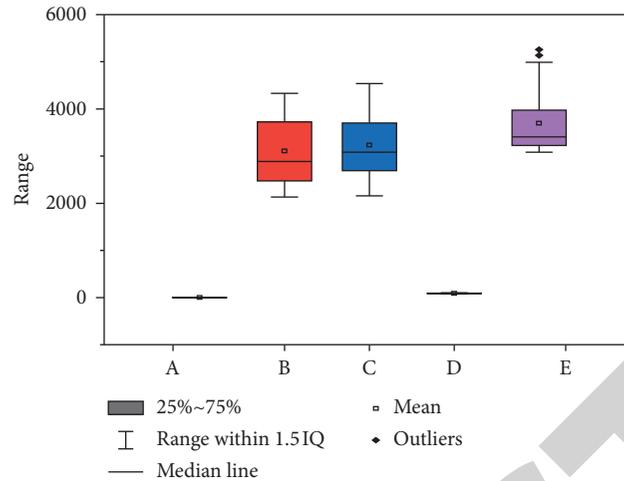


FIGURE 3: Comparison of axial force loss when the section deformation is stable.

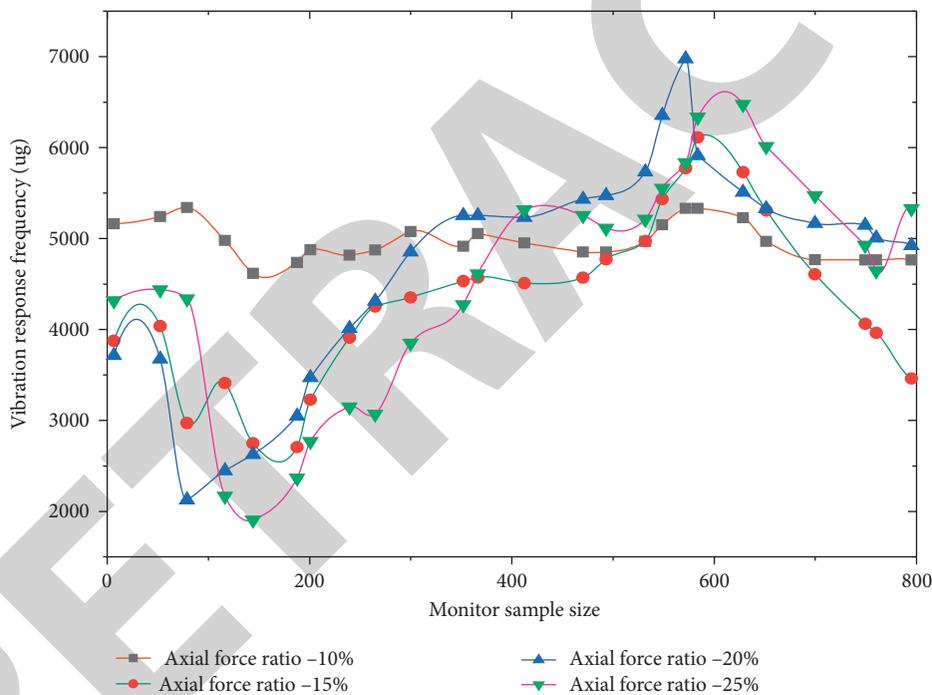


FIGURE 4: Comparison of pile displacement under the dynamic compensation state of section deformation axial force.

the soil has two floors, with 7680 units and 11700 units, and 360 contact surface units. Figure 5 shows the simulation results of axial force loss when the deformation of the foundation pit is stable.

In foundation pit engineering, the excavation of the soil layer is constructed in stages, so in the finite element simulation analysis, the incremental method is often used to solve the calculation of the excavation of the foundation pit. Its outstanding advantage is that it can consider the step-by-step application of loads and the excavation and unloading of soil, which can not only reflect the changes in stress-strain and deformation at a certain stage of the construction process but also adopt nonlinear constitutive relations. At this time, it can better reflect the nonlinear characteristics of

the soil, more realistically simulate the excavation and construction process of the foundation pit, and simulate the change of the soil settlement behind the wall and the horizontal displacement of the retaining structure with the step-by-step excavation. Figure 6 shows the distribution of the maximum force on the pile body under the dynamic compensation state of the axial force of the foundation pit section.

As the rigidity of the envelope structure increases, the curvature of its displacement-depth curve decreases. Enlarging the envelope structure within a certain range can effectively reduce the horizontal displacement of the envelope structure, but after a certain limit, its role will gradually decrease. Therefore, the effect of increasing the rigidity of the

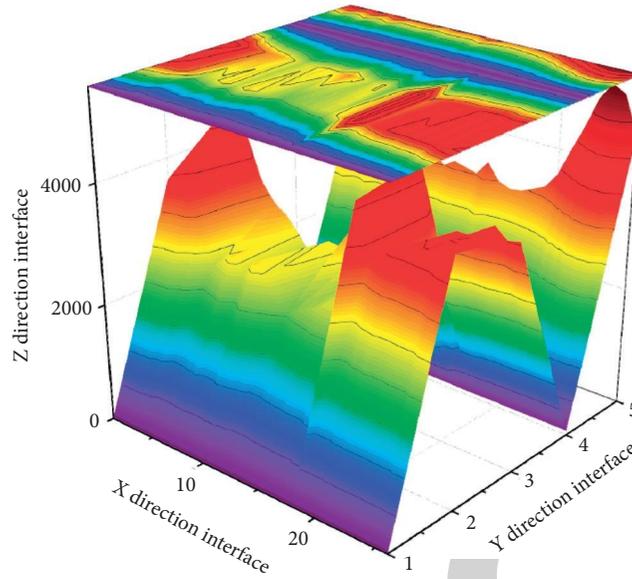


FIGURE 5: Simulation results of axial force loss when the deformation of the foundation pit section is stable.

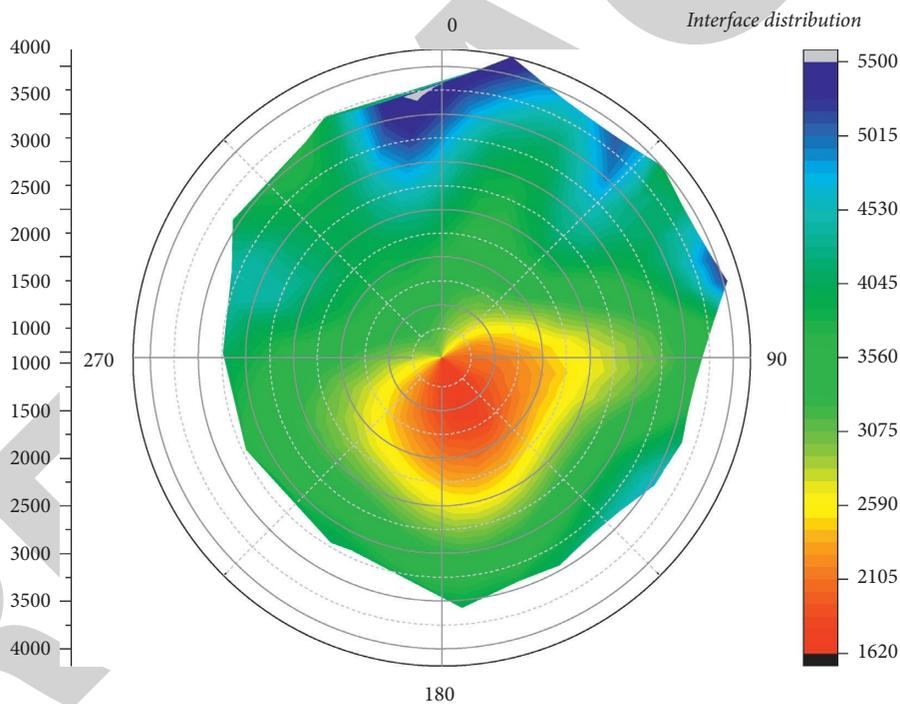


FIGURE 6: The distribution of the maximum force on the pile body under the dynamic compensation of the axial force of the foundation pit.

enclosure structure to reduce the horizontal displacement of the enclosure structure wall is limited, and to increase the rigidity of the enclosure structure (the thickness of the enclosure wall), the amount of concrete is also relatively large. Comparison test results of the RBF neural network method and other methods are shown in Figure 7.

In order to verify the effectiveness of the method in this article, we use the RBF neural network method proposed in this article and other methods (such as convolutional neural network and radial basis neural network) in the safety risk management of deep foundation pit engineering [36–38].

The test result is shown in Figure 7. RBF neural networks can be widely used for classification and time series prediction due to their simple topology. The main advantage of RBF neural network is its strong enough nonlinear fitting ability, and its robustness and storage ability are very good.

As the rigidity of the enclosure structure increases, the maximum displacement point of the abdomen of the enclosure structure moves upward, and the horizontal displacement of the abdomen of the wall body decreases. The calculation and analysis of a building foundation pit engineering example show that the maximum horizontal displacement of the envelope

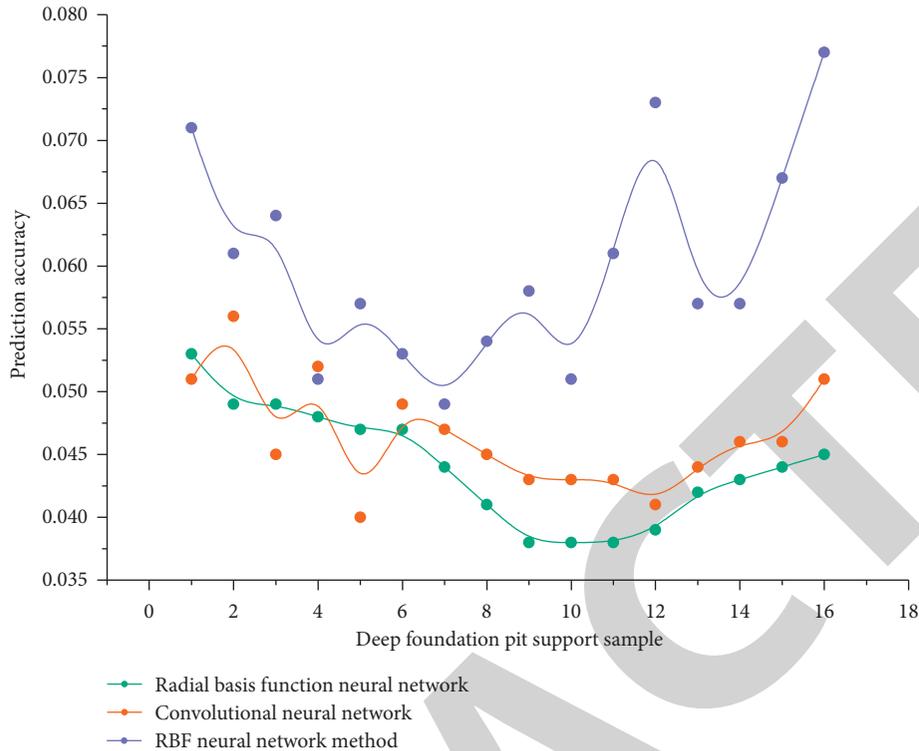


FIGURE 7: Comparison test results of RBF neural network method and other methods.

calculated by the finite element is compared with the engineering monitoring value, and the maximum horizontal displacement of the envelope calculated by the finite element is slightly smaller than the engineering monitoring value. The calculated value of the finite element horizontal displacement curve is in good agreement with the engineering monitoring value. The optimization design of the foundation pit supporting system shows that the method is feasible.

## 5. Conclusion

Whether it is the construction of deep foundations of high-rise buildings or the construction of underground spaces, large-scale underground excavation is inevitable, which is accompanied by a large number of deep foundation pit engineering problems.

This thesis divides the foundation pit into 1-1 and 2-2 slopes through different analyses of the construction site environment, surrounding environmental conditions, geotechnical engineering conditions, and foundation pit depth of a high-rise office building project. According to the calculation and comparison of technical and economic conditions by many schemes, construction safety shall prevail. The supporting structure mainly adopts soil nail walls, slope spraying silicon, etc. This form of support is easy to construct, has a short construction period, and can also save costs. Based on a large number of theoretical results in related fields at home and abroad, this paper systematically analyzes related influencing factors and introduces advanced mathematical algorithms such as neural networks from the relevant characteristics of building deep foundation pit support construction. Whether it is a

geotechnical engineering survey or foundation pit stability calculation, it provides valuable information for the design and construction of foundation pits, can ensure the safety and reliability of foundation pit engineering, and has important guiding significance for the entire foundation pit engineering. In the future, we will continue to work on the integration of cyber security research and high-rise buildings.

## Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

## Conflicts of Interest

The author declares that he has no conflicts of interest.

## Acknowledgments

The study was supported by the Natural Science Projects of Colleges and Universities in Anhui Province (KJ2020A0739).

## References

- [1] A. A. Kasimzade, O. Abrar, G. Atmaca, and M. Kuruoglu, "New structural seismic protection for high-rise building structures," *Journal of Vibroengineering*, vol. 22, no. 4, pp. 831–848, 2020.
- [2] H. Wang, "Effect of genetic algorithm in optimizing deep foundation pit supporting structure," *Arabian Journal of Geosciences*, vol. 14, no. 4, pp. 1–6, 2021.

- [3] H. Ramm, O. Reul, A. Ruiken, W. Kissel, and E. Toker, "Hochhaus omnium—baugrube und gründung unter komplexen innerstädtischen randbedingungen," *Bautechnik*, vol. 97, no. 9, 2020.
- [4] Y. Lu, M. Liu, H. Nie et al., "Direct fabrication of metal-free hollow graphene balls with a self-supporting structure as efficient cathode catalysts of fuel cell," *Journal of Nanoparticle Research*, vol. 18, no. 6, pp. 236–245, 2016.
- [5] R. A. Fulford and B. M. Gibbs, "Structure-borne sound power through multiple contact points between machines and supporting structures," *The Journal of the Acoustical Society of America*, vol. 95, no. 5, p. 3007, 1994.
- [6] Y. Tanaka, M. Ikehara, and T. Q. Nguyen, "Higher-order feasible building blocks for lattice structure of oversampled linear-phase perfect reconstruction filter banks," *Signal Processing*, vol. 89, no. 9, pp. 1694–1703, 2009.
- [7] S. Jang, C. H. Goh, and H. J. Choi, "Multiphase design exploration method for lightweight structural design: example of vehicle mounted antenna-supporting structure," *International Journal of Precision Engineering and Manufacturing-Green Technology*, vol. 12, no. 6, pp. 122–134, 2015.
- [8] L. Tan, L. Li, S. Gu, and D. Wang, "Multi-objective topology optimization to reduce vibration of micro-satellite primary supporting structure," *Journal of Vibroengineering*, vol. 19, no. 2, pp. 831–843, 2017.
- [9] C. Zhang, "Control force characteristics of different control strategies for the wind-excited 76-story benchmark building structure," *Advances in Structural Engineering*, vol. 15, no. 4, pp. 423–434, 2016.
- [10] T. Q. Nguyen, M. Ikehara, and Y. Tanaka, "Higher-order feasible building blocks for lattice structure of oversampled linear-phase perfect reconstruction filter banks," *Signal Processing*, vol. 13, no. 2, pp. 432–445, 2009.
- [11] M. Braham and J. P. Jaspert, "Is it safe to design a building structure with simple joints, when they are known to exhibit a semi-rigid behaviour?" *Journal of Constructional Steel Research*, vol. 60, no. 3-5, pp. 713–723, 2004.
- [12] D. A. Shultz, "Structure-property relationships in cross-conjugated, high-spin, dinuclear ligands: building blocks for open-shell molecules and materials," *Polyhedron*, vol. 20, no. 11–14, pp. 1627–1631, 2001.
- [13] J. Xu, M. F. Crowley, and J. C. Smith, "Building a foundation for structure-based cellulosome design for cellulosic ethanol: insight into cohesin-dockerin complexation from computer simulation," *Protein Science*, vol. 18, no. 5, pp. 949–959, 2010.
- [14] S. Chad, K. Thomas, and M. Leon, "Continuously phase-matched terahertz difference frequency generation in an embedded-waveguide structure supporting only fundamental modes," *Optics Express*, vol. 42, no. 1, pp. 321–335, 2008.
- [15] M. P. Dittmer, P. Kohorst, L. Borchers, and M. Stiesch, "Influence of the supporting structure on stress distribution in all-ceramic FPDs," *The International Journal of Prosthodontics*, vol. 23, no. 1, pp. 63–68, 2010.
- [16] B. Park and Y. C. Choi, "Hydration and pore-structure characteristics of high-volume fly ash cement pastes," *Construction and Building Materials*, vol. 35, no. 9, pp. 236–243, 2020.
- [17] Z. Giovanni, *Opportunities for Materials Science: From Molecules to Neural Networks*, Mrs Bulletin, Cambridge University Press, Cambridge, UK, 2019.
- [18] Z. Tariq and M. Mahmoud, "A new correlation for gas deviation factor for high temperature and high-pressure gas reservoirs using neural networks," *Energy & Fuels*, vol. 33, pp. 2426–2436, 2019.
- [19] F. Liao, X. Chen, X. Hu, and S. Song, "Estimation of the volume of the left ventricle from MRI images using deep neural networks," *IEEE Transactions on Cybernetics*, vol. 49, no. 2, pp. 495–504, 2019.
- [20] X. Jian, Z. Zhigang, W. Shiping, W. Ailong, and W. Leimin, "A unified framework design for finite-time and fixed-time synchronization of discontinuous neural networks," *IEEE Transactions on Cybernetics*, vol. 32, no. 9, pp. 345–356, 2019.
- [21] A. Sivaram, L. Das, and V. Venkatasubramanian, "Hidden representations in deep neural networks: part 1. classification problems," *Computers & Chemical Engineering*, vol. 134, no. 4, pp. 106669.1–106669.17, 2020.
- [22] N. Ichinose, "Quasiperiodic-chaotic neural networks and short-term analog memory," *International Journal of Bifurcation and Chaos*, vol. 13, no. 9, pp. 453–462, 2021.
- [23] P. W. Stokes, D. G. Cocks, M. J. Brunger et al., "Determining cross sections from transport coefficients using deep neural networks," *Plasma Sources Science and Technology*, vol. 29, no. 5, pp. 58–65, 2020.
- [24] G. H. H. V. Bergen, P. Duenk, C. A. Albers et al., "Bayesian neural networks with variable selection for prediction of genotypic values," *Genetics Selection Evolution*, vol. 52, no. 1, pp. 291–302, 2020.
- [25] D. Minghao, B. Shaolan, Z. Xianfei, L. Yaguang, L. Tanda, and S. Ruijie, "Mode angular degree identification in subgiant stars with convolutional neural networks based on power spectrum," *Monthly Notices of the Royal Astronomical Society*, vol. 33, no. 9, pp. 23–43, 2018.
- [26] R. Pires, D. E. Lima, K. F. Welch et al., "Convolutional neural networks as an aid to biostratigraphy and micropaleontology: a test on late paleozoic microfossils," *Palaios*, vol. 35, no. 9, pp. 391–402, 2020.
- [27] G. Ziyu, Y. Gao, and X. Liu, "Optronic convolutional neural networks of multi-layers with different functions executed in optics for image classification," *Optics Express*, vol. 35, no. 99, pp. 34–52, 2021.
- [28] C. Huang, P. Liu, and L. Fang, "MXQN:mixed quantization for reducing bit-width of weights and activations in deep convolutional neural networks," *Applied Intelligence*, vol. 15, no. 4, pp. 87–101, 2021.
- [29] N. Vlassis and W. Sun, "Sobolev training of thermodynamic-informed neural networks for interpretable elasto-plasticity models with level set hardening," *Computer Methods in Applied Mechanics and Engineering*, vol. 3, no. 9, pp. 321–348, 2021.
- [30] J. Wang, X. Wang, N. Xie, J. Xia, and H. Shen, "Fuzzy-model-based  $\mathcal{H}_{\infty}$  pinning synchronization for coupled neural networks subject to reaction-diffusion," *IEEE Transactions on Fuzzy Systems*, vol. 35, no. 99, pp. 13–31, 2020.
- [31] H. Liu, Z. Wang, W. Fei et al., "Resilient H<sub>∞</sub> state estimation for discrete-time stochastic delayed memristive neural networks: a dynamic event-triggered mechanism," *IEEE Transactions on Cybernetics*, vol. 23, no. 99, pp. 731–748, 2020.
- [32] Y. Naoyuki, T. Keitaro, K. Hiroki, D. Shi, Y. Shinatru, and I. Shinsuke, "Artificial neural networks for selection of pulsar candidates from radio continuum surveys," *Monthly Notices of the Royal Astronomical Society*, vol. 13, no. 4, pp. 731–748, 2020.
- [33] M. Scheuerer, M. B. Switanek, R. P. Worsnop, and T. M. Hamill, "Using artificial neural networks for generating probabilistic subseasonal precipitation forecasts over California," *Monthly Weather Review*, vol. 148, no. 8, pp. 3489–3506, 2020.

- [34] J. R. Perez, C. Leigh, B. Liquet et al., "Detecting technical anomalies in high-frequency water-quality data using artificial neural networks," *Environmental Science and Technology*, vol. 26, no. 4, pp. 423–448, 2020.
- [35] Q. Yang, H. Ji, H. Lu, and Z. Zhang, "Prediction of liquid chromatographic retention time with graph neural networks to assist in small molecule identification," *Analytical Chemistry*, vol. 2, no. 3, pp. 56–67, 2021.
- [36] Y. Ding, Z. Ma, S. Wen et al., "AP-CNN: weakly supervised attention pyramid convolutional neural network for fine-grained visual classification," *IEEE Transactions on Image Processing*, vol. 30, pp. 2826–2836, 2021.
- [37] M. Zhang, H. Li, S. Pan, J. Lyu, S. Ling, and S. Su, "Convolutional neural networks based lung nodule classification: a surrogate-assisted evolutionary algorithm for hyperparameter optimization," *IEEE Transactions on Evolutionary Computation*, vol. 11, 2021.
- [38] M.-H. Wang, S.-D. Lu, and R.-M. Liao, "Fault diagnosis for power cables based on convolutional neural network with chaotic system and discrete wavelet transform," *IEEE Transactions on Power Delivery*, vol. 6, p. 1, 2021.