Research on neural network in consolidation effect of soft foundation

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Abstract. The method and application situation of neural network is universal application. Datum of project and monitoring from a project of soft foundation by vacuum preloading was filtrated and summarized. After analysis and comparison, establishment of optimization neural network model was used to evaluate the consolidation effect. By the sensitivity of impact factors, it was analyzed that the main parameter of soft foundation consolidation process.

1. Preface
It is a mathematical model for distributed parallel information processing, which can imitate the behavior characteristics of animal neural network. This kind of network depends on the complexity of the system, through adjusting the relationship to achieve the purpose of processing information. Neural network learning algorithm is widely used in pattern recognition, data prediction, system identification, image processing, speech understanding and function fitting and other fields [1,2]. Since the late 1980s, artificial neural network has been applied in civil engineering, such as construction process simulation, construction cost budget, earthquake hazard prediction, stress-strain relationship of sand, hardening and softening of residual soil in the loading process, and prediction of pile bearing capacity [3-8]. The wide application of neural network shows that it has practical significance in solving geotechnical problems.

Artificial neural network has the characteristics of nonlinearity, nonlimitation, very qualitative and nonconvexity. However, the process of vacuum preloading reinforcement is affected and restricted by many factors. It is difficult to describe the natural law of reinforcement effect with known mathematical expression. This kind of nonlinear problem is very suitable for artificial neural network.

2. Neural network modeling
2.1 Basic principles
At present, the vacuum preloading technology in China is in the leading position in the world. Under the condition of good construction, the vacuum degree can reach 80 kPa. Compared with the surcharge preloading method with loading effect, the vacuum preloading method is not only economical, but also greatly shortens the construction period. Usually, the degree of consolidation is calculated by fitting the settlement data, so the settlement is the core index in the process of vacuum preloading method to strengthen soft soil foundation, which is related to the project quality and construction period. In practice, the degree of consolidation calculated by monitoring data can reach the unloading index, but...
the shear strength is low, and the soil moisture content is also high. That is, the foundation can not meet the indicators at the same time, this situation can not accurately measure the effect of soft foundation reinforcement, which is very unfavorable to the judgment of construction unloading.

BP network model is a multilayer feedforward network trained by error back propagation algorithm. BP network can store and learn a large number of input-output pattern mapping relationships without knowing the mathematical equations of this mapping relationship in advance. S (sigmoid) type function is usually used for the action function of neurons in each layer. Neurosolutions software is selected to realize the network, which is a highly graphical neural network development tool.

2.2 Determination of parameters
The most direct evaluation index of vacuum preloading reinforcement effect should be in-situ test or soil sampling test. The in-situ tests of strengthening area mainly include vane shear test and plate load test. The index of soil test is water content, because it can reflect the compression degree of saturated soft soil. In this paper, the average strength of vane above the original mud surface is taken as the output parameter. There are many factors affecting the strength and moisture content of the vane after reinforcement, such as reinforcement time, site parameters, dredger fill parameters and observation data can be used as input parameters. In addition, the construction quality factor is also an important index in the current project management. For the consideration of the research object in this paper, an index for comprehensive evaluation of the drainage board, sand cushion quality, membrane surface sealing, pump start-up situation.

2.3 Model structure
The convergence speed and convergence of network training depend on the topological structure of the network (hidden layer number, hidden layer node number). When the network topology is not suitable, the training time will be too long or oscillation, and even lead to network paralysis. At present, it is considered that the forward three-layer BP neural network is the most mature and widely used neural network, and it is most suitable for simulating the approximate relationship between input and output.

3. Engineering practice

3.1 Sample processing
Vacuum preloading area is selected as the sample source to extract samples. The total reinforcement area of the project is 4.7 million square meters, with 178 zones. The foundation reinforcement depth is 20 meters and the hydraulic fill thickness is 10 meters. According to the constructions, supervision and monitoring data and the contents of the previous section, nine data are selected as input parameters, including the thickness of dredger fill, construction days, average moisture content before construction, average plasticity index, settlement during printing, settlement during vacuumizing, average vacuum degree, shape coefficient of preloading area and construction quality index as input parameters, and hydraulic fill is selected as output parameters. The average strength of cross plate after lamination. A total of 60 groups of data were selected, including 55 groups for training and 5 groups for test data.

3.2 Sample training and testing
In practical application, in order to avoid the oscillation of learning and slow convergence, the momentum term is added when BP algorithm modifies the weight. The decimal product of the previous weight adjustment is added to the weight adjustment of this error calculation, which is used as the actual weight adjustment of this time. According to experience, this training adjusts the learning step length to 5, the momentum adjustment rate is 0.5. The number of hidden nodes can be between 4 and 23, and different node numbers are selected for training comparison, as shown in Table 1. According to the mean square error, 12 hidden nodes are selected as the optimal test network. Through the test, the maximum error of vane strength prediction is 1.9 kpa, which has practical application value.
### Table 1. The mean square error of training with different hidden nodes

| Number of hidden nodes | 4    | 7    | 8    | 10   | 12   | 13   | 23   |
|------------------------|------|------|------|------|------|------|------|
| Training times         | 40000| 40000| 40000| 40000| 40000| 40000| 40000|
| Mean square error       | 0.0081| 0.0050| 0.0033| 0.0054| 0.0025| 0.0063| 0.0062|

#### 3.3 Application and analysis of achievements

By optimizing the training network, the effect of the vacuum preloading area near the sample area to be unloaded is evaluated. Through the prediction, it is considered that unloading can be carried out. After the construction is stopped, the result is about 3kpa smaller than the predicted value. The sensitivity of each input parameter has different influence on the prediction results. The sensitivity measurement method is to make the average value of each input data into the mean input data, increase or decrease one of the parameters with a fixed small proportion (0.1% - 0.5%), and the other parameters remain unchanged. An output value is obtained through the network, 100 output values are obtained by repeated operation, and the standard deviation of 100 output values is calculated, which is the network sensitivity of the changed parameters.

The sensitivity analysis module can be directly used in Neurosolutions software. Vacuum degree, shape coefficient and construction quality index are relatively sensitive factors. In engineering practice, the guarantee of vacuum degree is also one of the important contents. The shape coefficient reflects the boundary conditions more, and also guarantees the vacuum degree. On the one hand, the construction quality index includes the guarantee of vacuum degree, on the other hand, it is also the reflection of drainage channel. The relatively weaks are the thickness of dredger fill, construction days, water content before construction, settlement during plate making and settlement during vacuum pumping. The sensitivity between construction days and water content before construction is relatively close. Although the water content is high, it needs more time for drainage, and the corresponding vacuum degree requirements are also higher. Through sensitivity analysis, it can be found that the prediction deviation is more caused by the inaccurate value of vacuum degree and construction quality index.

#### 4. Conclusion

(1) Combined with the mechanism of soft foundation reinforcement, the neural network has reference application value in the vacuum preloading reinforcement effect analysis, which avoids the diaphragm rupture for vane detection, and is more intuitive and reliable than the traditional consolidation degree prediction.

(2) The sensitivity analysis of influence factors is added in this study, which has a good guiding role for the key indicators of vacuum preloading reinforcement process.

(3) In this study, the selected indicators are too concentrated, so its scope of application may be limited to the surrounding areas. If the network can have a wide range of application effects, it needs more in-depth experimental research, especially the selection and processing of influence factors. The increase of a large number of samples will increase the training burden of BP neural network, and more efficient learning rules are needed. Neural network is a data induction and summary system, and it will not analyze its essential relationship, so it should be cautious in engineering application.
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