Study on prediction of cement-soil gravity retaining wall security risk based on BP

Li Cai-hui[1,2]

1.College of Management and Economics Tianjin University, Tianjin 300073, China;

2.Jizhong Energy ResouCo., LTD, Hebei, Xingtai 0540211,China

***Abstract*—In order to forecast the security risk of cement-soil gravity wall, an index system whose function is to forecast the security of cement-soil gravity wall is established from four aspects of soil properties, mechanical properties of mixer, materials, error of a pile position and verticality deviation. We introduce BP neural network to the training of sample data, then BP neural network model is established to predict the security risk of cement-soil gravity retaining wall. Combined with a base engineering project, the validity and practicability of this forecast is testified.**

Keywords-cement-soil gravity retaining wall; safety forecast ;BP neural network

I. INTRODUCTION

With the increasingly development of high-rise buildings and underground structure, the excavation of deep foundation pit engineering and its maintenance technology is becoming more and more common and extensively appreciable, in order to maintain the stability of foundation pit slope soil and ensure the safety of the basement, underground engineering construction and surrounding environment. Meanwhile cement-soil gravity retaining wall with double functions of retaining and watertight is widely used[1] [2]. Cement-soil gravity retaining wall takes cement based materials as curing agent and forms the continuous overlapping reinforced retaining wall with soil cement column which adopts grouting process and mixes the foundation soil and curing agent forcefully in the mixer. As the maintenance structure, the security of the wall itself is particularly important .In order to maintain its security, selecting the appropriate risk warning model which can predict the risk quickly and accurately, provides reference for taking feasible measures[3].

Risk warning is regarded as important means of IT construction of retaining structure for deep excavation .According to the characteristics of the study, risk warning is a system which can monitor the change trend of risk factors that affect safety , evaluate the degree of deviation from the warning line at various risk states ,issue warning signals to policy makers and take pre-control countermeasures in advance[4].

II.BP NEURAL NETWORK

BP (Back Propagation)neural network, proposed in 1986 by Rumelhart and other scientists, is based on a multilayer feed forward network trained with error back propagation[5]. Its learning process consists of two processes of the information of forward and backward error propagation Its steps are listed:

- Set the BP structure of the network graph, which is composed of input layer, hidden layer, output layer, and set all the weights for arbitrarily small randomly[5] [6].
- Provide the training sample:

$x_p = (x_{p_1}, x_{p_2}, x_{p_3}, \cdots x_{p_n})$, x_p -input value of the p sample; x_{p_n} -the p sample of index From the hidden nodes and output nodes, and communication signal through the transfer function, the output results respectively:

hidden node: $v_k = f(\sum_{j=1}^{n} w_{ik} x_{p_j} - \beta_k)$;

output node: $y(p) = f(\sum_{k=1}^{m} w_k v_k - \alpha)$

w_{ik} -the input layer of the i node to the connection weights of the k node of hidden layer;

β_k -the threshold of the k node of hidden layer;

w_k -the hidden layer of the k node to the connection weights of the output layer;

α -the threshold output layer node;

v_k -the output value of the K node of hidden layer;

$y(p)$ -the output value of the output layer sample p

- Weight adjustment

In the network learning process, use the error back-propagation algorithm of multilayer feed forward neural networks with nonlinear continuous transfer, from the output nodes to the hidden nodes, and then the hidden node to the input node, with which modifies the weights and thresholds ,and then achieve minimizing mean variance of the actual output and the expected output of the network[7] .

- Calculation of the mean variance of the actual output and the expected output of the network

Define the actual output of the p sample $y(p)$ and the desired output of the p sample $r(p)$, the P sample variance function: $E = \frac{1}{2p}\sum_{p=1}^{p}(y(p) - r(p))^2$ .If the learning $E < \varepsilon$ ends ,output the adjusted weights and thresholds, otherwise, return to step 2and study $E < \varepsilon$ until now.

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III.THE FOREWANING MODEL OF CEMENT SOIL GRAVITY RETAINING WALL SECURITY RISK

A. The determination of forewarning index against cement soil gravity retaining wall security risk

Combined with the domestic and foreign forewarning research results of cement soil gravity retaining wall security risk and reference to foundation pit engineering handbook, the security of cement soil gravity retaining wall is analyzed from three aspects of characteristics of soil properties, mechanical properties, raw materials and pile and forewarning index against cement soil gravity retaining wall security risk is determined such as soil bulk density and moisture content by using risk identification method. Security risk caused by the mechanical properties include the motor power, stirring head number, stirring head diameter, pin spacing etc. Raw materials safety risk include cement quality ,the amount of cement, water cement ratio. And the risk caused by pile characteristics. includes pile bottom elevation, elevation of pile top, pile deviation, the vertical deviation and the lap[8].

B. The forewarning model of cement soil gravity retaining wall security risk

In this paper ,the cement soil gravity retaining wall security risk forewarning evaluation index system, which is quantitative evaluation, has no unified standard, so it is difficult to compare, and does not accord with the requirement of the input vectors of BP neural networks. Therefore, before the security risk evaluation of underground continuous wall, normalize the index data and quantify index to [0, 1].In a gravity retaining wall safety risk evaluation. A specific value with its range[0,1],will be got when this value belongs to[0.8,1] it showed the security risk of the underground continuous wall for danger alarm; in [0.6,0.8)for heavy police; in [0.4,0.6)for the general alarm; in [0.2,0.4)for alight alarm; in [0,0.2)for security alarm. Ten sets of cement soil gravity retaining wall of security risk assessment data through field investigation are pointed in Table 1.

The process of algorithm realization based on BP of cement soil gravity retaining wall security risk forewarning mode is listed:

- The determination of the number of network layers and each layer nodes

Adopt the 3 layer BP network structure, which has 9 neurons and the input layer stands for the real estate investment risk forewarning evaluation index. According to the formula $y=\sqrt{s+q}+b$ (s -the input layer neuron number; q -the output layer neuron number; b -the integer of [1， 10]),determine 7hidden layer nodes The output layer has only one neuron, which means an output node. that is a numerical range[0, 1],which stands for the real estate investment risk forewarning evaluation results. The numerical value is greater, which means that forewarning risk of the project is more heavier. Therefore, establish an input layer, hidden layer and output layer neuron number node of 9,7,1for the BP neural network respectively.

- Model training

Aiming at the retaining wall security risk forewarning of cement soil gravity problem, and taking MATLAB as the tool, in the table 1,1-9 samples are as training samples and a sample of 10 test the trained samples. Through the parameter setting, start the network training, and iterate continuously until meet the learning accuracy. The results of training neural network is shown in Figure 1.After 159 times of training, the network convergence reaches a predetermined learning accuracy of 0.00001and the training ends.

- Model checking

Tested data of tenth groups in table 1 is inputted into the trained neural network and the comprehensive evaluation results is 0.595,which is consistent with the actual survey data of expected results and the error rate between the expected output and the result was 0.99%, which illustrates the correct relationship between reflected input and output of neural network model and can be effectively applied to cement soil gravity retaining wall safety risk forewarning research.

- Model preservation

Store the trained neural network into the file, and when it comes to cement soil gravity retaining wall safety risk, forewarning problem, just input index vector into the warning project and start the neural network and the risk assessment results are obtained.

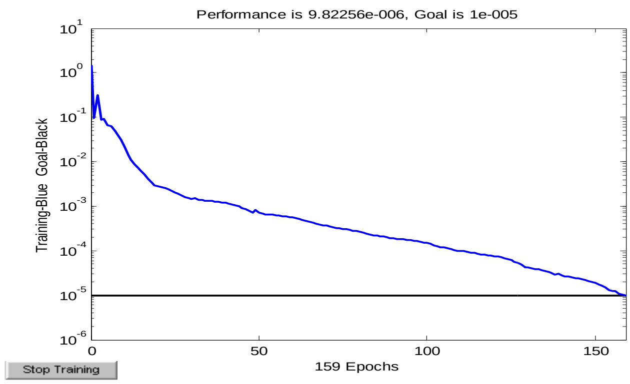

Figure 1. the results of training network diagram

TABLE I. THE TRAINING SAMPLE DATA

index	project number									
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Soil bulk density	0.6	0.58	0.55	0.64	0.54	0.67	0.63	0.62	0.61	0.67
moisture content	0.5	0.54	0.59	0.65	0.56	0.6	0.59	0.59	0.53	0.61
motor power	0.68	0.6	0.6	0.58	0.5	0.51	0.58	0.54	0.61	0.58
stirring head number	0.62	0.58	0.6	0.6	0.54	0.52	0.63	0.73	0.66	0.72
stirring head diameter	0.56	0.6	0.55	0.51	0.51	0.62	0.64	0.63	0.6	0.58
pin spacing	0.76	0.6	0.6	0.56	0.56	0.66	0.61	0.6	0.53	0.66
cement quality	0.64	0.64	0.57	0.57	0.55	0.53	0.55	0.59	0.67	0.65
cement content	0.68	0.54	0.54	0.49	0.5	0.6	0.56	0.59	0.56	0.65
Water cement ratio	0.56	0.64	0.63	0.63	0.63	0.53	0.63	0.66	0.58	0.6
pile bottom elevation	0.62	0.56	0.53	0.47	0.55	0.56	0.55	0.54	0.5	0.55
pile top elevation	0.56	0.56	0.54	0.51	0.54	0.58	0.61	0.65	0.64	0.7
error of a pile position	0.5	0.58	0.5	0.54	0.52	0.54	0.61	0.57	0.53	0.53
verticality deviation	0.62	0.52	0.49	0.57	0.47	0.54	0.58	0.53	0.66	0.64
overlap	0.58	0.58	0.54	0.59	0.52	0.6	0.56	0.55	0.5	0.54

IV.APPLICATION OF EXAMPLE

Cement soil gravity retaining wall is applied in a project of Tianjin city, and the first phase of the project risk forewarning is measured by the trained BP neural network model

Evaluation indexes of project risk forewarning are judged. Considering many factors of quantitative evaluation indexes and different dimensions, according to the risk ,each index was given to the numerical range of [0,1]by using the expert evaluation method. The results of the evaluation indexes of the project are listed:

The risk caused by bulk density:0.85;the risk caused by moisture content:0.64;the risk caused by motor power:0.25;the risk caused by stirring head number:0.24;the risk caused by stirring head diameter:0.13;the risk caused by pin spacing:0.36;cement quality:0.42; cement amount 0.45;water cement ratio 0.65; pile bottom elevation 0.32;pile top elevation 0.43;pile deviation:0.22; vertical deviation :0.47;lap:0.36.

the above data are stored into neural network model. Comprehensive evaluation score of the continuous wall security risk is0.577,belonging to the general alarm, which is consistent with the actual situation of the project and proves the effective application in the security risk forewarning of underground continuous wall can be based on BP neural network model.

V.CONCLUSION

This paper uses BP algorithm to set up the neural network model of retaining wall security risk forewarning .This model by using neural network iterative refinement adapts to the nonlinear relationship between influential factors better, and reduce the impact of subjective factors in the process of risk forewarning and has higher prediction precision. So it is an effective way to solve the problem of security risk forewarning continuous wall.

[1] Liu Keqin ,Deng Zeting ,Ke Bairong. The application of the cement mixing pile in deep foundation pit support[D]. Fujian Architecture Construction,2012(07).

[2] Li Jianxin.Research of application of cement treated gravity retaining wall[D].Tianjin: Tianjin University,2003

[3] Li Guofeng. Study on financial early-warning model based on BP neural network[J] .Science and technology information, 2010(34).

[4] Zhang Xingwen,Liao Yingxia. An empirical study on financial early warning listing Corporation based on Logistic regression model[J]. Chinese securities and Futures,2011(06).

[5] Li Rong,Wang Zhiren,Wang Qing. An empirical study on financial early warning based on BP neural network[J]. Journal of Liaoning Normal University(Natural Science Edition) ,2009(04).

[6] Zhao Zhijin,Ying Huiqing.Concise handbook for design and construction of foundation pit engineering[M].Beijing:China Building Industry Press,2000.

[7] Gong Xiaonan. Construction of deep foundation pit engineering design manual[M] .Beijing: China Building Industry Press,1998.7.

[8] Odom M D, Sharda R A. Neural network for bankruptcy prediction[A]. International Joint conference on Neural Network[C] .1990, June:17-70.