Research on the Whole Process Quality Control Method of Water Conservancy and Hydropower Construction Based on BP Neural Network

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Abstract. The traditional quality control method of the whole construction process is lack of process quality evaluation, which leads to the low overall quality score of the project after the completion of the project construction. A whole process quality control method of water conservancy and hydropower construction based on BP neural network is designed. First, set up water conservancy and hydropower construction site monitoring, and design data acquisition equipment for the whole construction process according to different construction positions; According to the acquisition equipment set above, collect the water conservancy and hydropower construction data at different locations and use them as the control data; On this basis, the framework structure of BP neural network is established, the control network level is determined, the back propagation function is determined, and the collected data of the whole process of water conservancy and hydropower construction are trained to complete the whole process quality control of water conservancy and hydropower construction. The example analysis results show that the whole process quality control of the project using the design method can effectively improve the construction quality.

Keywords: BP neural network · Water conservancy and hydropower projects · Whole process quality control · Data acquisition

1 Introduction

The construction of small and medium-sized water conservancy projects is generally small in scale, simple in structure, few key technical problems, and the construction is not difficult, so the quality problems become particularly prominent. Quality is the lifeline of small and medium-sized water conservancy projects, but often due to the lag in planning and design, the quality of the preliminary planning work is not high; the project volume is small, the unit price is low, and there are many local contradictions; the quality control system is not perfect, the evaluation mechanism is not perfect, and

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the management is not in place [1, 2]; The quality awareness is weak. The front-line construction workers generally have low quality and high mobility, which cause the project quality to fail to meet the standards, and some even have serious consequences such as quality defects and quality accidents. These problems The control of construction quality brings great difficulties [3, 4]. With the advent of the Twelfth Five-Year Plan, Daxing water conservancy has become a key task for the country to protect people's livelihood and promote development, especially the rapid development of a large number of small and medium-sized water conservancy projects that serve the "agriculture, rural areas, and farmers" such as small and medium-sized river management, drinking water safety, and water-saving irrigation.. Therefore, strict quality control is both a technical task and a political task. It is necessary to combine quality control and quality evaluation to promote efficient, comprehensive and in-depth implementation of quality control through quality evaluation to ensure that the quality of the project meets the design standards and specifications., To enable small and medium-sized water conservancy projects to give full play to economic and social benefits in accordance with quality and quantity, and to ensure the safety of people's lives.

Therefore, this paper designs the whole process quality control method of water conservancy and hydropower construction based on BP neural network. The main technical route of this method research is as follows:

(1) Set up water conservancy and hydropower construction site monitoring, and design data acquisition equipment for the whole construction process according to different construction positions;
(2) According to the above set acquisition equipment, collect the water conservancy and hydropower construction data at different locations as the control data;
(3) On this basis, the framework structure of BP neural network is established, the control network level is determined, the back propagation function is determined, and the collected data of the whole process of water conservancy and hydropower construction are trained to complete the whole process quality control of water conservancy and hydropower construction.

2 Research on the Whole Process Quality Control Method of Water Conservancy and Hydropower Construction Based on BP Neural Network

2.1 Layout of Water Conservancy and Hydropower Construction Site Monitoring

The construction site based on hydropower project is usually in a remote place, and there is usually no suitable office place around it. Therefore, the office place is often located at a certain distance from the construction site. It is usually troublesome to check the construction situation on the construction site. Setting up surveillance cameras to remotely monitor the construction situation is a good solution. Cameras shall be arranged at the construction site to transmit the working conditions of the construction site in real time in the form of video to the office away from the construction site through wired network.

Cameras shall be set at the construction sites of various concealed works to control and manage the construction of concealed works Video data shall be stored according to the needs of the project for post observation. In the field monitoring of this paper, wireless network transmission technology is generally used for monitoring, and wireless video monitoring system is used to monitor the whole construction site and key positions in the project construction, so as to comprehensively and timely understand the construction dynamics, respond quickly to unexpected situations, eliminate potential safety and quality hazards in time, and provide analysis basis for existing problems, So as to further improve the safety management and quality management of engineering construction, and greatly improve the modern, scientific and standardized level of engineering construction site management and construction technology. The video monitoring system consists of three parts:

1) remote part (monitoring point): mainly composed of camera and video server. The camera collects video information and transmits it to the video server, which converts, encodes and compresses the video signal [5, 6].
2) Data transmission part: responsible for transmitting the remote video signal to the monitoring center, and transmitting the control commands of the monitoring center to the remote. There are two transmission methods: wireless and wired. Wireless transmission includes analog microwave and digital wireless networks, and wired transmission includes cables or optical cables.
3) Monitoring center: All remote monitoring signals are gathered here for information browsing, storage, conversion and interactive control operations. It is mainly composed of video server, computer, monitoring terminal and other equipment [7, 8]. Due to the temporary nature of project construction, the deployment of wired or optical cables in the data transmission link part is costly and has a long period. However, wireless transmission is in line with the needs of project construction due to its flexible system construction and short construction period.

In the process of the deployment of no online webcams, in addition to the deployment of wireless webcams on the construction site of the dam, for hydropower plants, spillway tunnels and other projects, the cameras are added or moved at any time according to the actual project.

After the installation is completed, in the surveillance video storage and subsequent use, in addition to real-time monitoring video screens of the construction site, it also provides the current monthly construction data video. The camera data that needs to be retained such as key processes and concealed projects are stored in the monitoring center On the server of, for those who need to inquire about the recording.

2.2 Data Acquisition Equipment in the Whole Process of Design and Construction

In the process of quality control, data collection in the construction process is also an important link. For the signal acquisition in the construction process, the secondary voltage and current signals in the experimental process of the acquisition point are generally used. The method adopted in this paper is to obtain the voltage and current signals at the secondary side of the acquisition point at the same time, and then calculate the dynamic resistance of the acquisition point according to Ohm's law. The advantage of this method is that the measurement is direct and high measurement accuracy can be obtained. However, due to the large secondary side current, a large range current sensor needs to be used. This chapter will introduce the coil sensor and other data acquisition equipment used for high current sensing in detail.

Since there are many factors that affect the quality of water conservancy and hydropower construction, it is necessary to carry out various combinations of these factors for testing to fully reflect the quality changes in various situations. In order to combine various influencing factors and reduce experimental workload, the designed data acquisition equipment is shown in the figure below:

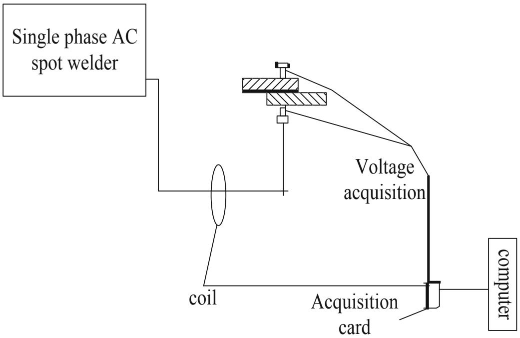

Fig. 1. Schematic diagram of the composition of data acquisition equipment

The main components of data acquisition are shown in Fig. 1. The system consists of a single-phase AC spot welder, secondary side current air-core coil current sensor, inter-electrode voltage sampling wire, A/D signal acquisition card, PC, and sampling software.

The air-core coil current sensor can output the differential waveform of the secondary side current and convert it into a voltage waveform that meets the amplitude requirements of the A/D signal acquisition card. This signal is sent to the A/D signal acquisition card together with the voltage signal between the electrodes. The A/D signal acquisition card in the experiment can perform 16-channel 12-bit analog-to-digital conversion, which can meet the accuracy and rate requirements of the measurement.

The traditional transformer with iron core has a very narrow frequency band, and the secondary signal waveform is seriously distorted when the magnetic saturation is used as relay protection, the reaction speed lags behind and is easy to cause relay misoperation. Air core coil current sensor can overcome a series of problems brought by traditional electromagnetic transformer. Its characteristics are simple structure, no direct circuit connection with the measured current, no iron core, no hysteresis effect and no magnetic saturation. The coil is mainly composed of annular hollow coil. As shown in Fig. 2.

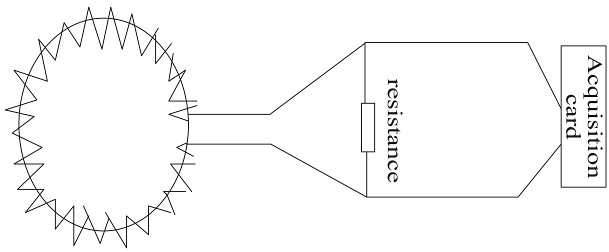

Fig. 2. Schematic diagram of coil structure

Connect a suitable resistor in parallel with the output terminal of the sensor coil to obtain a suitable output voltage amplitude. In order to obtain the original waveform of the welding current, it is necessary to integrate the waveform on the sensing coil and calibrate the integrated amplitude. The parameters of the sensor coil used in this article are as follows: the number of turns is 1200, the wire diameter is 0.4 mm, the size of the flexible skeleton is 3 × 25 mm, and the output resistance is 100 Ω/0.25 W. This test needs to collect two analog signals: the differential waveform of the secondary current and the voltage between the electrodes. The differential waveform of the spot welding current is an alternating signal with a maximum amplitude of about 4 V. The voltage between the electrodes is also an alternating signal, the maximum amplitude is about 3 V. Therefore, select the 0 channel and 1 channel of the A/D signal sampling card to perform spot welding current differential waveform and inter-electrode voltage sampling respectively, and the range is set to ± 5 V. Start AD1674 for conversion. When A/D current channel conversion is completed, it can be shorted to PC bus interrupt request signal RQ5 through jumper SX1 1–2. A/D occupies 4 consecutive port addresses: 310 H – 313 H. The A/D input range is selected by the 4-digit DIP switch SW2. The A/D input signal is accessed by the XS1 25D socket. Pins are No. 1 and No. 14, which are voltage and current signals respectively, and the input voltage range is ± 5 V. This completes the design of the data acquisition equipment.

2.3 Design a Quality Evaluation Model Based on BP Neural Network

BP neural network is also called multilayer feed forward neural network. The network has input layer, output layer and one or more hidden layers. The network is composed of several layers of neurons. It is a multilayer perceptron structure.

Figure 3 shows a very typical BP neural network model with input, output and hidden layers. The figure shows the topology of a BP network with only one hidden layer, and there is no feedback connection between neurons.. The non-linear function is the activation function generally used in the hidden layer, and the S-type function is the most commonly used. The output layer of the network can use linear functions as activation functions and non-linear functions as activation functions [9, 10], which depends on the mapping relationship between the input and output of the specific situation.

In the learning process of the BP neural network, the working signal is propagated forward, and the error signal is propagated back, so it is repeated to train the neural network.

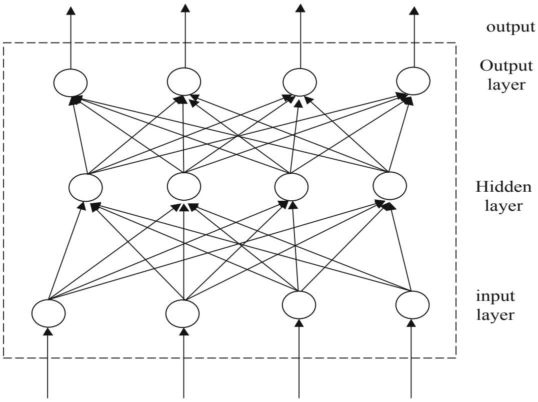

Fig. 3. Frame structure of BP neural network

Table 1. Meaning of letters

Letter	Meaning	Letter	Meaning
P	Network input	s_2	Number of neurons in output layer
r	Number of neurons in input layer	f_2	Output layer activation function
s_1	Number of hidden layer neurons	S	Network output
f_1	Hidden layer activation function	T	Target vector

Table 1 shows the letters and their meanings, which will be used in the following description.

The sequential propagation of working signal along input layer, hidden layer and output layer is called forward propagation. In the process of signal transmission, the weight of neural network is fixed, and the state of neurons in any layer only determines the state of neurons in the next layer. When the output layer does not get the expected output, this process will turn into the back propagation process of error signal.

The output of the i neuron in the hidden layer is:

$$\begin{cases} a_{1i} = f_1\left(\sum_{j=1}^{T} w_{1ij}a_{1i} + b_{2k}\right) \\ i = 1, 2, \cdots, s_1 \end{cases} \tag{1}$$

The output of the k neuron in the output layer is:

$$\begin{cases} a_{2k} = f_2\left(\sum {}_{j=1}^{s_1} w_{1kj}a_{1i} + b_{2k}\right) \\ k = 1, 2, \cdots, s_2 \end{cases} \tag{2}$$

The error of the function is defined as:

$$E(W, B) + \frac{1}{2}\sum {}_{K=1}^{S_2} (t_k - a_{2k})^2 \tag{3}$$

Back propagation of error signal: the error signal is the difference between the actual output and the expected output of the neural network. The back propagation of error means that the signal is transmitted from the output layer to the input layer through the hidden layer. In the back propagation process, the weight of the network is adjusted by error feedback.

The weight of the output layer changes from the i input to the k output as follows:

$$\begin{cases} \Delta w_{2ki} & = -\eta \frac{\partial E}{\partial a_{2k}} \frac{\partial a_{2k}}{\partial a_{2ki}} \\ & = \eta (t_k - a_{2k}) f_2' a_{1i} \\ & = \eta \delta_{ki} a_{1i} \\ \delta_{ki} & = (t_k - a_{2k}) f_2' \\ & = e_k f_2' e_k f_2' \\ e_k & = t_k - a_{2k} \end{cases} \tag{4}$$

The same can be obtained:

$$\begin{cases} \Delta b_{2k} & = -\eta \frac{\partial E}{\partial b_{2ki}} \\ & = -\eta \frac{\partial E}{\partial a_{2k}} \frac{\partial a_{2k}}{\partial a_{2ki}} \\ & = \eta (t_k - a_{2k}) f_2' \\ & = \eta \delta_{ki} \end{cases} \tag{5}$$

The weight of the hidden layer changes. From the j input to the i output weight, the amount of change is:

$$\begin{cases} \Delta w_{1ki} & = -\eta \frac{\partial E}{\partial w_{1ij}} \\ & = -\eta \frac{\partial E}{\partial a_{2k}} \frac{\partial a_{2k}}{\partial a_{1i}} \frac{\partial a_{1i}}{\partial w_{1ij}} \\ & = \eta \sum_{k=1}^{S_2} (t_k - a_{2k}) f_2' w_{ki} f_1' P_j \\ & = \eta \delta_{ij} P_j \\ \delta_{ij} & = e f_1',\ e_i \sum_{k=1}^{S_2} \delta_{ij} w_{2ki} \\ \Delta b_{1i} & = \eta \delta_{ij} \end{cases} \tag{6}$$

When dealing with problems such as non-linear classification, it is achieved by adjusting the scale of the BP neural network (the number of input nodes, the number of output nodes, the number of hidden layers and the number of hidden layer nodes) and the connection weights in the network. The BP neural network can Approximate any nonlinear function with arbitrary precision.

The determination of the number of layers of the network, the number of neurons in the hidden layer, the selection of the transfer function, the training method and the selection of parameters are the main contents of the network structure design. The reliability of the evaluation results is directly affected by the designed network performance.

(1) Determine the number of layers of the network

A neural network must have at least one input layer and one output layer, which is the premise. The selection and design of a reasonable hidden layer will directly determine the performance of the neural network. The complexity of the problem to be solved determines the number of hidden layers. Research shows that if you want to strengthen the solution to more complex problems, you can achieve it by increasing the number of hidden layers.

(2) Number of neurons in the hidden layer

In BP neural network, the reasonable setting of hidden layer neurons is very important, which directly determines the realization of the function of the network model. The number of neurons should be appropriate, not too much or too little. Too much will make the learning time of the network longer. If it is too short, it is difficult to deal with complex problems. Repeated comparison is the main method to determine the number of hidden layers, because there is no effective and scientific method to determine the number of neurons.

(3) Training method and parameter selection

For dealing with different problems, BP neural network has many training methods, as well as how to select the training function and its parameters.

First, we must establish a sound and reasonable high-rise building construction site safety evaluation index system and neural network evaluation model. Then carry out the application of safety evaluation and ensure the accuracy of the mathematical model of safety evaluation according to the actual situation of the high-rise building construction site. The steps for the safety evaluation of high-rise building construction site based on neural network are as follows:

1) Determine the number of hidden layers, the number of nodes in the input layer, output layer and hidden layer;
2) Establish a safety evaluation index system;
3) Collect appropriate learning samples and determine a reasonable neural network training method;
4) Choose a suitable transfer function;
5) Training the BP neural network model as a knowledge base for enterprise safety evaluation;
6) Use the trained BP neural network to obtain the evaluation result by using the learned knowledge through the MATLAB simulation technology;
7) The evaluation results obtained can be used as training samples of BP neural network, and can enrich and strengthen the performance of enterprise safety evaluation knowledge base.

3 Case Analysis

In the experiment, firstly, the basic situation of the experimental project is analyzed, the experimental scheme is set according to the situation, the water conservancy project construction data acquisition system is designed in detail, and the quality of water conservancy project facilities is detected according to different modules set in the system.

Finally, the experimental results are analyzed to reflect the effectiveness of the proposed method through the analysis of experimental data.

3.1 Project Overview

The experiment selects a large-scale water conservancy and hydropower project in the middle reaches of the river where a hydropower station is located, which mainly focuses on power generation and has comprehensive utilization benefits such as flood control and sediment blocking. The dam controlled drainage area of the hydropower station is 68512 km^2, accounting for 88.5% of the whole drainage area. The power station has 6 installed units, single unit capacity of 550 MW (maximum capacity of 600 MW), total installed capacity of 3300 mw, guaranteed output of 926 mw, and multi-year average annual power generation of 14.58 billion kw. H.

The hydropower station selected in the experiment is composed of river blocking dam, water diversion and power generation structure, flood discharge tunnel, emptying tunnel, Niri river water diversion project and so on. The river retaining dam is composed of gravel soil straight core rockfill dam and 3 spillways with a width of 12 m; The crest elevation of gravel soil straight core rockfill dam is 856 m. The dam crest is 14 m wide, the dam axis is 573.5 m long, and the maximum dam height is 186 m. The water diversion and power generation structure is composed of bank tower water intake, 6 pressurized water diversion tunnels, underground powerhouse, underground main transformer chamber, underground Tailrace Gate Chamber and 2 pressureless tunnels. Niri river diversion project consists of head hydroproject and diversion tunnel.

The normal storage level of the power station reservoir is 850.00 m, the operating limit water level during the flood season is 841.00 m, the dead water level is 790.00 m, the drawdown depth is 60 m, and the total storage capacity is 5.390 billion m^3, of which the flood regulation storage capacity is 1.056 billion m^3 and the regulation storage capacity is 3.882 billion m^3, which is an incomplete year. Regulate the reservoir. The maximum Kui water height in front of the dam is 173 m, and the main stream backwater reaches the Shimian County Town Crossing River Bridge. The backwater length is 72 km and the reservoir area is 84.14 km^2. The river course of the reservoir is 72 km, involving 3 counties including Hanyuan, Ganluo and Shimian.

3.2 Experimental Scheme

The experimental selection of hydropower stations also used remote video monitoring, electronic document management, and the use of three-dimensional models to express the appearance of the dam body for management. However, the various subsystems are not well integrated, and an integration needs to be established. This chapter mainly takes the GPS real-time monitoring system established in this mode as an example to build a unified platform for similar large-scale projects in the future.

In the Pubugou Dam construction process, if conventional inspection methods that rely on manual on-site control of rolling parameters (such as rolling speed and number of passes) and manual digging test pit sampling are still used to control construction quality, it is different from large-scale mechanized construction. It is also difficult to meet the corresponding construction quality requirements. Therefore, it is necessary to study a dam filling and rolling construction quality monitoring system with the characteristics of real-time, continuity, automation, and high precision, to adapt to the experimental selection of the river where the hydropower station is located. The experiment selects the construction quality of the main dam of the hydropower station. Management requirements. Accumulate experience for the construction of gravel soil dams similar to core walls in the future.

3.3 Experimental Data Acquisition

The experiment developed by the research institute selects the river where the hydropower station is located. The experiment selects the GPS real-time monitoring system for the construction quality of the dam of the hydropower station. With the GPS system, wireless network communication system and computer hardware as the core, it has developed a filling and grinding system for the dam. The software platform for real-time, high-precision, continuous, and automatic monitoring of the construction quality of the compaction project, realizes the highly automatic operation and operation monitoring of the rolling compaction construction, and can grasp the location and operation execution status of the rolling construction vehicle in real time, The system can record the trajectory, speed and direction of each vehicle, and calculate the thickness and number of passes of the paving layer, providing a basis for accurate construction and inspection judgments.

The GPS real-time monitoring system for dam filling construction quality adopts C/S (client/server) architecture to realize mutual communication and service between mobile remote end and monitoring center. In addition to the traditional keyboard and mouse operation, the mobile terminal is equipped with touch screen operation to realize man-machine dialogue. The communication adopts GPRS/CDMA wireless network to realize network data transmission through public Internet network. The acquisition and setting of GPS data are realized through RS232 serial port. The server side of the system uses broadband static IP address to access the Internet. The system operation principle is shown in Fig. 4 below:

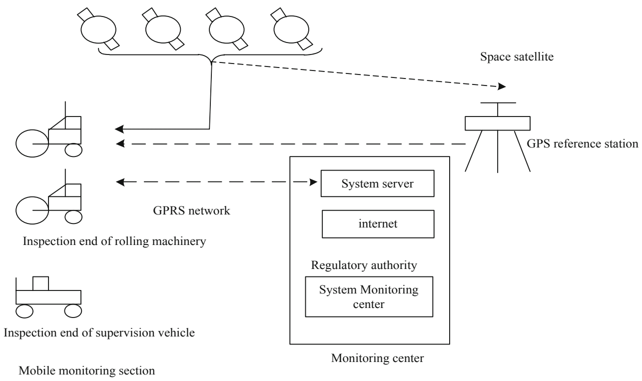

Fig. 4. GPS real-time monitoring system for dam construction and rolling

The GPS real-time monitoring system for dam filling construction quality is mainly composed of three parts (as shown in Fig. 1):

Reference station part, mobile monitoring part and monitoring center. The mobile monitoring part is composed of various mobile monitoring terminals, including all rolling machinery and engineering supervision vehicles. It navigates the operators, requires the operators to operate according to the specifications, reports to the operators, provides parameters and information to the server, and receives server instructions. The benchmark station is mainly used to set the engineering measurement parameters and provide differential information. Considering the long-term site stability, simplicity of setting and diversity of environmental conditions, a separate part is established. The system server provides data channel and data storage, and provides services to supervisors and management departments.

The GPS mobile monitoring terminal installed on the quality supervision vehicle is mainly composed of GPS and industrial computers. According to the needs of project monitoring and at the same time, in order to further improve the accuracy of GPS observation, the system is specially equipped with quality supervision work vehicles for construction supervision units. The main task is to carry out GPS mobile observation. The main observation item is to measure the thickness of the paving soil after the soil is paved, and to provide data for calculating the compaction rate; save the data in the industrial computer in the car and save it in real time The observation results are sent back to the monitoring center, and the monitoring center receives the positioning data of the GPS mobile monitoring terminal sent by the mobile monitoring terminal (including the data of controlling the number of rolling passes of the rolling machine and the thickness of the rockfill layer before rolling, and the data of the rolling range, etc.) At the same time, it can request the monitoring center to receive the results of its further analysis, and guide the on-site construction from the perspective of quality management.

The GPS mobile monitoring terminal installed on the rolling machinery is similar to the GPS mobile monitoring point installed on the quality supervision vehicle. The hardware configuration is also composed of GPS and industrial computers. The observation items are mainly the rolling passes and driving of the rolling machinery. The speed, driving direction and the final rolling thickness of the paving soil are stored in the industrial computer in the car and displayed on the touch screen, and the observation results are sent back to the monitoring center in real time. The computer's touch screen also reflects the rolling situation in real time, and guides the construction work of the rolling truck operator.

3.4 Results and Analysis

Through the investigation and investigation of the bidding documents and the early stage of the construction site of the project, based on the communication with the project management personnel, this paper comprehensively analyzes the preparation control measures before the construction of the project, classifies and arranges the collected data and documents, and lists the specific indicators of the construction quality prediction of the project, The research results of traditional water conservancy and hydropower construction whole process quality control method and water conservancy and hydropower construction whole process quality control method based on BP neural network are shown in Table 2:

Table 2. Data of construction quality prediction indicators for high-rise buildings

Influence factor		①	②
People	Technical proficiency of construction personnel U11	0.12	0.10
	Comprehensive quality of management personnel U12	0.41	0.50
	Training proportion of construction personnel U13	0.73	0.76
Material Science	Concrete U21	0.34	0.50
	A steel bar U22	0.35	0.50
	Template U23	0.08	0.10
Mechanics	Working condition inspection of mechanical equipment U31	0.65	0.63
	Repair and maintenance of machinery U32	0.52	0.37
	Allocation of construction machinery and equipment U33	0.09	0.10
Method	Construction technical scheme U41	0.87	0.90
	Construction organization design U42	0.41	0.37
	New technologies and methods U43	0.76	0.90
Environment	Construction environment U51	0.69	0.67
	Construction quality management environment U52	0.57	0.63

In Table 2, ① represents the traditional method, ② represents the quality control method designed in this paper based on the BO neural network, and the data obtained from the quality prediction in the BP neural network model. Enter the evaluation results obtained in the above table into the software. After the traditional method is calculated, the score obtained under a certain weight is 70 points, that is, the construction quality of the proposed building predicted according to the prior control measures is qualified. If the quality target of this project is not reached, it indicates that there are problems with the preventive measures for these factors that affect the construction quality in advance, so strict improvement is needed.

Using the BP network model to change the data of each factor, the evaluation score obtained is 83.7 points. Under the evaluation of this score, the predicted value can reach the quality target of the project. When changes are made to the factors of concrete, steel bars, and on-site construction environment, the predicted value can meet our quality requirements, indicating that there are problems with the control measures in these aspects during the pre-construction preparation stage. Therefore, the quality control method of the whole process of water conservancy and hydropower construction based on BP neural network is better than the traditional method of quality control of the whole process of water conservancy and hydropower construction.

The source of concrete and reinforcement in the project is purchased by the construction party. When selecting the source of material supplier, it is easy to buy some materials with poor quality because the information of material market and manufacturer is not comprehensive enough. Therefore, it is suggested to use the bid inviter to purchase important materials, The quality requirements of engineering materials can be met through the review of manufacturers and the assessment of field investigation and research. In addition, the construction environment control measures have not been done well. We should pay attention to the improvement of the plane and working environment conditions of the construction site, plan the roads on the site, stack materials reasonably, and have good flood control and drainage capacity, construction lighting, safety protection facilities, etc., so as to ensure the construction quality of the project. This result can be used as an important reference for the construction unit to control the construction quality of the project in advance.

4 Conclusion

Combined with the specific examples of water conservancy and hydropower construction projects, starting from the factors affecting the construction quality, this paper analyzes the specific measures of construction quality prior control, uses the BP neural network model to predict the water conservancy and hydropower construction quality level, and proves the objectivity and superiority of BP neural network in water conservancy and hydropower construction quality prior control.

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