Corrosion Detection of Structural Reinforcement Based on Artificial Intelligence Technology

Hong Fei¹ and Zifu Hu²,*

¹Architectural and Surveying & Mapping Engineering Institute, Inner Mongolia Technical College of Construction, Huhhot 010010, Inner Mongolia, China
²Institute of Mining and Technology, Inner Mongolia University of Technology, Huhhot 010010, Inner Mongolia, China

*Corresponding author
huzifu@imut.edu.cn

Abstract. Due to the environmental degradation caused by soil erosion, it is of great significance to establish the relationship model between geological environmental factors and piping erosion. The method to determine the prone area of pipeline corrosion is limited. This paper introduces the mechanism of reinforcement corrosion, points out the non-destructive detection methods of common steel corrosion, and puts forward the measures to prevent and maintain the corrosion of reinforcement from the aspects of design, construction and material selection, so as to prolong the service life of concrete structure. Abrasion, capitation and chemical attack in concrete hydraulic structures can lead to deterioration of spillways, stilling basins, chutes, slabs and transverse joints, concrete blocks under sluices and any irregular surfaces affected by high flow rates. There are numerous coatings on the market that can be used to repair damaged surfaces. However, the basic data provided by the manufacturer is very limited, and if so, it is usually limited to room temperature values. The results show that the data of concrete, corrosion solution and chloride ion are 0.534, 0.673 and 0.384 respectively.

Keywords: Artificial Intelligence, Steel Corrosion, Durability, Quality Control.

1. Introduction

With the continuous progress of Internet technology, intelligent information technology has become an indispensable part of our life. Artificial intelligence technology has penetrated into our lives and brought us a lot of convenience. We have applied artificial intelligence technology to our travel, work, food, clothing, housing and transportation [1].

Due to the continuous progress of computer technology, many experts have studied artificial intelligence technology [2]. For example, some teams in China have studied the durability of concrete structures in the Yellow River Delta region using artificial neural networks, and have used the advantages of artificial neural networks in dealing with nonlinear and complex relationships; In addition, the feasibility of the neural network is evaluated by using the neural network theory. Some experts have studied the salt damage concrete test based on computational intelligence. A state evaluation model of presented concrete continuous rigid frame bridge is established through artificial seawater promotion test, and a concrete plastic damage constitutive model suitable for seismic analysis of concrete dams is proposed. The rate independent model always includes the effect of strain.
softening, which is represented by the separate damage variables of tension and compression. Each random node is reconstructed into a differentiate function of its parameters and a fixed distribution of random variables. After reconstruction, the loss gradient propagated by the chain rule through graph is a low variance unbiased estimation of the expected loss gradient. Although many continuous random variables have such computerization, discrete random variables are less useful. A simple scalar degradation model is used to simulate the effects of damage on elastic stiffness and stiffness recovery after crack closure. The corrosion resistance tests of concrete specimens and concrete members are carried out. The algorithms proposed in the literature are discussed and the expected resources needed to run these algorithms are given. On this basis, the application effect of the state evaluation system of presented concrete continuous rigid frame bridge is tested. In order to solve the problem of concrete salt damage, an intelligent model of salt damage is established based on the calculation of concrete salt damage. Some experts have studied the data mining and database establishment of concrete strength evolution in marine environment. Based on the mechanical performance index of concrete comprehensive strength in marine environment, cluster analysis is carried out, and data mining methods such as regression analysis are used to process the rough data. The random changes of pore moisture and stress in half space are analyzed. The diffusion equation and the superposition integral of stress relaxation are used. The main factors affecting the strength of concrete in marine environment are screened out. The database of mechanical properties and influencing factors of concrete is established by using three mathematical statistical methods: correlation analysis, Grey correlation analysis and principal component analysis. On the basis of data processing, many factors involved in the study are determined as material factors. Environmental factors include ion concentration, dry wet cycle system and exposure age. It effectively solves the problem of complex cement varieties and makes the data comparable. According to the existing experimental research results, the strength values of specimens with different sizes are standardized to make the strength of cylinder and Cube Specimens of different sizes comparable [3]. Although the research results of artificial intelligence are quite fruitful, there are still some deficiencies in the detection of structural reinforcement corrosion by artificial intelligence technology.

In this paper, in order to study the corrosion detection of structural reinforcement with artificial intelligence technology, a mathematical model for predicting the carbonation depth of concrete is found. The results show that the artificial intelligence technology is conducive to the detection of structural steel corrosion.

2. Method

2.1. Artificial Intelligence Technology

2.1.1. Artificial intelligence technology. Artificial neural network is a theoretical mathematical model of human brain neural network. It is an information processing system that imitates the structure and function of brain neural network. The basis of computational intelligence is connectionism, and its various algorithms are deeply related. Neural network and immune network, genetic algorithm and immunity, agent has a considerable relationship [4]. When the artificial neural network is used to solve the problem, when the accumulation reaches a certain degree, new individuals will be generated to ensure the efficiency. When the interaction reaches a certain degree, the subsystems involved in the interaction will be regarded as the subsystems of the new high-level system and cannot be independent, and the high-level system will have the behavior ability that each subsystem does not have. The independence of subsystems decreases with the enhancement of hierarchy [5]. It is a feed forward artificial neural network with teacher (supervised learning) and error back propagation (error correction learning). It is proved theoretically that multilateralism BP network has the ability to approximate nonlinear mapping arbitrarily.
2.1.2. Artificial neural network. It is a large-scale parallel system with a large number of interconnected simple processors. Artificial neural network is a theoretical mathematical model of human brain neural network. It is an information processing system based on imitating the structure and function of brain neural network [6]. The interaction between ANN neurons is reflected by the weight of the connection. The output of a neuron is a function of its input. Information is not stored in one place, but distributed in different places. Each neuron of artificial neural network receives a large number of inputs from other neurons, and produces output through parallel network, affecting other neurons [7]. Artificial neural network can obtain the weight of the network through training and learning, showing a strong self-learning ability and adaptability to the environment. Neuron is the basic processing unit of neural network, which is generally a nonlinear device with multiple input and single output. The neuron model is often described by first-order differential equation, which can simulate the change of synaptic membrane potential of biological neural network with time [8]. Part of the network also stores more than one kind of information. Neural network system can adapt to the environment and increase the capacity of knowledge through learning. Therefore, even if the LAN is destroyed, distributed storage still has the function of recovering the original information. It can automatically induce rules from known data to obtain the inherent laws of these data, and has strong nonlinear mapping ability.

2.1.3. BF neural network. BF neural network corrects the error in the process of back propagation. It is multilateralism feed forward network with unidirectional propagation composed of nonlinear elements. It is the most widely used neural network in neural network model, mostly in the form of network or its derivative calculus. Among many neural networks, neural network is also one of the earliest and most widely used networks [9]. By studying the structure of human brain and the way of information processing, using some characteristics of brain neural network, an intelligent system with some functions similar to the brain is designed to process various information and solve different problems. From the above analysis, the network is more suitable for the prediction and control of nonlinear bridge system [10]. The output information of the hidden node is propagated to the output node, and the output result is given. If the output layer cannot get the expected output, that is, there is an error between the actual output value and the expected output value, then the back-propagation process will be turned on, and the error information will be returned along the original connection path [11]. The hidden layer can be one or more layers, and the neurons in each layer are called nodes or cells. The original input of a network activity represents the information entered into the network activity. Therefore, by modifying these weights, the hidden cell can select what it represents.

2.2. Mathematical Model for Predicting Carbonation Depth of Concrete

The results show that the high alkalinity of concrete is the most important condition to protect the reinforcement from corrosion, and pH > 11.5 is usually called the critical value of reinforcement protection. In the process of using, it leads to the steel bar's dullness. The classical theory of concrete carbonation is based on Fick's first diffusion law:

\[
Q = -D \frac{\partial C}{\partial X} \tag{1}
\]

\[
D = K \sqrt{T} \tag{2}
\]

Fick's second law is basically based on empirical hypothesis and can well fit the measured results of existing structures. It is assumed that the distribution of pores in concrete is uniform, and the concentration gradient only changes along the direction from the exposed surface of concrete to the surface of reinforcement:
\[
\frac{\partial C}{\partial T} = D \frac{\partial^2 C}{\partial X^2}
\]  
\[
C = C_0 + (C_x - C_0) \text{erf}\left(\frac{x}{2\sqrt{D}\tau}\right)
\]

3. Experience

3.1. Experimental Object Extraction

The design of database involves three aspects of user information base: data information base, specimen information base and environment information base. Among them, the data information base is mainly used to create files for data sources, so that users can find data sources. In the database information base, the "data source" is first involved, that is, the acquisition of recorded data is obtained from literature, experiment or related database; and the data obtained from literature is the main data source of data mining of this project, so "literature title", "literature author" and other information are the main data sources of data mining of this project, and the "journal name", "literature author" and other information are the main data sources of the project data mining "Research unit "and create" data time "to determine the time of data generation, to achieve the monitoring of data timeliness.

3.2. Experimental Analysis

The specimen information database is mainly used to record the matching information, size and initial strength of the specimen, which represents the initial state of concrete before deterioration. It includes "cement type", "cement strength (28d)"; "water cement ratio", "sand ratio", "mineral admixture" and other mix proportion information; it involves "specimen type (shape)", "specimen size", "surface area" and other specimen size information and initial strength information. At the end of the database, there is an environmental information database, which mainly records the strength deterioration state of concrete in marine environment (or simulated environment). Firstly, it includes "ion concentration of erosion solution", which mainly includes the concentration information of Na+, Mg2+, Cl- and SO42- ions; secondly, the dry wet circulation system, namely "wetting temperature", "wetting time", "drying temperature", "drying time", "drying cycle" and "drying time"; finally, the determination of the final degradation strength gives the dry wet cycle in the ionic solution Sample after ring.

4. Discussion

4.1. Data Collection

As the test data is obtained after a series of more rigorous tests, some distortion has been eliminated in the process of the test. Although in the actual structure, when the crack width is greater than the allowable value, it does not necessarily lead to the durability failure of the structure, but when the actual crack width is less than the allowable value, the durability of the structure cannot be guaranteed. In the analysis of the adaptive neural network, we don't have to worry about the distortion; we can directly bring the test data into the analysis. As shown in Table 1.

| Table 1. ANFIS training data (part) |
|---------------------------------|-----------------|-----------------|-----------------|
| type  | concrete | Corrosive solution | Chloride ion volume |
| data  | 0.534    | 0.673             | 0.384             |

From the above, the concrete data is 0.534, the corrosion solution data is 0.673, and the chloride ion data is 0.384. The results are shown in Figure 1.
Figure 1. ANFIS training data (part)

It can be seen from the above that the corrosion solution data is the highest, the chloride ion data is the lowest, and the concrete data is higher than the chloride ion data.

4.2. Performance Test of Raw Materials

In engineering, water reducing agent is used most. Although the exchange rate of concrete is very low, it can reduce the water binder ratio, reduce the amount of cement, improve the workability, mechanical properties and durability of marine cement, and reduce the impact of weather or environmental factors on construction. Therefore, it has become an important part of high performance concrete. It should be considered to improve the frost resistance index and reduce the water loss rate. When selecting water reducing agent, the corresponding water reducing agent should be selected according to the required performance of concrete and the performance of raw materials. The compatibility of admixtures and cement should be paid attention to when they are used together. As shown in Table 2.

| chemical composition | CaO  | SiO₂ | Al₂O₃ | Fe₂O₃ | SO₃ | P₂O₅ | K₂O |
|----------------------|------|------|-------|-------|-----|------|-----|
| Content%             | 11%  | 8%   | 21%   | 16%   | 14% | 6%   | 24% |

From the above, the content is CaO 11%, SiO₂ 8%, Al₂O₃ 21%, Fe₂O₃ 16%, SO₃ 14%, P₂O₅ 6% and K₂O 24%. The results are shown in Figure 2.
From the above, $K_2O$ the content is the most, $P_2O_5$ the content is the least, $CaO$ the content is higher than $Al_2O_3$ the content, $Fe_2O_3$ the content is higher than $SO_3$ the content, $P_2O_5$ the content is higher than the content.

5. Conclusion

Under severe environmental exposure, concrete becomes more and more vulnerable to wear / erosion degradation, especially when the service conditions are combined with chloride penetration, sulfate bonding and freeze-thaw cycles, which leads to repeated maintenance or service interruption of major water conservancy and marine infrastructure, resulting in huge economic losses. The corrosion mechanism of concrete is introduced. Based on the analysis of geological conditions, the corresponding anti-corrosion scheme is proposed, and the concrete construction scheme is formulated. Impermeability test and freeze-thaw test show that it can meet the construction requirements and save the cost of concrete maintenance. The application of artificial intelligence technology in environmental protection in recent years is reviewed. In terms of application, the problems to be solved include avalanche assessment and path analysis, forest fire prevention, soil erosion prediction, water ecological process management, landslide control and weather forecast. According to the survey, all the methodological features can be of great benefit to environmental protection.

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