Research on Durability Design Method of Building Structure based on BIM Technology

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Abstract: There are still some problems in the nondestructive testing technology of building structure, such as single testing object, subjective judgment error, lack of continuous testing ability and comprehensive evaluation of multiple indicators. Therefore, the design of wireless monitoring system for the durability of building structure can effectively monitor the durability parameters of the structure in real time, and optimize the storage of the collected durability data information of the building structure, which is of great significance for the comprehensive evaluation and analysis of the later durability of the building structure. Therefore, the research on durability design method of building structure based on BIM Technology is proposed, and the simulation test of building structure is carried out with ns-allinone-2.34 three-dimensional policy software to ensure the safety and effectiveness of the durability design results of building structure

Keywords: BIM; Building structure; Durability; Building wear

1. Introduction

Due to the influence of the production environment and natural environment, the durability of the building structure is becoming more and more serious, which makes the building unable to reach the ideal service life and poses a serious threat to the production safety. Moreover, the degradation and deterioration of the performance of the building structure make the maintenance and reinforcement cost of the building structure increase continuously in the later period, which brings great impact to the national economy Big loss [1]. Therefore, the design and optimization of the wireless monitoring system for the durability of building structures can not only make up for the technical defects of the traditional building structure detection, but also ensure the safety of the production process, which is of great significance to promote the development of national economy. For a long time, the building structure suffered from natural disasters, environmental erosion, material degradation and deterioration and other factors, which caused various degrees of damage to the building structure. After a long-term accumulation of these damages, it led to various durability problems of the building structure. The building structure is composed of steel structure, reinforced concrete structure and other structures.

However, compared with many developed countries, the development of engineering construction in China started late, and reinforced concrete structure still occupies the majority of the building structure. Although the durability of concrete structure is better than that of other materials, but the building is different from the civil building, and the building often serves in all kinds of harsh environment, the corrosive medium in the production process has a serious impact on the durability of the building structure. The durability deterioration of concrete structure is mainly caused by concrete carbonization, steel corrosion, freeze-thaw damage, chloride ion erosion, alkali aggregate reaction, etc [2]. Most heavy production, such as ore dressing, sintering, coking, chemical industry, smelting, casting, papermaking, printing and dyeing, are affected by corrosion, humidity, high temperature, heavy load and other environmental effects. Many concrete structure plants have serious durability problems before their designed service life, so they have to be reinforced or rebuilt. In the national metallurgy, chemical industry, petroleum, textile, papermaking and other departments, due to the long-term use, processing or production of corrosive substances to reinforced concrete structures, the corrosion damage to plant structures is often reported. The light ones need to be repaired and reinforced, and the heavy ones need to be demolished and rebuilt. The direct and indirect losses caused by this are quite amazing. If the initial design, construction or later use of the building structure is unreasonable, the durability damage of the building structure may occur earlier.

Therefore, on the basis of investigating the domestic and foreign research status of building structure durability monitoring system, this paper summarizes the current situation of building structure durability detection technology, and analyzes its defects. First of all, the category of building structure durability monitoring parameters and the overall architecture of wireless monitoring system are determined [3]. Through the hardware selection and software design of building structure durability wireless monitoring system, the overall design of building structure durability wireless monitoring system is completed. Secondly, the network simulation software ns-allinone-2.34 is used to simulate and analyze the wireless monitoring network of building structure durability. By comparing with the traditional disjoint path algorithm, the advantages of the adaptive distributed disjoint multi-path topology control algorithm in wireless monitoring network fault tolerance, node connection repair and network life are verified. Finally, the paper studies the application of big data technology in the wireless monitoring system of building structure durability [4]. By classifying the big data types of building structure durability, the paper designs the big data model of building structure durability, and realizes the visual analysis of building structure durability data and the storage and management of durability visual data by using tableau big data analysis tool

2. Durability Designer of Building Structure

2.1. Non destructive testing of building structure

Reinforced concrete structure is one of the common structural forms in building structure. In general, the deterioration of reinforced concrete structure is relatively slow, but the building structure is generally under the action of severe extreme environment or special external force for a long time, which will accelerate the deterioration of the building structure and then produce structural damage, resulting in the degradation of the building structure performance. According to the research at home and abroad, the main non detection technology of the existing building concrete structure is shown in the table.

Table 1. Main NDT contents of building concrete structure

Test Method	Principle	Detection Objects	Performance Overview
Optical inspection	Internal flaw detection of optical fiber endoscope	Internal damage of concrete, end of truss beam, protective layer of reinforcement Surface peeling, water leakage and crack	Image parsing
Infrared thermal image detection	Detection of surface cracks by thermal conductivity and temperature difference of clay	Compressive strength, surface homogeneity and wear characteristics	Affected by surrounding conditions, degree of temperature difference, specific heat rate difference between damaged and undamaged parts
Rebound strength test	Evaluation of concrete performance by rebound degree of impact hammer	Crack detection, deterioration monitoring and loading times in continuous loading	Measure the degree of four convexities on the surface, dry and wet conditions, thickness of components, age of mud concrete
Elastic wave inspection	Inspection lake of elastic wave generated by small tracing	Reinforcement condition, thickness of protective layer and change of reinforcement diameter	Affected by noise, receiver sensitivity and analytical accuracy
Electromagnetic testing	Electromagnetic sentimentality of alternating current electromagnetic field on steel bars	Member thickness, internal void	Non contact detection can meet the requirements of 10cm flaw detection on the surface of clay
Impact echo detection	Analysis of transmission time, velocity and reflection wave of ultrasonic wave	Uniformity of structure and components	Affected by impact rebound and structure size
Ultrasonic testing	Evaluation of realization of contrast reflection wave	Concrete quality change, internal void, crack depth	Non contact detection, 3-5cm depth
GPR Detection	Fluoroscopy	Thickness of mud and concrete at the position of internal void and reinforcement	As above, the maximum depth of crack and steel is 20cm
X-ray examination	Measurement of impedance changes due to corrosion of reinforcement	Reinforcement condition, reinforcement diameter, thickness of protective layer, PC reinforcement protective layer, location of embedded components	According to the projection image, identify the internal void of steel and concrete
Electrochemistry	-	Corrosion of reinforcement and damage of protective layer	Affected by water content in concrete, ambient temperature and electrode conditions

Similar to the concrete structure of buildings, the steel structure of buildings also needs to carry out routine inspection and detailed inspection under special circumstances [5]. According to the inspection plan of relevant management specifications, the steel structure of buildings should be effectively managed and maintained [6]. In the current detection methods of building steel structure, the detection methods corresponding to the main detection contents are shown in the table.

Table 2. Inspection method of building steel structure

Detection objects	Detailed inspection
Abnormal disturbance, noise, vibration	Level measurement
Deterioration of coating	Photography, salt detection and image processing
Corrosion	Ultrasonic plate thickness detection and stress detection
Crack	Ultrasonic flaw detection and stress detection
Bolt shedding	Bolt calibration point inspection,
Deformation and buckling	Laser ranging, image processing
Water leakage and ponding	ultrasonic flaw detection stress detection (bearing capacity evaluation)
Displacement and dislocation	noise detection and vibration detection

Although the nondestructive testing of building structures can provide more intuitive and reliable structural damage information than the traditional manual testing, and the existing hand-held instruments and equipment are easy to operate and mature in technology, they have been applied to the daily testing of various small and medium-sized building structures, as well as the local testing and accurate inspection of large structures [7]. However, due to the wide variety and different performance of the current detection technology of building structures, if the detection mechanism cannot be fully understood, it is difficult to ensure the validity of the structure detection data, which is easy to cause misjudgment [8]. The wireless monitoring system for the durability of building structure is to monitor the environmental parameters and the structural parameters of the building by using the sensing technology and the communication technology [9]. The structural monitoring reflects the service status, stress status, damage and other information of the building under the influence of various factors. It can provide information for the preliminary design of the new building and the diagnosis, evaluation and later maintenance and reinforcement of the durability of the existing building [10]. Data reference. It is of great significance to study the subject of building structure for the safe operation of building, to avoid accidents such as personal safety caused by the damage of building structure, to reduce the maintenance and reinforcement costs in the later period. The main parameters for the durability monitoring of building structure include the monitoring of physical structure stress parameters, the monitoring of damage state of building structure components (such as the development of structural cracks), and the influencing factors of building service environment on the durability of building structure (such as building) under the limit conditions (such as casting, smelting, sintering, beneficiation and other production environments, under the multiple effects of heavy load, high temperature and corrosion) [11]. Monitoring of temperature, humidity and other parameters of the environment where the building is located.

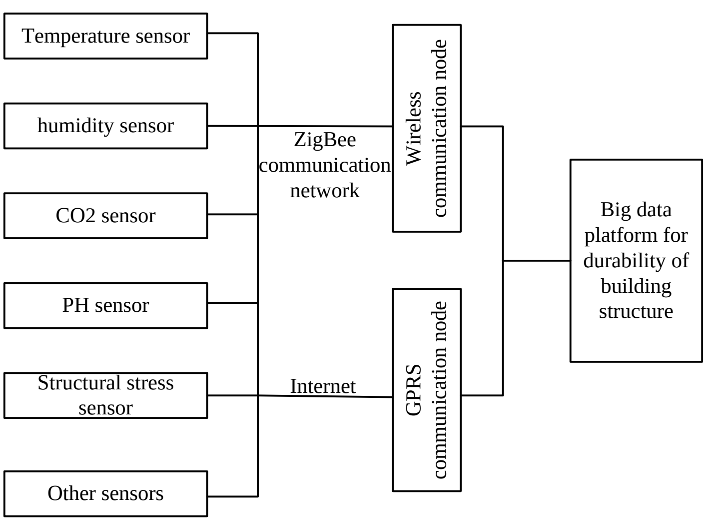

Figure 1. Wireless monitoring framework for durability of building structure

The basic process of wireless monitoring of building structure durability is to first monitor the service status of the building in various external environments through relevant sensors, and then transmit the collected data of building structure durability to the management server and big data platform through wireless sensor network, and then analyze the collected parameter data combined with the corresponding building structure model to analyze the building structure Intelligent diagnosis is made for the damage condition (specific location and degree of damage) of structure durability[12]. Finally, the service reliability, structure durability and force of the building are analyzed through the diagnosis results, so as to achieve the purpose of building structure durability monitoring [13]. Therefore, the building structure monitoring system can be roughly divided into three parts, wireless sensor monitoring part, wireless communication part and building structure durability analysis and evaluation system.

2.2. Optimization of wireless monitoring steps for durability of building structures

The temperature, humidity and CO: gas concentration data collected by the wireless monitoring system for durability of building structure reach the aggregation node through Zig Bee transmission module. The aggregation node needs to convert the transmission mode of the collected data from Zig Bee transmission to remote GPRS transmission to realize remote web access and data storage. For the monitoring and short-range transmission of temperature, humidity and gas concentration in the building environment, it is necessary to design necessary software for Zig Bee wireless monitoring node to achieve the stability of monitoring data transmission. When using the temperature, humidity and gas concentration sensors of the wireless monitoring system for the durability of building structures, it is necessary to design drivers for various sensors according to the sensor manual [14]. When using the temperature sensor, it needs to go through the process of power on initialization, reading and writing. Unlike the program flow of the temperature sensor, the HM1500 humidity sensor needs to conduct D/A conversion for the collected data in the process of collecting the relative humidity of the environment. The program flow of the HM1500 sensor is shown in the figure.

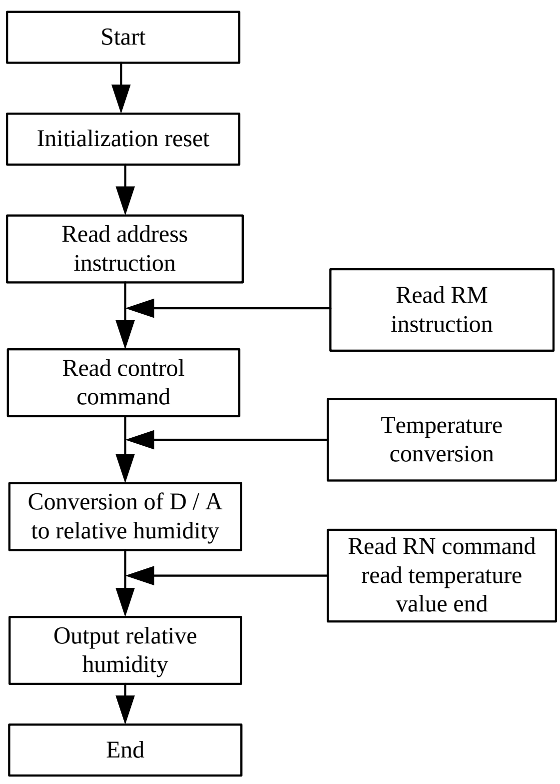

Figure 2. Operation flow of HM1500 sensor

The Zig Bee monitoring node in the wireless monitoring system of building structure durability realizes the monitoring of the durability data of the bottom structure of the whole system. The stm32f030f4p6 microprocessor is mainly used to collect the temperature, humidity and CO2 concentration data of the building site, and through zig The bee module transmits the collected data to the convergence node [15]. When the temperature and humidity of the building structure durability wireless monitoring system and the data collected by the CO2 gas sensor are transmitted to the convergence node through the Zig Bee module, the network design of the coordinator needs to be carried out. The network design of the coordinator mainly includes the initialization settings of hardware configuration, protocol stack, external interface and network configuration. After completing the above initialization settings, the coordinator will keep the network monitoring waiting state. When receiving the network access request from Zig Bee monitoring node, the coordinator will perform network address allocation and update neighbor node information and other operations for this node.

After completing the network of Zig Bee monitoring node, the wireless transmission of temperature, humidity and CO2 gas concentration data of Zig Bee monitoring node to the aggregation node is realized. The GPRS module of the wireless monitoring system of building structure durability designed in this paper is sim900a module, and the at command set provided by it can be used to realize the TCP / IP protocol transmission of structure durability monitoring data. Ieee802.15.4/zig bee protocol is used for short distance communication of data collected by wireless sensor network for durability of building structure, while TC P / IP protocol is used for communication between convergence node and Internet network. In the convergence node of wireless monitoring system for durability of building structure, the gateway communicates data with sensor node through Zig Bee protocol downward, and connects telecommunication network and upper management platform through 2G / 3G, DSL and other access methods upward. Therefore, after receiving the structural durability data sent by Zig Bee module, the aggregation node should convert the data into protocol and repack it, and then transfer the converted structural durability data to the management platform through the Internet. In addition to receiving the data uploaded by the sensor network, the gateway should also be able to carry out some management and control functions for the sensor nodes; for example, the gateway receives the application command and issues the command to the sensor nodes after processing (protocol conversion, etc.), so as to realize the management and control of the platform above the gateway for the lower layer of the sensor network through the gateway. The flow chart of the aggregation node is shown in the figure.

According to the monitoring node test of wireless monitoring system for durability of building structure, the temperature and humidity sensor, stm32f030f4p6 module and MAX7219 digital tube display module are used to realize the real-time collection and display of temperature and humidity. During the temperature and humidity monitoring and testing, the I / O port of stm32f030f4p6 module needs to be configured first, and the MAX7219 digital tube display module can realize the real-time display of the monitored temperature and humidity. MAX7219 is an integrated I / O serial common cathode display driver. It connects the microprocessor and 8-digit 7-segment digital LED display. It can also connect the bar graph display or 64 independent LEDs. It includes a B-type BCD encoder, multi-channel scanning circuit, segment driver, and an 8 * 8 static RAM for storing each data. At the same time, it has limitations The section drive of slewing current to reduce electromagnetic interference is as follows: MAX7219 and stm32f030f4p6 are connected. The change of structural resistance with time is a very complex irreversible process. The influence factors of structural resistance can be roughly divided into three aspects, i.e. load action a, environmental action B and action C in structural materials. For reinforced concrete structure, the structure is composed of two materials: concrete and reinforcement. Therefore, the material performance of reinforced concrete structure should consider two aspects: concrete and reinforcement. Through investigation and analysis, the statistical parameters of concrete strength and reinforcement section area or reinforcement strength change with time. The random process of structural resistance is expressed as

$$L=\sum\sum\lim_{x\to\infty}\frac{\log 4\pi R(t)}{(\mathrm{a+b+c})\ \mathrm{t+1}} \tag{1}$$

Where R (T) is the structural resistance of structural members at time t. If K (n) is a deterministic function, the random process model is designed, and the randomness of the resistance at the time of M is assumed to depend on the randomness of the resistance at the time of M = 0. The distribution of the structural resistance R (m) is almost the same at the time of M. if the corresponding average value is Z, the coefficient of variation is:

$$\Delta\mathrm{u}=\begin{cases}\prod\sin\frac{\sqrt{3}}{2}\pi La[R(\mathrm{m})-\mathrm{R(t)}]^{m+t}/z\\ \bigcup\cos\frac{1}{2}\pi Lb[k(n)-1]/z\\ \iiint\lim_{1\to\infty}2\pi\mathrm{Lc(m+t-1)/z}\end{cases} \tag{2}$$

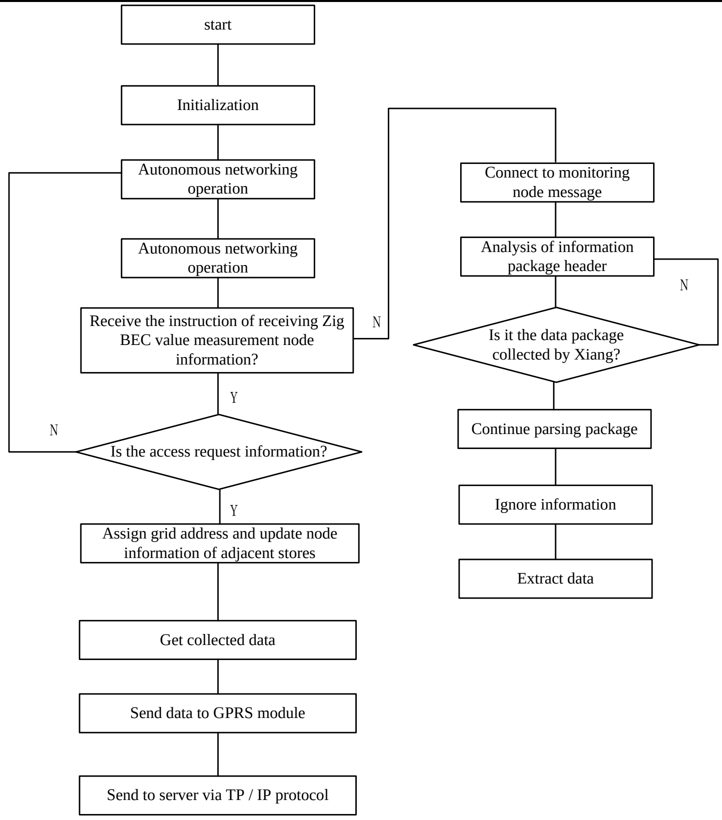

Figure 3. Inspection procedure of building structure convergence node

With the increase of the design reference period, the decrease of the reliability index of the beam is smaller. At this time, the decrease of the reliability index is due to the increase of the design reference period and the higher probability of the occurrence of the variable load in the design reference period. When considering the decrease of beam resistance with time, the decrease of reliability index is larger with the increase of design reference period. In this case, there are two reasons for the reduction of the reliability index of the beam: one is the increase of the design reference period, the probability of the occurrence of high variable load increases, and the other is that the reduction of the resistance reduces the resistance of the beam to the load. When the structure is used for a certain time, the reduction of beam resistance will control the change of reliability index.

2.3. Durability test of building structure

The management of building structure durability data runs through all aspects of wireless monitoring network design. From the design of structure durability monitoring node to the realization of wireless monitoring network layer routing protocol and application layer structure durability data processing, in these stages, it is necessary to closely integrate the building structure durability data management and wireless monitoring network to further achieve an efficient Stable wireless monitoring system for durability of building structure. The basic idea of wireless monitoring network centered on the durability data of building structure is to use the durability sensor as the sensing data source of the wireless monitoring system of building structure durability, use the wireless monitoring network of structure durability as the sensing data space, and take the durability data management of building structure as the application target of the wireless monitoring network. Data management mainly includes the acquisition, storage, query, mining and operation of perceptual data. The purpose is to separate the logical view of data on the sensor network from the physical realization of the network, so that users and applications only need to care about the logical structure of the query, and do not need to care about the details of the implementation of the sensor network. The application type of the durability data of the building structure is shown in the figure.

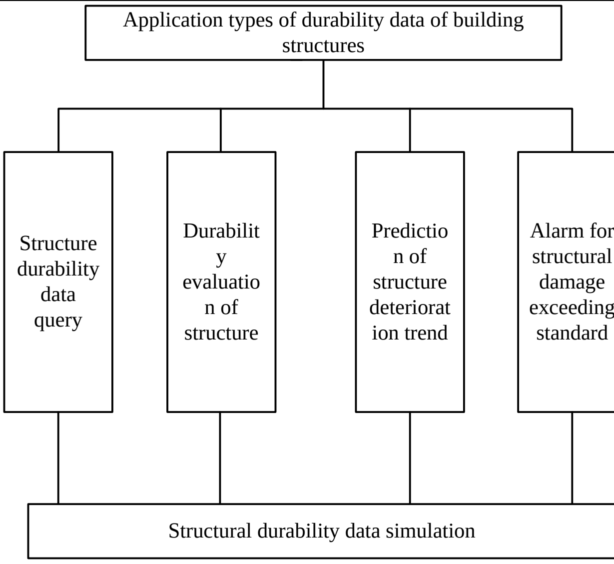

Figure 4. Application types of durability data for building structures

In order to study the change rule of the failure probability of the beam with time in the whole life of the structure, the risk rate of the beam is studied below. The risk rate of structure is defined as the conditional probability that the structure can work well until I time, but fails in the following D (I) time period. If h (I) is used to represent the risk rate of structure at h time, then the numerical algorithm for determining the classification standard can be expressed as:

$$\Delta\lambda(A,B)=\sum\lim_{x\to\infty}\frac{\sqrt{3}}{2}\pi L/\Delta u[h(i)+d(i)] \quad (3)$$

Among them, determine the measurement data category matrix as follows:

$$A=\begin{bmatrix}0,1,1,0,0,1,1,0\\1,0,0,1,1,0,0,1\\0,0,1,1,0,0,1,1\\1,1,0,1,1,1,0,1\end{bmatrix} \quad (4)$$

$$B=\begin{bmatrix}0.054, & 0.065, & 0.032, & 0.083\\0.061, & 0.051, & 0.051, & 0.067\\0.064, & 0.045, & 0.061, & 0.082\\0.061, & 0.053, & 0.072, & 0.090\end{bmatrix} \quad (5)$$

The wireless monitoring network for durability of building structure adopts mesh network topology structure, which is a new type of wireless sensor network structure. Compared with the traditional wireless network structure (plane network structure, hierarchical network structure, hybrid network structure), mesh network structure has some structural and technical differences. By using the wireless mesh network structure and wireless sensor network topology control technology, the wireless monitoring node of building structure durability can be forwarded by multi hops, accessed to the wireless monitoring network of structure durability through the monitoring base station (or convergence node, gateway), screened and processed the collected structure durability information at the task management node of the monitoring network, and finally collected the building The structural durability parameter information is transmitted to the data management system. The structure of wireless monitoring network for durability of building structure is shown in the figure.

The adaptive distributed disjoint multi-path topology control algorithm selected for wireless monitoring network of building structure durability is an adaptive distributed fault-tolerant topology control algorithm. The goal of adpv algorithm is to establish a topology structure of k-vertex convergence node connection to extend the life of wireless sensor network of building structure durability. The adpv algorithm controls the structure durability wireless monitoring network topology by dynamically adjusting the transmission range of the structure durability sensor nodes, and considers the failure factors of the structure durability nodes. The adpv algorithm only needs one hop information of neighboring sensor nodes, and constructs the architecture durability wireless monitoring network topology structure through message exchange. So as to realize the detection and analysis of the durability of the building structure.

3. Analysis of Experimental Results

In order to verify the practical application effect of the durability design method of building structure based on BIM Technology, the traditional method is compared and tested.

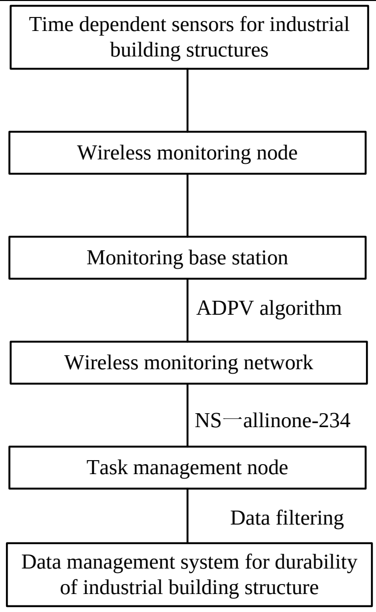

Figure 5. Wireless monitoring steps for durability of building structure

3.1. Experimental environment

In the simulation experiment, the disjoint path algorithm of adpv algorithm is selected for comparison, and the total information transmission, fault tolerance and network life of wireless monitoring network are compared and analyzed, and the number of node connection repair of wireless monitoring network using adpv algorithm is analyzed. Therefore, it is necessary to carry out the network simulation experiment and adopt two algorithms for wireless monitoring The result of the simulation experiment. The number of network information transmission of wireless monitoring network in the application of the two algorithms can be seen from the two groups of figures. The number of information transmission of adpv algorithm in the application of wireless monitoring network is more than that of non intersecting path algorithm; In the application of the two algorithms, the number of wireless monitoring network information transmission will increase with the increase of the number of sensor nodes, and decrease with the increase of durability.

3.2. Experimental result

Based on the above environment, the durability test results of the traditional method and the method in this paper are compared and recorded as follows。

3.3. Empirical conclusion

Comparison of durability between laboratory accelerated test and real environment. Understanding the durability of materials is the basic premise of studying the durability of reinforced concrete structures. At present, our country has issued the standard of durability test of structural materials, such as "test method of long-term performance and durability of ordinary concrete, the standard test method has made strict regulations on the temperature, humidity and other conditions in the test, which is undoubtedly beneficial to the study of the mechanism of corrosion resistance and aging resistance of materials, as well as the comparison of durability of different materials. However, there are great differences between the actual environment and the standard experiment in the laboratory. For example, the temperature and humidity in the natural environment are changing all the time, with its regularity and unpredictable randomness. The random changes of the environmental conditions lead to the great differences between the durability of the concrete structure in the actual environment and the laboratory test results. How to consider this kind of change in durability analysis and design of structure is worthy of further study.

In the natural environment and service environment, due to the corrosion of corrosive medium and the aging of materials, the performance of the structure is constantly deteriorating. The result is that the service life of the structure is shortened. The life assessment of structures is a probability problem. At present, there are many researches on the prediction of the service life of structures, but these researches either infer the future state of structures only according to the current state of structures, without considering the change of structure performance with time, or infer the service life of structures according to the assumed degradation law of structure performance. In fact, the attenuation law of structural performance with time is extremely complex. Due to the influence of material manufacturing, construction, maintenance and other factors, the performance of different structures in the same region, even different parts of the same structure, varies greatly with time. Therefore, the evaluation of the service life of the structure should be based on the change rule of the performance of the structure or the component itself with time. However, how to reveal the change rule of the structure performance with time according to a small number of test data is a difficult subject, which needs to be studied in depth, which will involve the imperfection of information.

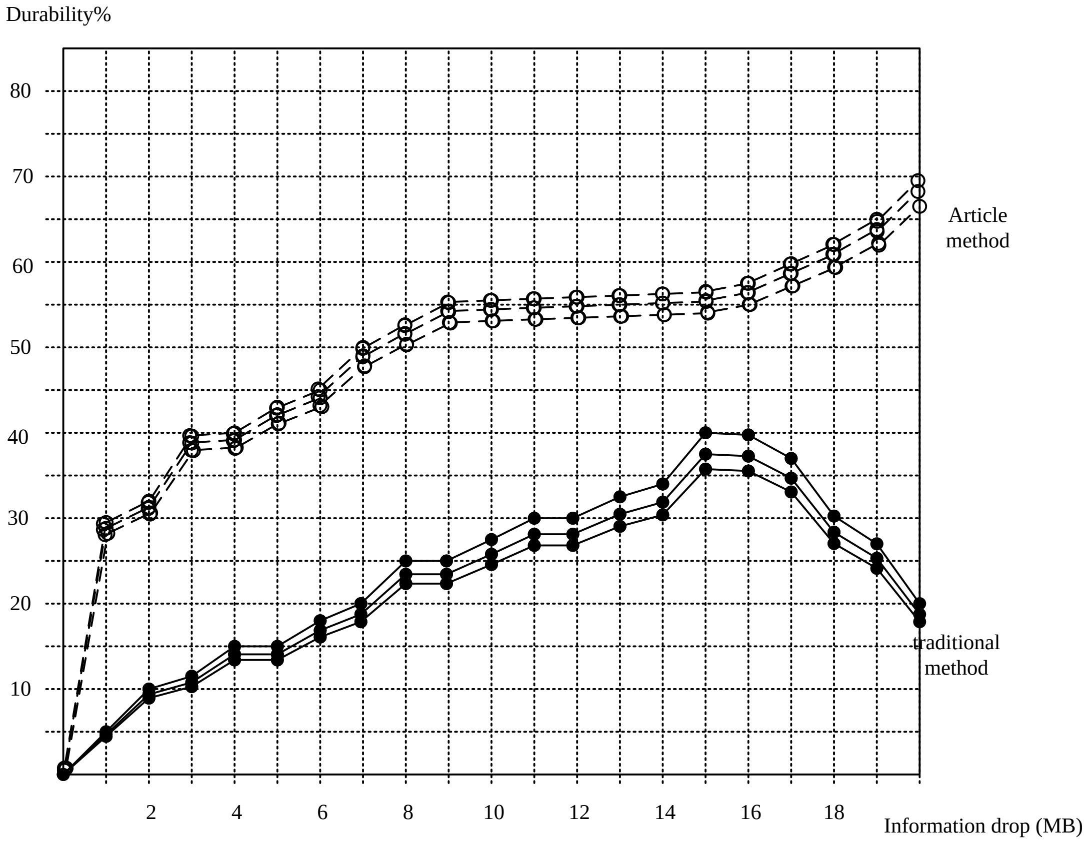

Figure 6. Comparison test results

In the corrosion environment, the influence of steel corrosion on the fatigue performance of reinforced concrete structure is more serious than that on the static performance. This is because the corrosion not only weakens the effective section of steel, but also causes the stress concentration of steel. This paper has put forward the analysis method of fatigue reliability of reinforced concrete structure in corrosive environment, but it still needs the influence of corrosion on the fatigue performance of reinforcement, as well as the experimental or measured data of the fatigue performance of reinforcement changing with time under different environment and different concrete material characteristics. At present, there are not many researches in this field, which need to be strengthened. It can be imagined that whether from the experimental method or from the experimental process, the structural fatigue experiment is more complex than the static experiment, so it is more difficult. The insufficient durability of reinforced concrete structure not only affects its safety, but also reduces its applicability. Many structures need to be repaired and strengthened not only because of safety problems, but also because of the large deformation and wide crack of the structure, as well as air leakage and water seepage. At present, most of the research focuses on the impact of durability on the safety of the structure.

4. Concluding Remarks

The damage to the durability of the building structure will not only shorten the service life of the building, but also cause serious personal safety threats to the site staff. Although the construction of large-scale construction facilities in China is relatively late, the maintenance and management costs in the later period are huge and rapidly increasing year by year, which also brings great losses to the national economy. Due to the special use of the building and its bad service environment, the daily inspection of the building structure will consume a lot of human and financial resources, and the operation and maintenance of the building structure cannot achieve the ideal effect only by manual inspection. Therefore, in view of the durability of the building structure, the corresponding wireless monitoring system and big data platform are designed and developed to monitor the durability parameters of the building structure in real time, to ensure the personal safety of the on-site staff, to provide theoretical basis for the intelligent diagnosis and reliability research and evaluation of the building structure, and to effectively utilize and sustain the social resources Development is of great significance to reduce the loss caused by durability damage of building structures.

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