Internet of Things Health Detection System in Steel Structure Construction Management

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Abstract
In recent years, the development of computer network technology, especially the hot Internet of things, has brought great convenience and comfort to people’s life. Steel structure is also more and more widely used in the field of construction in China. The purpose of this study is to explore the application of Internet of things health monitoring system in steel structure construction management. In this study, through the use of example analysis, comprehensive data analysis and other methods, combined with steel structure health monitoring system and construction process management analysis. The results show that the relative deviation of the data within 1-33 is mostly less than 10\%, but the relative deviation of 34-40 suddenly increases to 60\%, and the actual data suddenly decreases, resulting in the deviation of about 50\%. It is concluded that the time series model established in this study can objectively reflect the change trend and law of strain data, has certain prediction accuracy, and has certain value significance for monitoring data analysis and construction management of steel building structures.

Index Terms
Internet of Things Technology, health monitoring system, steel structure, construction management.

I. INTRODUCTION
With the active development of social economy, the application of steel structure in the field of construction in China is more and more extensive. In China, more and more buildings, such as production plants and residential commercial houses, have gradually changed from traditional concrete buildings to reinforced buildings, and the construction technology in China has also begun a huge innovation. However, most of the existing research is about the qualitative description of the concept and theory of steel structure engineering quality management. Because the research of feedforward signal of safety hazard in steel structure construction has not been paid attention to, the accuracy of risk prediction is far from the requirement of real-time prediction.

As a kind of material with excellent performance, steel has become one of the most important building materials in the construction field because of its simple manufacturing, convenient use, excellent performance and other excellent characteristics, and is widely used. Therefore, the construction of reinforced structure has gradually replaced the traditional reinforced concrete as the main support structure of the construction site, changed the traditional operation of the concrete production trouble project, greatly shortened the production cycle of the project operation. Steel structure has a long history in the field of construction, is widely used, has a wide range of development prospects, marking the modernization of China’s construction industry.

Valinejadshoubi believes that modular or off-site building units are gaining momentum. Therefore, it is very important for him to use SHM technology to monitor the vibration, strain and deformation of the module. The main purpose of his research is to explore building information model (BIM) technology to promote effective data management and the performance of sensing elements in SHM system, and to present or visualize the damage or destruction of building
elements according to the interpretation of sensing element data. His framework is composed of two main modules: (1) automatic data acquisition and storage module based on sensors, extracting sensor data from the corresponding relational database; (2) data and damage visualization module. Although such construction methods have advantages in cost competitiveness and delivery time, they have many problems related to structural integrity and secondary stress caused by vibration during transportation and dislocation during installation [1]. Zhou believes that steel and reinforced concrete are one of the most commonly used structural materials in the construction industry. In the selection of building structure system, cost and construction speed are usually the main standards, so the environmental impact of structural materials is sometimes ignored. Providing an easy-to-use tool for environmental assessment of structural alternatives encourages such assessment in the decision-making process. He studied and introduced an automatic tool for environmental assessment in the field construction process of building structure system. The tool compares the energy consumption and carbon emission of building structure system as parameters. Design / method / method - this assessment tool is implemented using the building information modeling (BIM) platform to extract structural elements and their key attributes, such as type, geometry, and location data. These data are processed together with the productivity database to calculate the working hours of the machine, and then use the predefined energy and carbon inventory to evaluate the energy consumption of the structure, which still has many shortcomings [2].

This study is mainly about the application of Internet of Things health monitoring system in steel structure construction management. First, this study introduces the three quality management of steel structure engineering and its technical characteristics. The safety evaluation method equation of reliability analysis in steel structure construction is used to explain. This study also focuses on the process and content of health monitoring system. It also analyzes the significance of steel structure health inspection, quality management elements, evaluation indexes and construction monitoring scheme. So as to verify the performance of the detection system in this study. It provides effective value and practical significance for the construction and management of large-scale sites and buildings.

II. INTERNET OF THINGS HEALTH INSPECTION AND STEEL STRUCTURE CONSTRUCTION MANAGEMENT

A. THREE QUALITY MANAGEMENT OF STEEL STRUCTURE ENGINEERING

1) TOTAL QUALITY CONTROL

Integrated quality management is the overall management of product and work quality. For steel structure engineering, the comprehensive quality management includes the overall management of product and work quality of four structural engineering organizations. The owner, the general contract for investigation and design and construction, the contractor, the supplier of materials and equipment, the supervisor, etc., either party is generally at fault or has no linked quality responsibility. Affect the quality of steel structure process [3], [4].

2) WHOLE PROCESS QUALITY CONTROL

The quality management of the whole process starts from the source and advances the whole process according to the formation rules of quality. According to the construction procedure, the steel structure project is proposed by the project proposal [5]. After multiple links, it constitutes the whole process of building steel structure project. There are many related activities in the specific process of each link. Therefore, in order to carry out the quality management of the whole process, the process method must be applied [6], [7].

3) TOTAL QUALITY CONTROL

Full participation in management means that all employees participate in system activities, implement quality policy and play a role in quality function. According to the theory of objective management, it is necessary to decompose the whole objective into the lowest level. From individual to department team, in order to form the bottom, control and guarantee the relationship between layers [8].

B. TECHNICAL CHARACTERISTICS OF STEEL STRUCTURE ENGINEERING

1) ADVANTAGES OF STEEL STRUCTURE ENGINEERING

1) Light weight of steel structure: compared with other building materials, steel structure has larger capacity and weight, but it is much higher in strength. Under the condition of bearing the same load, steel structure is more light. The concrete performance is that the dead load is light and the section of the component is small.

2) Good prefabrication and universality of steel structure: due to the characteristics of steel itself, it can carry out large-scale industrial production; at the same time, the modulus of steel structure building can be “coordinated and unified”, which makes different materials, shapes and even different manufacturing methods of building steel components interchangeable or universal.
3) Steel has a very high plasticity and toughness: steel has a very strong elongation and plasticity due to its own advantages, so that it will not break due to the emergence of sudden force. At the same time, due to the good toughness of steel, it has a stronger bearing capacity for the movement force, so the use of steel structure provides sufficient security for industrial buildings.

4) Steel structure building can meet the requirements of super high and long span: steel can be made into a building with more flexible span due to its own properties, which can greatly reduce the building area of walls, beams and other traditional structures, thus increasing the unit use area of steel structure building. According to statistics, the capacity of steel structure with the same area is 25% more than that of concrete structure. In fact, it increases the use value of steel structure engineering, reduces the production cost and improves the economic benefits of engineering [9], [10].

2) DISADVANTAGES OF STEEL STRUCTURE ENGINEERING
1) Small rigidity of structural components: in steel structure engineering, the cross-section size of components made of light and high-strength steel is small, compared with concrete components, its slenderess ratio is large, the rigidity of lateral bending resistance and torque are smaller than concrete components, and the overall stability is easy to lose. However, the large ratio of width to thickness is easy to lose its local stability. So in the design and calculation of steel structure, these are easy to occur problems.

2) Poor fire resistance of steel structure: the performance of steel is changing with the change of temperature. When the temperature of heated steel exceeds 200 °C, the hardness and toughness of steel will be greatly reduced. When the temperature exceeds 600 °C, the steel will lose its original high bearing capacity [11].

3) Poor corrosion resistance of steel structure: when the steel structure is in a humid environment, the steel is extremely vulnerable to corrosion. When the corrosion reaches a certain extent, the steel will lose its original bearing capacity. The low temperature performance of steel is poor, and the members are prone to brittle fracture [12], [13].

C. SAFETY ASSESSMENT METHOD OF RELIABILITY ANALYSIS IN STEEL STRUCTURE CONSTRUCTION
1) STRUCTURAL RELIABILITY AND FAILURE PROBABILITY
The reliability of steel structure refers to the probability of completing the predetermined function of the structure in the specified time and under the specified conditions, which is the probability scale of the reliability of the structure. If a specific part or whole of the structure exceeds a specific state, the structure will have a specific functional requirement that does not meet the requirements, that is, the boundary state of the structure. The corresponding limit state is the benchmark for measuring the completion of various functional indicators of the structure and judging whether the structure is reliable [14], [15].

The n probability variables affecting the structure function are X1,X2,...Xn. When using the function function to define the limit state of the structure, the structure function is as follows:

\[ Z = g(X_1, X_2, \ldots, X_n) \]  (1)

X1,X2,...Xn represent the geometric dimensions, external effects and material parameters of the component. In the case of Z > 0, the structure is still safe and the specified function is not affected. Z < 0 indicates that the function specified by the structure is missing. Z = 0 indicates that the structure is already in a restricted state [16]. Similarly, the limit state equation is constructed as follows:

\[ Z = g(X_1, X_2, \ldots, X_n) = 0 \]  (2)

If the function of the structure is known, then the joint probability density function of the basic random variable can be multidimensional integrated to obtain the failure probability Pf:

\[ P_f = \int_{Z<0} \cdots \int f_X(x_1, x_2, \ldots, x_n) dx_1 dx_2 \ldots dx_n \]  (3)

The solution formula of structural reliability Pr corresponding to failure probability Pf is as follows:

\[ P_r = \int_{Z>0} \cdots \int f_X(x_1, x_2, \ldots, x_n) dx_1 dx_2 \ldots dx_n \]  (4)

According to the above formula, reliability and failure probability have the following relationship:

\[ P_r + P_f = 1 \]  (5)

2) STRUCTURAL RELIABILITY AND RELIABILITY INDEX
Taking the limit state equation of two normal variables R and s as an example, the normal distribution variable Z ~ N(mz, σz) is transformed into the standard normal distribution Y ~ N(0, 1). Therefore, the failure probability is expressed as:

\[ R_f = \frac{1}{2\pi} \int_{-\infty}^{-m_z/\sigma_z} \exp(-\frac{y^2}{2}) dy = \phi(-m_z/\sigma_z) \]  (6)

\[ m_z = m_R - m_S, \quad \sigma_z = \sqrt{\sigma_R^2 + \sigma_S^2} \]  (7)

Reliability index \( \beta \), formula:

\[ \beta = \frac{m_z}{\sigma_z} = \frac{m_R - m_S}{\sqrt{\sigma_R^2 + \sigma_S^2}} \]  (8)

\[ P_f = \phi(-\beta) \]  (9)

Based on the above calculation formula, it can be concluded that \( \beta \) corresponds to the reliability of the structure one by one and is inversely proportional. In modern engineering, the reliability index \( \beta \) is more used to reflect the reliability of structure.
3) CALCULATION OF STRUCTURAL RELIABILITY

The first-order second moment method is used to expand the function function in Taylor series at a certain point, and approximately take the first-order polynomial to linearize the function. Then calculate the reliability index.

Taylor expansion is performed at \(X_{oi}(I = 1, 2, \ldots, n)\) to obtain:

\[
Z = g(X_{o1}, X_{o2}, \ldots, X_{on}) + \sum_{i=1}^{n} (X_i - X_{oi}) \frac{\partial g}{\partial X_i} \bigg|_{X_o} x_o + \sum_{i=1}^{n} \frac{(X_i - X_{oi})^2}{2} \frac{\partial^2 g}{\partial X_i^2} x_o + \cdots (10)
\]

The linear limit state equation is obtained by taking only one term of the above equation:

\[
Z \approx g(X_{o1}, X_{o2}, \ldots, X_{on}) + \sum_{i=1}^{n} (X_i - X_{oi}) \frac{\partial g}{\partial X_i} \bigg|_{X_o} x_o (12)
\]

Then the mean value of \(Z\) is:

\[
m_Z = g(X_{1*}, X_{2*}, \ldots, X_{n*}) + \sum_{i=1}^{n} (m_{X_i} - X_{i*}) \frac{\partial g}{\partial X_i} \bigg|_{X_o} x_o (13)
\]

D. CHARACTERISTICS OF STEEL STRUCTURE HEALTH MONITORING

The soundness monitoring of steel structure is based on the main performance indexes (reliability, durability, etc.) of the structure, combined with non-destructive test and structural characteristic analysis (including structural response), in order to diagnose the structure, the data obtained from the action state of the structure are processed to determine the damage degree and the impact on the structural damage in the case of damage. By monitoring and evaluating the state of steel structure, early warning signals of buildings can be triggered under special climate, traffic conditions or severe operation conditions of buildings, providing basis and guidance for maintenance, repair and management decisions of buildings [17].

The steel structure system is complex, and there are many factors that affect the deformation. The basic characteristics of its monitoring are as follows:

1) From the point of view of deformation characteristics, steel structure buildings are mostly composed of accumulated deformation and sudden deformation, which requires comprehensive use of static monitoring and dynamic monitoring.

2) According to the monitoring content, the steel structure needs to monitor the direction vector information (displacement, axial force, stress, strain, etc.) and non direction scalar information (height, carbonation depth, etc.) [18].

3) From the beginning of the monitoring period, the monitoring period of the steel structure building is long. According to the selection of the observation frequency, the instrument is adjusted according to the progress of the monitoring. The design of the alarm level needs to correspond to the times.

4) From the point of view of monitoring accuracy, steel structure has various requirements for monitoring accuracy in different periods. In the construction process, due to the large stress adjustment deformation, the accuracy requirements will be slightly lower. The change of displacement in the action is usually small, but the corresponding observation accuracy requirements become higher [19], [20].

E. CONTENTS OF HEALTH MONITORING FOR STEEL STRUCTURE BUILDINGS

1) CONTENTS OF HEALTH MONITORING IN THE PROJECT

In the construction stage, the steel structure buildings do not meet the national design requirements, and will be subject to deformation or stress due to the influence of building load or natural environment factors. The state meets the design requirements and requires health monitoring during the construction phase. The main contents of monitoring are as follows [21], [22].

1) Geometry detection. This is mainly to obtain the actual geometric parameters (altitude, span, structure or cable shape, structural deformation and displacement, etc.) of the complete building structure.

2) Steel structure section stress monitoring. This is the most important safety monitoring content in the bridge construction stage, including the monitoring of concrete stress, reinforcement stress and reinforcement structure stress [23], [24].

3) Monitor cable forces. The cable force of the cable-stayed bridge, the main cable of the suspension bridge and the suspension bridge of the suspension bridge are important parameters for design and the main content of safety monitoring of steel frame construction [25].

4) Pressure monitoring. It mainly monitors the real tension of pressure, pressure loss, pressure and permanent pressure value [26].

5) Temperature monitoring. The temperature effect of long-span reinforced buildings is very obvious. The expansion and contraction of the branch cable of the inclined building after the temperature change directly affects the height of the main beam. The shape of the main cable of the suspension bridge type building also changes with the temperature. Temperature monitoring is required.

6) Monitor the substructure. In large buildings, the distribution of structural foundation is concentrated, and the load concentration is usually very large, so it is necessary to monitor the internal and external deformation of the foundation, the anchoring stress and the axial force of the main tower pile foundation.
2) CONTENTS OF HEALTH MONITORING IN OPERATION AND MAINTENANCE STAGE

1) Load monitoring. Wind, earthquake, temperature, traffic load, sound load, etc.

2) Surface morphology monitoring. Monitor the static position, dynamic position, settlement, inclination, linear change, displacement, crack, point, pit, etc. of each part of the iron structure of the bridge.

3) Intensity monitoring. Monitor distortion, stress, cable force, dynamic response (frequency mode), torque, etc. of steel structure buildings.

4) Vibration monitoring. Monitor structural vibration, impact, mechanical admittance and modal parameters.

5) Non structural parts and auxiliary rotation. Monitoring support, damping equipment, etc.

III. FRAMEWORK DESIGN OF HEALTH MONITORING SYSTEM

Steel structure health monitoring system is divided into five layers: user access, application layer, data support, data service and platform foundation.

User visit is divided into field maintenance, system management, technical support, designer, implemener and enterprise cadre. This system can be accessed from PC desktop, mobile phone and other terminal hardware devices. The system can access services that meet the needs of users and provide users with various data.

The application layer is divided into system site, online and offline data system support and information feedback. It mainly provides application services for user access, customizes lightweight data interface, and effectively guarantees the stability and reliability of user access.

Data support is the core of the whole system, which can be roughly divided into data service support system, business work flow system, general data exchange system, data storage and analysis system, maintenance management system and user integrated management system. Data support mainly includes data service layer, effective separation and additional packaging and processing. The business work flow system specifies the working methods and management methods of monitoring system personnel, including the report and feedback of monitoring data. General data exchange system is to solve the problem of data processing in the upstream and downstream of the system. For example, the upstream data of hardware is mainly byte stream, which needs to be formatted due to the influence of network bandwidth and field environment factors., data format customization, data grouping splicing, etc. The downstream data must assemble the received operation instructions according to the actual situation, find the port mapped by the frontend hardware in the storage, and send it for processing in time.

Data service is real-time monitoring data, theoretical model data, system correction data, personal third-party intervention database. The real-time monitoring data is the original data collected by various sensors, including the validation of the data, but also need to be filtered and processed. The theoretical model data is the theoretical value based on the calculation and deduction of the bridge structure model. The core of monitoring system data analysis. In order to obtain a reliable structural integrity analysis report, it is necessary to compare the actual data collected with the theoretical data. Maintenance and operation. Their own databases and third-party databases can modify and evaluate the results through empirical data. At the same time, the design idea of data sharing will also be concrete.

The platform of the system mainly includes Internet, server storage, Linux server, J2EE / SQL / MySQL, etc. The basic design and architecture of the system does not include the development of copyright and patent barriers. At the same time, the use of open source system and programming framework helps to follow up the project, such as secondary development and version iteration.

IV. HEALTH MONITORING AND ANALYSIS OF STEEL BUILDINGS

A. SAFETY ACCIDENT ANALYSIS OF STEEL STRUCTURE BUILDINGS

The safety accidents of construction projects are mostly caused by various reasons: complex structure, uncertainty, accuracy and stability of monitoring equipment, cumulative loss of structure caused by long-term use, fire or earthquake in operation and use stage, etc. Figure 1 shows a collapse accident of a construction project.

An effective health monitoring platform can comprehensively grasp the various load and environmental factors of the building structure, as well as the structural reliability, durability, supporting force, safety margin and other structural performance, and make intelligent evaluation on the health and safety status of the structure.

B. ANALYSIS OF MODERN STEEL STRUCTURE

As shown in Table 1 is a comprehensive comparison of steel structure and concrete structure, it can be seen that the use and performance comparison of steel structure and concrete in construction.

With the deepening of comprehensive deepening reform, China’s economic and social development continues to be comprehensive and sound. Since China’s steel production increased by 11.35% in 2017, China’s annual steel production has exceeded 1 billion tons in three years. According to the data released by the data statistics center, China’s steel production reached 1122 million tons in 2018, ranking first in the world’s steel production. Mass production of iron and steel will not only bring flexibility to China’s economic and social development, but also bring development space to steel construction projects. Figure 2 is a statistical chart of China’s steel production and growth rate from 2017 to 2019.

As shown in Figure 2, at the beginning of the 20th century, with the development of new materials, new technology, new equipment and modern structural design theory, steel works
TABLE 1. Comprehensive comparison between steel structure and concrete structure.

| Project            | Steel structure | Reinforced concrete composite structure | Concrete structure |
|--------------------|----------------|----------------------------------------|-------------------|
| Dead weight        | 1              | 1.22                                   | 1.72              |
| Structural area    | 0.28           | 0.37                                   | 1                 |
| Construction period| 1              | 1.33                                   | 1.6               |
| Steel consumption  | 1.45           | 1.23                                   | 1                 |

FIGURE 2. Statistics of China’s steel production and growth rate from 2017 to 2019.

FIGURE 3. Significance of steel structure health inspection.

are small and medium-sized enterprises, businesses, communities, culture, education and healthy buildings. Up to the 1960s, the international developed countries have developed the structural form of steel structure and formed several main structural systems.

C. SIGNIFICANCE ANALYSIS OF STEEL STRUCTURE HEALTH INSPECTION

As shown in Figure 3, the significance of health inspection for steel structure buildings.

It can be seen from Figure 3 that real-time damage monitoring and state evaluation can be realized through the research and development of steel structure health monitoring. This is also very important for the verification and research and development of steel structure design. The dynamic and static responses obtained by the steel structure health monitoring system can be used to test theoretical models and calculation assumptions. At the same time, the steel structure health monitoring data information can further verify and improve the steel structure design method and corresponding code standards, and further improve the environmental load. The research and application of reasonable modeling steel structure monitoring system is very important for ensuring the safety and reliability of steel structure, prolonging the service life, scientific research and exploration.

D. ESTABLISHMENT OF QUALITY MANAGEMENT ELEMENTS AND EVALUATION INDEXES

According to the construction experience and evaluation requirements of the steel structure of the project, the quality elements and evaluation grades that affect the quality of the steel structure project are determined through analysis. See Table 2 for details.

1) SKILLS AND QUALITY OF CONSTRUCTION PERSONNEL

The index refers to the technical level and practical experience of the person in charge of steel engineering, which reflects the professional level of the whole team. This index is based on the proportion of people in the middle and above occupations. People with intermediate or above occupations have many years of construction experience and high technical level. These are the backbone forces in the construction of steel structure projects directly related to the formation of engineering quality relationship.

2) QUALITY OF STEEL

The quality of iron and steel products mainly includes the identification of the manufacturer and the inspection of materials. The specification and material of steel are the same, the product quality can meet the requirements of national standards, but different manufacturers, different quality, different ability to meet the use conditions. Material inspection mainly checks whether the inspection of material list and material review meet the requirements of quality documents. This indicator will be graded according to the expert evaluation data.

3) QUALITY OF WELDING MATERIALS AND OTHER AUXILIARY MATERIALS

Auxiliary materials mainly include welding materials, bolts, coatings and other materials. This index is an important factor affecting the quality of steel structure engineering, so it has
nothing to do with steel. Like steel, it directly affects the use and safety function of steel structure engineering. The evaluation of this index mainly depends on the adaptability of experts to review the relevant data of score ring.

4) GEOMETRY OF COMPONENT PROCESSING
According to the geometric dimension deviation inspection record and the quality approval of inspection lot, the expert inspection and scoring method is used to evaluate the processing quality of components.

5) STRUCTURE SETTING GEOMETRY
According to the geometric dimension deviation inspection record of steel structure setting and the quality acceptance of inspection lot, the expert evaluation and scoring method are used to evaluate the quality of steel structure setting.

6) STRUCTURAL CONNECTION QUALITY
The indicator includes two items: welding connection and high-strength bolt connection. In the evaluation process, the expert evaluation and scoring method are used to evaluate the inspection records of steel structures and the acceptance of inspection batch quality.

7) PERCEIVED QUALITY
After the completion of the project, through on-site inspection, the structural appearance, geometric characteristics, welding appearance, appearance of high-strength bolt connection joints, painting appearance of the steel structure project were evaluated and evaluated by experts.

E. CONSTRUCTION MONITORING PLAN
1) PURPOSE OF MONITORING
The main purpose is to provide the monitoring data of stress, distortion and displacement of each stage, main components and main nodes of the setting project based on the size of each monitoring value, and to compare and analyze the design requirements in real time to ensure the stress analysis of the components. Data for. Through early warning of possible dangers, information-based design and construction, to achieve the highest economic benefits.

   1) Always master the change information and working status of the support system and provide them in time.
   2) Analyze monitoring data in time and take accident prevention measures.
   3) Guide safety construction, modify construction parameters or construction procedures, verify and modify design parameters.
   4) Accumulate experience in regional design, construction and monitoring.

2) TEST IMPLEMENTATION
Each monitoring point shall be installed in place according to the layout of monitoring points. The layout of corresponding monitoring points is shown in the detection model in Figure 4:

3) TEMPERATURE MONITORING
The steel structure is greatly affected by the surrounding temperature during its use. Due to the temperature change,
the overall deformation of the structure is too large, and the stress of the local members of the structure changes suddenly, which affects the overall stress state of the structure.

The main purpose and function of temperature monitoring is to provide the temperature monitoring results of the main parts of the steel frame structure of ski resort in different periods. Analyze the monitoring results, compare the historical trend, obtain the period that has the greatest impact on the temperature, and analyze the structure during that period. Monitor changes. Analyze the temperature monitoring data, obtain the distortion caused by the temperature of the main part of the structure, and obtain the early warning value of the temperature change (temperature difference). It can predict the cold brittle failure of steel. Use the temperature monitoring results to correct the monitored distortion and complete the temperature makeup.

4) ENVIRONMENTAL MONITORING
Wind load is one of the main loads of skiing leisure area. Generally, the wind speed and direction shall be measured. Temperature monitoring includes ambient temperature and structure temperature. The combination of ambient temperature monitoring point and wind environment monitoring point. The combination of structural temperature monitoring point and structural strain monitoring point can obtain the temperature distribution of the structure and provide temperature compensation of structural strain.

5) HEALTH MONITORING SYSTEM
According to the function and purpose that the system needs to meet, the subsystem and functional modules of the iron structure engineering monitoring system of the urban ski resort are determined: sensor subsystem, data collection, transmission, storage subsystem, operation health and safety assessment, early warning subsystem and data management center subsystem.

6) SYSTEM PROCESS
1) The data collection system collects the data obtained by the sensor subsystem and sends it to the site collection station through the data transmission system. After receiving the data, the collection station first judges and preprocesses the data, and then saves it in the data management center.

2) The security evaluation system of data management center calls the data of data management center to evaluate the security and comfort of the structure.

3) The security assessment results are displayed on the monitor of the monitoring center in real time by visualization technology, and the warning is issued in special status, and the security assessment results are saved in the database of the central server. In addition, the database data of the central server will be sent by the local network.

When the health monitoring system is completed, it will be monitored using periodic tests and accumulated data. After completion, the system will collect 7 days of data every quarter and provide the following information on a regular basis: monthly, quarterly and annual structural safety assessment information, regular structural safety information, structural maintenance and repair plan information. Collect sudden conditions (extreme disasters, weather, etc.) at any time.

7) CONCLUSION OF MONITORING RESULTS
As shown in Table 3, it is the summary of monitoring results in the West and east areas.

According to the monitoring frequency once on January 1, the summary of the week and the summary of the data in January, from the analysis of the monitoring results, the deformation of the construction parts in the construction process is very small, and the results are normal within the normal warning range. In order to ensure the continuity of follow-up work, it is recommended to protect monitoring points during the construction process.

F. ANALYSIS OF STEEL STRUCTURE HEALTH MONITORING
Part of the data collected from the strain measurement points of steel buildings, in order to obtain a higher prediction accuracy model by observing the original data, a relatively stable data period is selected for analysis through data observation. The data sampling interval is 15 minutes, and the time series model is used to predict the corresponding variable measurement points. Each step is extended outward to predict 5 distortion measurement points. 50 distortion measurement points are predicted in 10 steps. Figure 5 shows the sample data of strain measuring points.
In the process of maintenance and management of steel structure buildings, it is inevitable that they will not be affected by the external environment. For example, under the influence of water flow and large vehicle operation, the distortion value of the concrete surface of the bridge building will change, and the value of the data will also change according to the situation, and the amplitude will become larger, showing the abnormal value. On the other hand, due to the reliability of the distortion sensor itself, abnormal data may be displayed in the process of data collection. Generally speaking, the value of data burst is called special value or abnormal value, but because of the existence of special value, it will bring great error to the modeling and analysis of time series and affect the accuracy of data prediction.

In order to accurately predict the follow-up value of the distortion measurement point, the processed data is predicted first. Next, the predicted data is unprocessed. When the above model is used to predict the distortion points of the bridge, the number of prediction steps is 4, and after 10 times of prediction, 40 distortion data can be predicted. Figure 6 is a comparison between the actual data and the predicted data after the reverse processing.

However, compared with the actual data, before confirming the accuracy of the prediction model, the prediction data needs to be processed in reverse. In the stage of inverse pre-processing, the predicted data is restored to the characteristics before the difference, and the inverse difference operation is completed by using the formula. The trend item of data is restored by using the trend item fitting item. The trend items of data can more appropriately reflect the rules of actual data changes. The regularization of the data will redistribute the sequences belonging to the distribution function. Figure 7 shows the absolute deviation and relative deviation analysis diagram of data.

As shown in Figure 7, it can be seen that the relative deviation of data with serial number within 1-33 is mostly less than 10%, which verifies the reliability of the model, further reflects that the established time series model can more objectively reflect the change trend and law of strain data, has certain prediction accuracy, and has certain engineering significance for the analysis and mining of building structure monitoring data. But at the same time, it should be noted that the relative deviation of No. 34-40 is suddenly larger, and the actual data is suddenly reduced, resulting in too large deviation. The causes of large deviation usually include: whether the structure has a large deformation, resulting in a large sudden change of strain; or the strain sensor has a sudden failure, so the collected data is also distorted. Through the comparison between the measured value and the predicted value, on the one hand, it can verify the reliability of the data, on the other hand, it can remind the bridge structure maintenance personnel that when the deviation between the predicted data and the actual data of a certain measuring point is large, they can pay close attention to the structure near the measuring point, so as to ensure the safety of the bridge structure.

**V. CONCLUSION**

As a new type of structural system, steel structure architecture is widely used with the development of Chinese society, economy and technology. The construction of steel structure is very difficult, the development of domestic steel structure construction enterprises is uneven, and the factors affecting the quality of steel structure are complex, which leads to the obvious characteristics of steel structure in project quality management. The quality management of a project is very complex and has many management elements. The establishment of the quality management system of steel

### TABLE 3. Summary of monitoring results in West and east areas.

| Measurement items       | Maximum cumulative value and corresponding measuring point | remarks          |
|-------------------------|----------------------------------------------------------|------------------|
| Western settlement      | -1.01mm                                                  | 2                |
| Eastern settlement      | -1.97mm                                                  | 5                |
| Stress / strain in the  | +18.9MPa                                                 | 12               |
| West                    |                                                          |                  |
| Eastern stress / strain | -91.4MPa                                                 | 10               |
|                        | +35MPa                                                   | 9                |

| Cylinder column         | Mega frame beam |

**FIGURE 7. Absolute and relative deviation of data.**
structure engineering and the complete set of effective construction quality management is a very important aspect of steel structure engineering construction.

Using the technology of Internet of things, health monitoring system can be developed in the direction of real-time, automation, integration and network. Establish a health monitoring system based on the Internet of objects in the building. Therefore, it can continuously, real-time and online monitor and evaluate the health status of the steel frame structure, ensure the safety of use, and improve the operation and management level of the bridge steel frame building. In this study, the health monitoring system of steel structure building based on the Internet of things is proposed for the purpose of health monitoring defects. The evaluation subsystem of steel structure is put forward. The evaluation content and process of the subsystem are pointed out, and various methods of evaluating the state of steel structure are listed. For the evaluation method of engineering application examples, please select the level combination method.

In order to improve the quality of monitoring, the technical personnel for monitoring must improve the quality, find out the monitoring problems, solve the general problems in the monitoring process, and correctly handle the monitoring data. In the process of building steel structure construction, the construction monitoring mainly monitors the structure subsidence, stress, strain, deflection, displacement and health monitoring. In the process of monitoring, although it will be affected by various factors, in practice, it is necessary to select appropriate monitoring methods according to the characteristics of various monitoring points and site environment in order to meet the monitoring requirements to the maximum extent and make the monitoring business smoothly.

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