Application of non-destructive testing technology in construction steel structure industry

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Abstract. High-rise buildings are mostly made of steel structures, and the damage detection technology for the welding process of steel structures still needs to be improved. Especially in the current welding process, there are problems such as the lack of data-based control mechanism and the uneven quality of the staff. The use of non-destructive testing technology can effectively detect defects in the welding process, while ensuring the quality of use of the steel structure. This article will study the application of non-destructive testing technology in steel structures, and provide some opinions and suggestions on the development of the construction steel structure industry by analyzing the problems that occur in the welding process.

1. Introduction
Steel materials have a series of characteristics such as stable properties, strong structure, and strong corrosion resistance. Its low cost makes it widely used in the construction industry, but the steel structure requires a lot of welding processes during use. Once the welding quality is not up to standard, it will affect the overall construction quality. Therefore, management personnel must integrate non-destructive inspection technology to achieve rapid analysis and positioning of steel structures, clarify the types of failures, and propose effective solutions to ensure the stable development of the construction steel structure industry.

2. Development of non-destructive testing technology
The test technology evidence task has different directions and can be divided into three stages. In the early stage, the method of simulation experiment was first used to judge whether the steel structure is firm and safe through 3D model analysis, but in the actual simulation process, the simulation effect cannot be kept completely consistent with the real object. The second stage is to apply destructive experimental methods to spot-check the building steel structure. During the inspection process, the overall sample structure needs to be destroyed. The performance of the material is comprehensively evaluated through complex mathematics and garlic[1]. This method can directly and clearly find that there are connection methods and weld quality in the construction process, but the test results have a certain randomness and cannot represent the quality of the overall structure. With the continuous development of science and technology, the application of non-destructive testing technology emerges. Non-destructive testing technology uses detectors to monitor the internal environment of the square structure and analyze the internal physical parameters of the steel structure without affecting the
overall structure of the building. Non-destructive testing technology includes three aspects. The first is non-destructive detection. Non-destructive detection is to integrate ultrasound and magnetic field changes under the premise of ensuring that the building materials are not destroyed and preserved intact to monitor the internal environment to determine whether the building is distributed on average with damage or not. The second is non-destructive testing[2]. Non-destructive testing is developed on the basis of non-destructive testing. It is mainly used to determine the specific location of the scar and the shape of the defect. The last step is non-destructive evaluation. Non-destructive evaluation has a broader meaning. In a narrow sense, it refers to a comprehensive and scientific rating of the tested object when the tested object has a defect, and subsequent solutions are given.

3. Problems in welding of building steel structure
Steel structure is very important in overall building materials, and welding is often required to connect different steel structures. Common types of welds mainly include butt welds, trapezoidal welding and electric welding slag welding. During the welding process, due to the external environment and human factors, a series of problems such as slag inclusion, pores, cracks, and incomplete penetration are likely to occur, resulting in the strength of the overall steel structure not meeting the requirements and causing major safety hazards.

3.1. Backward view of quality supervision
As a personnel-intensive industry, the construction steel structure industry still has the idea of management in the current mechanism. Some managers lack a sense of responsibility, the inspection mechanism is too rigid, and the impact factor of non-destructive testing technology is not considered. The adoption of a single assessment mechanism in a large area has severely discouraged the enthusiasm of welders and affected the construction period of the project. In the actual management process, the focus of supervision is all on the technical and construction schedule, and the lack of quality and safety awareness has affected the development of the construction steel structure industry.

3.2. Welding personnel vary in quality
Welding as a special operation, different building steel structure needs to take different welding process, but the steel structure is constantly reformed. The traditional construction workers disappear, replaced by most of the migrant workers without preparation. The actual operation is strong mobility, and most of the employees have no qualification certificate. The phenomenon of unlicensed post is more serious, and the overall welding technology level is uneven, the lack of technical support. The welding efficiency is poor, and the construction quality is difficult to guarantee[3].

3.3. Lack of data control mechanism
There are a lot of data information and material storage management in steel structure industry. The internal technological process, organizational measures and inspection means are more complex. There are many problems in the process of data analysis. Once the monitoring means are not reasonable, it will lead to the difficult implementation of standards and norms.

4. Application of Non-destructive testing technology in construction steel structure industry

4.1. Comprehensively use a variety of testing methods
The important supporting role of steel structure in the building can effectively improve the stiffness and strength of the whole building and extend the service life of the building. Therefore, it is necessary to clearly analyze the common defects of steel structure welding, strictly implement the inspection standards of welding technology, constantly refine the key points of internal use, and improve the internal processing technology[4]. Several common test methods will be discussed below.
4.1.1 Visual inspection.
Appearance inspection is the basis of nondestructive inspection in the building structure steel structure industry. Appearance inspection is mainly artificial application of some simple mechanical equipment for the exterior surface of the building structure for investigation. It avoids a series of problems such as cracks, sags and crests and uneven color on the outer surface of the steel structure. Appearance inspection mainly uses artificial vision to test. In the actual process of time-consuming and laborious, due to human factors are likely to appear data problems for the comprehensive performance of the building with a certain impact.

4.1.2 X-ray detector.
Radiographic inspection is a commonly used method in appearance inspection. It analyzes the interior of the tested object by emitting some physical rays without damaging the steel structure, and analyzes whether there are defects, cracks and a series of problems in the interior of the tested object with the help of the strength of the change in the direction of rays from different structures.

4.1.3 Penetration inspection.
Penetration testing is also a kind of nondestructive testing. Osmosis testing is mainly the use of molecular permeability, fine scar for secondary examination. Penetration inspection is different from other inspection operation process, time-consuming, and it needs to wait a certain time[5]. In the process of operation, it is necessary to apply penetrant on the surface of the measured object to observe its infiltration into the inside of the building, which can clearly show the internal defects and cracks of the building, and the data is more accurate. But in the actual inspection process, the general penetration inspection is used for porous material not widely in the steel structure.

4.1.4 Magnetic particle inspection.
Magnetic particle inspection uses steel magnetism, which is a more extensive inspection method, relatively simple. Magnetic particle inspection uses the magnetic field principle through the analysis of the magnetic circuit phenomenon of the measured object. It can be more intuitive with clear expression of the measured object defect position. There is no complicated instrument in the inspection process, and the operation steps are relatively simple, but it has a certain impact on the surrounding ecological environment. Therefore, before and after inspection, magnetic powder and waste after inspection should be strictly treated.

4.1.5 Ultrasonic examination.
Ultrasonic inspection compared with other test methods have good directness. The detection depth is proportional to the law of the ground, and it can form on the different interface reflection, refraction, and other phenomena. Only inspection personnel through the electronic image on the display can be clear metal internal porosity, cracking, slag inclusion defects, such as rapid locating defects types, so that the subsequent repair measures. The management personnel should make comprehensive use of the
nondestructive inspection method to quickly locate the fault point, judge the fault type, supervise the construction personnel to take effective measures to optimize the internal performance of the steel structure. For example, in the process of ultrasonic inspection, different probes should be selected according to the different thickness of the inspection and the different carbon. Ultrasonic probe can be divided into straight probe, inclined probe, small tube probe, surface probe and so on[6]. In order to improve the accuracy of detection, inspectors need to choose the probe properly and ensure that the probe chip area within the range of 25 square millimeters to 500 square millimeters. Before inspection, pre-treatment should be done, and the weld surface should be cleaned to ensure smooth movement of the probe. Through grinding sound, it can improve the acoustic effect and reasonable control the room temperature. It can ensure that the steel structure in the room temperature or cooling state, as far as possible to reduce the damage to the probe. In the process of using ultrasonic inspection, digital ultrasonic can be comprehensively used to complete the production of DAC curve for the weld. According to the occlusal standard of the weld in different periods, the follow-up quality control points can be clarified, and the inspection surface cleaning and follow-up management can be completed by fully combining the thickness of the workpiece and the probe. At the same time, in the inspection process, the monitoring personnel need to choose the appropriate coupling agent according to the standard of the flaw detector probe, and give priority to the coupling agent with sound permeability and strong mobility to ensure that the ultrasonic wave can be effectively introduced into the surface of the steel structure, so as to improve the inspection efficiency.

4.2. Enhance data detail control
The inspection process of steel structure is relatively complex, so inspectors need to reasonably select the inspection surface according to the construction situation and the convenience of inspection, and complete the drawing of welding seam distance waveform diagram. It can determine the accuracy of flat line, quantitative line and scrap line, and comprehensively manage the use of steel structure to avoid overlapping probes as far as possible. The DAC curves and defects are analyzed quantitatively and qualitatively by direct contact method.

For example, the compensating gain classification should be adjusted properly during the nondestructive testing of welds. Generally between 6 dB and 4 dB in industry, the inclined probe and parallel scanning method should be selected as far as possible to achieve a comprehensive and quick inspection of the weld. It should observe the echo signal displayed in the wave screen in time, and quickly remember the abnormal weld position, so as to provide reference for the subsequent qualitative and quantitative defects. It can distinguish the grade frame rate between the defects, focus on the location of the second and third grade cracks. Various factors affecting the weld are considered comprehensively, and various parameters of echo are judged by K value to fit the horizontal and vertical distance of wave value.

4.3. Reasonable choice of testing methods
The specific parameters of different welds are different, and the management personnel should choose the monitoring method reasonably according to the groove of the welded joint. Welding industry is a highly practical course. During the inspection process, inspectors must interpret the steel structure description and the corresponding construction quality inspection specifications. It needs to clarify the physical and chemical properties of each component, confirm the inspection location, inspection quantity and the level and requirements of the weld quality, and meet the different needs of different buildings[7]. It should clarify the type of steel used internally, welding process, and welding type. Follow-up welding can only be carried out during the preliminary investigation. In the process of welding inspection, it is necessary to carry out a comprehensive quality acceptance based on the “Code for Construction Quality Acceptance of Steel Structure Engineering” in strict accordance with national standards. The general monitoring mainly includes welding seam and welding foot size to ensure that the deviation of actual size and standard size is within a reasonable range. And it should check the appearance to ensure that there are no obvious cracks, pores, arc scratches and other important defects
on the surface.

| Test object          | Test method              |
|----------------------|--------------------------|
| Fillet weld, T-weld  | Ultrasonic (UT), Magnetic (MT) |
| Groove position      | Ultrasonic (UT), Magnetic (MT) |
| Root clearing site   | Magnetic (MT)            |
| Butt weld            | Ultrasonic (UT), Radiographic (RT) |

Figure 2. Main test methods

For example, when inspecting trapezoidal weld defects, an oblique probe is generally used for the first inspection at the position of the trapezoidal weld near the web. At the same time, it is combined with a straight probe to conduct ultrasonic inspection on the outer welding seam. It should adopt a combination of secondary and primary inspection to improve the accuracy. It can quickly locate the defect type according to different waveform characteristics such as defect wave, external wave, internal wave[8]. It can try to choose a 5MHz dual crystal straight probe to cooperate. At the same time, the basic sensitivity value should be clarified during the inspection process. It ensures that the hole equivalent is within a certain range and fits the welding process of this project to the maximum extent. The waveform is compared with the classic defect echo characteristics to improve the accuracy of curve evaluation and qualitative analysis, laying a data foundation for subsequent maintenance methods.

5. Conclusion

Steel structure has been widely used in high-rise buildings and civil buildings due to its light weight and easy construction. However, due to the need for a large number of welding processes during use, a series of problems such as slag inclusion and bubbles often occur, which seriously affects the service life of the steel structure. Therefore, the corresponding management personnel should apply non-destructive inspection techniques, such as radiographic flaw detection, penetrant inspection and ultrasonic inspection, to strictly control the quality of welds and improve internal monitoring points. In the future, non-destructive testing technology will be organically combined with digital image processing technology and computer technology, and it will be faster and more scientific in terms of three-dimensional image acquisition and timeliness to ensure the safe use of building structures.

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