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Discussion on Construction Technology and Welding Deformation of High-Rise Steel Frame Structure

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Abstract: Because of urbanization, land resources in China's cities has become increasingly scarce. Therefore, modern buildings are becoming taller, making high-rise steel frame structures the new favorite of the construction industry. However, the construction of high-rise steel frame structures requires advanced technology. If the construction technology is effectively implemented and the welding techniques of the construction personnel align with the requirements for high-rise steel frame structures, it can help mitigate deformations in the steel structure, thus preserving the overall construction quality of high-rise steel frame structures. To enhance the applicability of steel frame structures in high-rise buildings, this paper focuses on analyzing the optimization path for the construction process of high-rise steel frame structures. It introduces a tailored approach to control welding-induced deformations in steel frame structures, aiming to make a valuable contribution to the advancement of China's construction industry.

Keywords: High-rise steel frame structure; Construction technology; Welding deformation; Structural stability

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1. Introduction

The issue of urban land use in my country is progressively intensifying. The majority of ongoing construction projects are high-rise buildings to optimize land utilization efficiently. High-rise steel frame structure refers to buildings with six floors or more than 30 m, with steel as the primary material. The main frame structure is built using techniques like bolted connection, welding, and other forms. Compared to traditional buildings, high-rise steel frame structures are of lightweight, strong, and earthquake resistant, making it ideal for modern high-rise buildings. Besides, it drives the sustainable development of China's construction industry. Therefore, it is imminent to optimize the construction technology of high-rise steel frame structures and analyze the causes of welding deformation to quality of buildings.

2. Technological characteristics of high-rise steel frame structure

2.1. High precision requirements for measurement and setting-out

The high-rise steel frame serves as the central structural core of the building, forming the primary foundation for subsequent construction in high-rise buildings. If there is misalignment within the steel frame structure due to inaccurate measurements, it will cause the steel frame structure to dislocate. As a result, the stress structure of the steel frame is affected, which may lead to safety accidents during subsequent construction [1].

Surveying and setting out are necessary for the construction projects. Proper measurements can provide essential data support for the construction of engineering projects.

Compared to other construction types, high-rise steel frame structures require higher precision in measurement and layout, with limited room for error. Inaccuracies can lead to irreversible outcomes, resulting in material wastage and reduced construction efficiency. Therefore, the technological characteristics of high-rise steel frame structures First of all, the accuracy of measurement and setting-out is exceptionally high.

2.2. Easily affected by the weather and temperature

High-rise steel frame structures primarily consist of steel materials, including section steel and steel plates. A substantial amount of auxiliary work is needed during processing and construction to achieve the construction goals of high-rise steel frame structures. Consequently, the weather and temperature significantly impacts the construction outcome of such structures [2].

First, temperature significantly affects steel as the primary construction material of high-rise frame structures. Generally, the thermal expansion coefficient of steel is 1.2 10^{-5}/°C. Taking a 100-meter steel structure as an example, when the temperature rises by 1°C, its length will increase by 0.65mm. If thermal expansion and contraction is not considered during the connection and welding of high-rise steel frame structures, the overall performance of the structure will be affected, which in turn affecting the quality of the project construction. Secondly, the necessary equipment for the construction of high-rise frame structures, such as welding and steel-cutting equipment, will seriously impact the performance of the equipment under temperature changes. On the contrary, even burning down construction equipment in a low-temperature environment, it is impossible to weld, in general, Secondly, the equipment required for high-rise frame structure construction, like welding and steel-cutting tools, can be greatly affected by temperature fluctuations. In cold conditions, below 15°C, welding becomes impractical, and there is a risk of equipment malfunctions. Therefore, welding equipment should be pre-heated to above 15 ℃ [3].

Weather conditions are a critical factor in steel frame construction. To ensure high-quality construction of high-rise steel frames, it is essential to assess the overall impact of weather conditions, thus preventing construction quality issues linked to adverse weather..

2.3. High-performance requirements for supporting machinery and equipment

Steel as the primary material of high-rise steel frame structures. Hence, the performance of steel processing and welding equipment is the pivotal factor influencing high-rise steel frame structures.

First of all, the cutting tool is the primary equipment in steel blanking. The sharpness of the cutting tool's teeth and the degree of deviation between its tooth edge and the intended scale are pivotal factors. Any deficiency in these aspects can substantially compromise the quality of steel processing, leading to the presence of burrs, discrepancies in steel dimensions, and non-uniform steel incisions [4,5].

The second important equipment is the welding equipment. If the performance of the welding equipment is poor, the output power of the equipment will be unstable, the welding spots will be uneven, and the welding

effect will be seriously affected, which will eventually affect the overall construction of the steel frame structure.

Lastly, in the construction of steel frame structures, the utilization of steel as the primary construction material is indispensable. Given the substantial workload, any inadequacies in the quality of the equipment used can readily result in equipment failures or damage during prolonged operations, consequently impacting both construction quality and efficiency.

3. Welding deformation analysis of high-rise steel frame structure

3.1. Types of welding deformation

The types of welding deformation of high-rise steel frame structures mainly include linear, angular, bending, and torsional deformation [6].

3.2. Causes of welding deformation

There are three main reasons for welding deformation. (1) Insufficient structural rigidity: Structural rigidity is essential for high-rise steel frame structures to support building loads. If the chord section and cross-sectional dimensions do not meet the engineering requirements, it will cause longitudinal deformation. (2) Welding location: The welding location serves as the point of connection in high-rise steel frame structures and is crucial for maintaining the system's center of gravity. Any asymmetry in the welding location can disrupt the structural integrity of the steel frame, resulting in bending deformation. Furthermore, if the weld section's center is not at an ideal position, it may lead to a displacement of the structure's center of gravity, causing angular deformation. (3) Welding process: The welding process is the main factor affecting the welding quality of high-rise structures. If there is current fluctuation or that the quality of the welding rods is poor, the welding outcome will be impacted. Ultimately, this can result in an insufficient connection between the steel materials, unable to support the structural load adequately, and consequently leading to deformation [7].

4. Methods of controlling welding deformation of high-rise steel frame structure

4.1. Optimizing the welding process

The deformation caused by welding can be effectively reduced by optimizing the welding process. First, the welding current and voltage should be reasonably selected This ensures that the weld is deep and wide enough while avoiding excessive thermal deformation caused by overheating. Additionally, following a proper welding sequence, starting from the interior and proceeding outward, helps minimize heat accumulation and reduces the risk of structural deformation [8].

During the welding process, it is important to ensure the stability and consistency of welding parameters. For large high-rise steel frame structures, the temperature distribution during the welding process may be uneven, so real-time monitoring and control during the welding process is required to ensure the stability of the welding parameters. At the same time, selecting high-quality welding materials and equipment can also reduce the risk of welding deformation and improve the welded joints' quality.

In addition to optimizing the welding process, it is also crucial to set up appropriate supports. During the welding process, by setting appropriate supports, the free deformation of the structure can be reduced. However, when setting supports, care should be taken not to over-constrain to not cause internal stress concentration but to affect the structure's overall stability [9].

4.2. Controlling stake-out and unloading

Stake-out is the first step in constructing high-rise steel frame structures, which involves converting the geometric information of the structure from design drawings into specific part sizes and shapes. During the lofting process, the design requirements should be strictly followed to ensure that the size and position of each part are accurate. Especially for details of welded joints, shrinkage and deformation of the weld should be considered during the setting-out process, and appropriate margin and compensation should be used to ensure that the actual size after welding is consistent with the design size.

Blanking control is closely related to lofting, which involves cutting the lofted standard-size part from the raw material. Suitable cutting methods and equipment should be used to ensure the accuracy and quality of cutting. In addition, due to the thermal expansion coefficient and thermal conductivity of different materials, the thermal influence during cutting should be reasonably controlled to reduce the thermal deformation of the material [10].

The keys to stakeout and blanking control are precision and consistency. The lofting and blanking of each part should be carried out in strict accordance with the standard operating procedure to avoid dimensional deviation and error accumulation. At the same time, before lofting and blanking, the quality of raw materials should be carefully checked to ensure that they are up to standard to avoid problems in the subsequent welding process.

4.3. Mechanical correction method

In constructing high-rise steel frame structures, welding deformation will inevitably occur, especially in large and complex structures. The mechanical correction method is widely used in to control welding deformation effectively. This method relies on automated means to adjust and modify the welded structure to achieve the geometric shape and size required by the design [1 1].

When using the mechanical correction method, it is first necessary to measure and analyze the post-weld deformation to accurately understand the deformation of the structure. Then, the appropriate automated correction means and process are selected according to the type and degree of deformation. Standard mechanical correction methods include hydraulic correction, stretching, pressure correction, etc. These methods can make targeted structural adjustments and eliminate or reduce welding deformation.

It is important to take note of the following aspects when employing the mechanical correction method. Firstly, the correction strength and direction should be reasonably determined according to the actual situation and deformation characteristics of the structure to avoid new deformation or damage. Secondly, sufficient tests and simulation analyses should be carried out to ensure the safety and effectiveness of the correction process. Moreover, the deformation capacity of structural materials and the potential for material yield should also be taken into consideration [12].

4.4. Flame correction method

Controlling welding deformation has always been a critical issue in the construction of high-rise steel frame structures. In addition to the methods introduced earlier, the flame correction method is also widely used in practical engineering [13].

The flame correction method involves using a high-temperature flame to locally heat the welded structure to change the shape and size of the system, thereby reducing or eliminating welding deformation. This method is usually suitable for local correction of welding deformation, especially for bending and twisting deformations.

In the flame correction method, the heating position, temperature, and time needs to be determined

according to the actual situation of the structure. Besides, the heating temperature should be strictly controlled to avoid melting or scorching the materials. In addition, adequate experiments and simulation analysis are required to ensure the safety and effectiveness of the correction process [14].

4.5. Rigid correction method

When using the rigid correction method, it is first necessary to design appropriate support and constrain schemes according to the type and direction of deformation that may occur during the welding process. The supports that can be used include temporary welding fixtures, supporting frames, or steel plates, so as to ensure the stability of the structure during welding. Constrain can be achieved by setting temporary welds or embedded fixtures to limit the deformation of the structure.

When using the rigid correction method, it is important to pay attention to the following aspects. First, the thermal deformation caused by welding should be considered to ensure that the supports and fixations will not cause stress concentration or uneven deformation inside the structure. Second, the arrangement of supports and constraints should be reasonable, covering areas where deformation may occur and ensuring the quality of welded joints.

The advantage of the rigid correction method is that it is simple and practical. By adequately setting rigid supports and constraints, the deformation of the structure can be reduced during the welding process, and its geometric shape can be kept stable. However, the rigid correction method also has some limitations, as this method might not be effective for large and complex steel frame structures [15].

5. Conclusion

In conclusion, the high-rise steel frame structure is one of the main structures of current construction projects. To ensure the construction quality of the high-rise steel frame structure, the construction unit should pay attention to the construction process and formulate targeted preventive measures for welding deformation, so that the effect of the structure can be maximized.

Disclosure statement

The authors declare no conflict of interest.

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