

Research on the Advantages and Disadvantages and Application Practice of Steel Structure in Architectural Design

Weiyu Zhan, Qingmei Ye

School of Architecture and Urban-Rural Planning, Zhuhai College of Science and Technology, Zhuhai 519040, China

Abstract

Compared with masonry, concrete and other structures, steel structure has strong advantages in mechanics and materials. This paper analyzes the basic characteristics, advantages and disadvantages and construction mode of steel structure, and focuses on the application of steel structure in industrial building design.

Keywords

Architectural Design; Building Structure; Steel Structure; Analysis of Advantages and Disadvantages.

1. Introduction

With the rapid development of economy, modern steel structure buildings are increasingly widely used in China. Steel structure buildings have developed rapidly and become the fashion of contemporary architectural plastic art. Due to its advantages in structure, quality, construction period and environmental protection, steel structure buildings are more and more applied to all kinds of buildings. With its unique material characteristics, it has become an important means of expression of contemporary architecture.

2. Advantages of Steel Structure in Architectural Design

2.1 It has Strong Toughness and Plasticity

In the construction field, steel structure has strong plasticity and toughness. Due to these two advantages, if the building is under load or overload, the steel structure can fully distribute the force, so that the stress variation range of the whole building can be controlled, and the problems such as disconnection and cracking of the steel structure can be avoided to a great extent.

2.2 Good Performance and High Benefit

In terms of materials and texture, the overall distribution of steel structure is very uniform, which is in high agreement with the assumptions of mechanics. At the same time, in terms of internal organization and structure, steel materials have a higher degree of consistency with all kinds of isotropy, and its material fluctuation range is relatively small, which has the most ideal elasticity among all building materials. Moreover, compared with other types of construction projects, steel structures are not easy to be affected by external factors such as environment and climate. In terms of production and processing, it can be directly transported to the construction site for assembly after the processing operation is completed inside the factory, which determines that it has a shorter construction period and will not have a great impact on the environment of the construction area, meeting the needs of civilized construction and green construction.

2.3 Low Cost

In the field of architectural design, the application of steel structure can effectively control the cost investment and ensure the economic benefits of enterprises on the premise of ensuring the overall safety and reliability. Compared with the application of reinforced concrete, the cost consumption of steel structure in high-rise buildings is relatively low, and the quality is lighter than that of reinforced concrete, reducing the transportation cost. The convenience of steel structure will speed up the construction progress and reduce the cost of labor and construction period.

3. Disadvantages of Steel Structure Application

3.1 Problems in Quality Control

Steel structure design needs to comprehensively consider many aspects, which makes the overall design cost higher and requires a lot of human resources investment. At the same time, the architectural design process based on steel structure is complex and the degree of completion is not high. Due to the lack of experience, some units participating in the design are difficult to meet the high standard of steel structure design quality, which affects the construction industry market. At the same time, China's construction industry has not formed a legal and supervision mechanism on steel structure design, which has buried hidden dangers for the design quality.

3.2 There are Deficiencies in the Design Scheme

Due to the high design cost, its design is usually distinguished from contracting, which leads to the lack of a certain depth of steel structure design, and the implementation of some designs is difficult to meet the original design requirements, especially in the design of column base. The three common types of column bases are outsourcing type, exposed type and embedded type, of which the exposed type is often used in the design of residential houses. The stiffness of the column base is mainly affected by the plastic and elastic factors of the bottom plate, and the deformation of the floor will also make the steel structure deform, which requires the designer to comprehensively consider to avoid the damage of the column base point, resulting in the overall problem of the building structure.

3.3 The Safety and Stability of Steel Structure under Fire are Insufficient

In case of fire in steel structure residence, under the thermal action of smoke and flame, the steel structure will rise rapidly, and temperature load will be generated in the process of temperature rise. When the steel structure is subjected to the combined action of external force load and temperature load, it is prone to structural deformation and displacement, and collapse in serious cases, resulting in insufficient safety of the overall steel structure.

4. Design Method of Steel Structure Industrial Building

Industrial buildings are houses serving industrial production, which can also be called factories. In small steel structure industrial buildings, designers need to start from the industrial attributes and select the framework space skeleton and plane shape according to the functional requirements to create a generous and beautiful architectural style.

4.1 Functional Space Design

For industrial service reasons, industrial plants often have diversified industrial attributes. Therefore, the basic industrial functions should be put in the first place in industrial architectural design. For example, some industrial buildings need to be equipped with good lighting facilities. At this time, daylighting openings and daylighting belts can be added to the roof structure, and sunken skylights can also be set between the upper and lower chord members with trusses to create light inlet conditions with the help of the bundle at the end of the truss. For modular buildings, high side windows can be designed by adjusting configuration and flexible combination.

4.2 Spatial Structure System Design

4.2.1 Portal Frame System

In the portal frame building system, the building skeleton is composed of a variety of steel structural members. Compared with other light steel structure building systems, this structure is more suitable for industrial production. After the demolition of buildings, resources can be reused to meet the construction needs of small and medium-sized warehouses and industrial plants.

4.2.2 Lattice Rigid Frame System

In the lattice rigid frame structure system, the light member system is the main component of the building skeleton. The whole is very light and transparent. The composite sandwich metal plate and curtain wall can be used as enclosure. The lattice rigid frame is its main rigid frame, and the rigid frame adopts beam column rigid connection, which is a two-dimensional system. The difference is that the basic beam column part has the characteristics of cell structure, and triangular lattice rigid frame is often used. In the longitudinal direction, the simply supported beams connected can be connected to the rigid frame. In order to improve the overall stiffness, the support can be increased. Different from the portal frame system, this structural system uses lattice frame, and the load capacity of the structure is enhanced, so the support system can be eliminated.

4.2.3 Roof Truss System

The roof truss system plays the role of bearing the roof load. Its skeleton is the roof system. The load it bears comes from the vertical and horizontal directions. The former includes the coverage load and the latter includes the earthquake and wind load. Therefore, the stiffness is the key point considered in the design. In the composition of the roof truss system, it is necessary to continuously combine multiple small members. The axial force of these members is responsible for bearing the load of the roof and increasing the transverse building span, which is very in line with the requirements of industrial buildings. For the composition of roof truss system, the structural member system shall be used, and then the lower compression column shall be connected for load transfer. Through the vertical arrangement, it shows that there is a lot of space under the roof from line to surface.

4.3 Space Separation Design

In industrial plant buildings, the design of internal space should ensure large and unobstructed. Generally, columns are used for internal space separation. For the large span and auxiliary buildings, it can be used as the main space, which can also be used as the main function of the middle and auxiliary buildings.

4.3.1 Comparison between Virtual and Real Walls

The use of lattice rigid frame pays attention to aesthetic expression and structural logic at the same time. Therefore, it can be used as both internal building envelope and exposed structural nodes.

4.3.2 Light Introduction of High Window

The design of side high windows can make the industrial plant have good ventilation conditions and make the internal architectural space more artistic. Architects can flexibly select treatment methods and design architectural details to increase the transparency of the building. Under the combination of artificial light and structure, the inside and outside of the building will be more aesthetic. There are four modes of introducing light into the high window: first, the light channel, such as through the triangular truss of the roof, the light can enter the room; Second, by reducing the shadow of the structure, the light is maximized; Third, change the light conditions through blur and reflection; Fourth, enhance structural perception by changing light.

4.4 Performance Structure Design

After lattice treatment, the portal frame system can form a lattice frame. Its main structural form is the member system, which can not only save materials and reduce weight, but also has strong strength and stiffness, and has certain aesthetic appreciation value. In lattice rigid frame, tie rod and compression rod are the basic units bearing axial force, and their section size is less than the length.

Compared with the solid web beam column system, the limited space of the member structure system is insufficient, so it is generally used for the internal and external spatial structure framework. In order to realize the continuity of the internal and external space of the building, it needs to be matched with the glass curtain wall. In revealing structural components, lattice system is often used, which combines the advantages of structural aesthetics and structural aesthetics and can reflect the construction of space. Bolt connection and welding are the main connection methods between slender rods. For example, in the design of an industrial building in Amsterdam, the architect combined the horizontal support with the lattice rigid frame system to form the architectural interface. By adding support at the transition part and using the external enclosure to cover up, the artistry of the structural building was vividly displayed.

4.5 Detail Node Representation

In the composition of steel frame, the structural design of exposed joints occupies an important part, which mainly plays the effect of decoration and performance. Therefore, in steel structure design, designers should seriously think about decoration design. In the development process of steel structure, the expressiveness of joints often needs careful design and treatment, so as to make architectural design have strong artistic expressiveness. Generally, the decorative effect can be realized by means of materials, structure, technology and so on. For example, in an industrial building in Amsterdam, prefabricated triangular lattice beams and three welding are designed on each frame, bolts are used on the corners, and triangular connecting plates with welding and pressure bearing plates are mainly used on the connecting materials. For each independent girder frame, the steel pipes located at the eaves height are used for connection, and the interconnected steel pipes have the same nodes. On the whole, the logical construction is reflected in the lattice members of each frame, coupled with the node connection of longitudinal steel pipe, which makes the details of each node more exquisite. In the design of steel structure, the design and treatment of detailed joints are the key. The refinement of joints reflects the degree of technological development and enriches the spatial expression of steel structure.

The design of small steel structure industrial buildings should make good use of the detailed nodes of the components themselves, and present the technical beauty with exquisite design. The main structural nodes include bolts, steel cables, pins, pull rods, etc., forming a close fitting whole, which can make the space give people strong sensory stimulation.

5. Summary

To sum up, the application of steel structure has been favored by more and more enterprises, which requires strengthening the research of steel structure design to ensure the safety, rationality and reliability of all aspects of design. Based on the analysis of the advantages and disadvantages of steel structure, this paper puts forward relevant application and strengthening application measures, in order to attract the attention of relevant technicians and practitioners. Relevant personnel should continue to strengthen the research on steel structure design, innovate and improve the specific design, and contribute to the sustainable and healthy development of the construction industry.

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