



On the Application of Fully Modular Prefabricated Steel Structure Stacking Box

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Abstract. The thor mountain, fire, mountain hospital rapid construction, bin structure solved the shortage of hospital beds, container structure system for the general engineering management personnel, but the construction industry personnel understanding of bin structure system, most of the stay in temporary prefabricated houses such as temporary building consciousness, because of its low structure performance, poor decoration perception, difficult to form the popular industry accepted and promotion, this article is based on the application of the actual project, the whole modular prefabricated steel structure bin to analysis, for similar projects[1].

Keywords: Full modularization; assembly; steel structure; stacking

1 Introduction

After the Wenchuan earthquake in 2008, the rapid reconstruction of disaster areas provided an opportunity for the application of container stacking. However, the application of prefabricated modular container stacking structure system still remained in the application of temporary container room and container mobile room. The sudden outbreak of COVID-19 in early 2020, the rapid construction of Leishenshan, Huoshenshan, Qibo Mountain and other hospitals, the container structure has solved the urgent shortage of hospital beds, and the container structure system is also familiar to the majority of engineering managers.

At present, most of the construction industry personnel's understanding of the box structure system stays in the awareness of temporary buildings such as temporary movable board houses, and this kind of building is often regarded as temporary office and living places by users. Due to its low structural performance and poor decoration appearance, it is difficult to form the industry to be accepted by the public and be promoted[2].

2 Classification of Prefabricated Buildings

According to different degrees of prefabrication, the prefabricated units of prefabricated buildings can be generally divided into: rod unit, plate body unit and module unit. The corresponding building structure system is: direct prefabricated structure system, prefabricated large plate structure system and modular building structure system[3-4].

2.1 Direct Assembly Structure System

All the rods in the structure are cut according to the design size, and the main holes are completed in the factory, and transported to the site in the form of single rods, connected by bolts or self-tapping screws, and completed on the site. The advantage is that the site can be modified to the factory equipment has low requirements, the economy is suitable for complex buildings, the disadvantage is that the on-site labor is relatively large.

2.2 Prefabricated Large Plate Structure System

The skeleton wall panels, roof panels and roof frames in the structure are prefabricated in the factory with special molds, and transported to the site for assembly. The construction speed is fast, the quality is easy to control, the high degree of automation, the site workload is small but the relative transportation cost is high, and the equipment needs to be improved on site.

2.3 Modular Building Structure System

The structure of a single room as a module is prefabricated in the factory, and the interior space of the module can be arranged and decorated in the factory. It is then transported to the site to lift the module as a whole. The modular building structure system has a high proportion of prefabrication, which can save manpower and material resources, reduce the construction period and create green environmental protection.

Modular building structure system: it is divided into fully modular building structure system and composite modular building structure system.

2.3.1 Full-modular Building Structure System

Buildings are all composed of module units, suitable for multi-storey buildings, the general number of floors is 4~8 floors. When the number of layers is too high, an independent lateral resistance system is needed as a pre-test. Modules are generally connected by bolts and modified panels, which is the force transmission path of the most modular building[5].

2.3.2 Composite Modular Building Structure System

In order to improve the structure and performance of modular building, it is necessary to compound modular building with other building forms, including: traditional frame composite structure system, structure composite system of plate body structure, shear wall, core cylinder composite structure system, etc.

3 Steel Structure Stacked Box Connection Form

3.1 Connecting Form Division

According to the European EC3 specification, the nodes are divided into three types: full strength nodes, partial strength nodes and articulated nodes. From the design point of view, the connection can also be divided into three types: rigid connection, semi-rigid connection and flexible connection according to the bending moment corner relationship of the connection. The rigid limit bending moment M_{u1} is not less than the plastic bending moment M_p of the beam, and the limit bending moment M_{u2} of the flexible connection is not greater than $M_p / 4$. The classification criteria are as shown in the figure. As shown in Fig. 1.

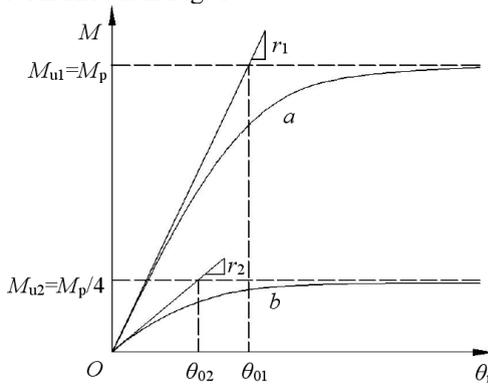


Fig. 1. Angle curve of beam and column connection bending moment

3.2 Rigid Connection

Between two connections, when a piece produces displacement or force, the individual piece connected to it does not produce displacement or relative deformation relative to the first piece, that is, two pieces are connected to a whole. Between members and components can transfer both vertical and horizontal action, and can transfer the rotational moment of the connection mode.

3.3 Articulation

Also known as flexible connection; is to allow the interconnected components to shift or corner, do not limit the deformation of a certain aspect, that is to say, allow defor-

mation, the common for the steel structure leg and cast-in-place concrete beam connection, to simplify the plan, the part is regarded as articulated, according to the specific connection form can be mainly divided into the following three kinds: bolt ball node, molten steel pipe node, primary and secondary beam hinge node;

3.4 Semi-rigid Connection

Between the rigid and hinge, that is, the connection can withstand a certain bending moment, and can produce a certain rotation.

According to the European Regulation EC4, when the rotational stiffness of the node is less than 0.5 times of the line stiffness of the beam, it can be regarded as articulation; when the rotational stiffness of the node is greater than 25 times of the beam, it can be regarded as rigid connection, the common is bolt connection, the two are heard as semi-rigid connection, China also has related research results, but it is more complicated.

The beam-column end plate is connected as a semi-rigid connection, and the beam-column produces relative angles. As shown in Fig. 2.

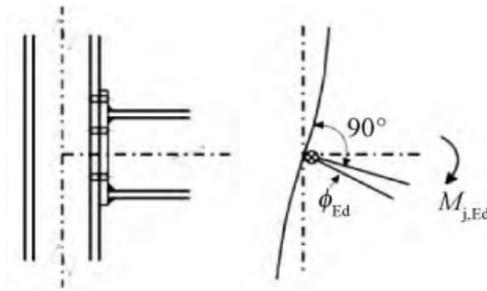


Fig. 2. Semi-rigid connection

4 Project Application Situation

4.1 Fully Modular Assembly of Rigid Connection Case

(1) Habitat 67 (habitat 67)

Moses safdi design Montreal Habitat 67 (habitat 67) with 354 reinforced concrete modular box (overhanging components, concrete node connection for rigid connection), each box of residential unit are set for unified module, and then prefabricated construction, again like a container in the form of uneven. As shown in Fig. 3.



Fig. 3. Habitat67

4.2 Fully Modular and Assembled Semi-rigid Connection Case

(1) The FREIAG flagship store in Zurich

Located beside the central Zurich railway station and the highway, the Zurich FREIAG flagship store is regarded by experts as one of the six most wonderful stores in the world, consisting of 17 scrapped used containers processed, cut, welded and assembled. The building has become a symbol of the Zurich city. As shown in Fig. 4.



Fig. 4. FREIAG flagship store in Zurich

5 Application Contrast

5.1 Advantages and Disadvantages of Rigid Connection of Fully Modular Prefabricated Steel Structure

5.1.1 Advantages

With high strength and stiffness, good stress performance, the design of the beam and column node is generally just connected, can bear the load is generally larger and also resist the wind load and horizontal earthquake caused by the displacement[6].

5.1.2 Disadvantages

Due to the adverse factors such as poor high altitude welding conditions, welding residual stress and so on, the design value of welding strength should be multiplied by the reduction coefficient of 0.9, so the bending bearing capacity of the weld is only

about 75% of the bending bearing capacity of the frame beam, which violates the basic principle of "strong node and weak rod"[7].

5.2 Advantages and Disadvantages of Semi-rigid Connection of Fully Modular Prefabricated Steel Structure

5.2.1 Advantages

Considering the relative deformation of the node area can alleviate the stress concentration in the rod; the energy dissipation under the seismic load can reduce the displacement reaction; the post-disaster structural reinforcement design is easy to handle; the semi-rigid node introduces the structural analysis to promote the attention to the structure design process; the design is closer to the real situation of the structure, with continuous force transmission and theoretical calculation are in line with the actual force. Simple structure, high overall performance and convenient installation. The shape of steel structure is more convenient, has a large bending moment bearing capacity, simple structure, convenient construction, the main feature of semi-rigid connection node is that it must have enough bending ability.

5.2.2 Disadvantages

Current building steel structure design process, the design of the half rigid connection node is difficult, if the design lack of rationality, may increase the elastic stiffness of steel structure, so will make the safety of the connection between the components is adversely affected, may bring safety hidden trouble for construction construction, or a threat to the future construction application.

6 Summary and Outlook

With the development of economy and the growth of people's demand for housing, prefabricated bin packing has gradually become a popular housing choice. With its advantages of rapid construction, environmental protection and energy saving, and mobility, prefabricated stacked houses, compared with traditional concrete and brick buildings, the materials used in prefabricated stacked boxes are more economical and environmentally friendly. Box reuse and recycling are also in line with the concept of sustainable development. In addition, prefabricated container houses can use some energy-saving technologies, such as solar panels, thermal insulation materials, etc., to improve energy efficiency, reduce the impact on the environment, and has a good development prospect.

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