Analysis of connection structure of prefabricated reinforced concrete exterior wall panels

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Abstract: By analyzing and discussing the connection structure related to the fabricated reinforced concrete external wall panel, including the material, technology, connection principle and form method of the external wall panel, the design principles of the fabricated reinforced concrete external wall panel connection structure are summarized.

1. Introduction

Book "principle and application of building structure", this definition building structure, building structure is "research component of structure form, structure, construction materials, structural optimization problem such as size and structure connection" [1], from this definition we can see that structure of materials, process approach and show the structure of the form is an important aspect of building structure. As a kind of building structure, the connection structure formed by different component materials and different processes is varied. However, the connection structure of the outer wall panel members is not only the need of construction, but also has an important impact on the construction effect of the building. Therefore, the study of the connection structure of the outer wall panel members should not only discuss a variety of technical methods to achieve the connection according to the material and process, but also choose the most appropriate connection form according to the different connection parts, the different size of the components and the architectural effect to achieve [2].

The connection structure of precast reinforced concrete exterior wall panels has three meanings: the first is the connection between the structural members and the retaining members, the second is the connection between the retaining members based on the precast reinforced concrete exterior wall panels, the third is the connection between the retaining members and the exterior decoration members. The three kinds of connections are not independent of each other. They are interrelated and influence each other to form a relatively complete architectural system [3-4].

In this paper, several common connection structures of prefabricated reinforced concrete exterior wall panels are selected. And the advantages and disadvantages, stress principle and construction technology of these connection structures are analyzed. The design principle of connection structure of prefabricated reinforced concrete exterior wall panel is summarized by analyzing the application of these connection structures in precast reinforced concrete exterior wall panels from the point of view of material properties and connecting parts.
2. Materials and methods

2.1. Material characteristics of prefabricated reinforced concrete exterior wall panels

Building materials are the most basic elements of architecture and the core of construction activities. The characteristics and forms of materials and other factors have a profound impact on the appearance, space, ecology and the relationship with the surrounding environment, as well as the use and life of buildings. For prefabricated reinforced concrete buildings, the exterior wall panels are mainly prefabricated reinforced concrete exterior panels, but other materials such as steel, aluminum alloy, glass and wood will also be introduced in addition to concrete. Connection structure is the integration of architectural elements into a whole will inevitably involve the problem of materials, so the characteristics of materials themselves and the principle of force have a profound impact on the connection structure.

The application of concrete materials in precast concrete prefabricated buildings is mainly in several aspects[5]: firstly, as precast reinforced concrete exterior wall panels, together with steel, wood and other components of the building envelope; secondly, as structural materials, such as frame beams, columns, shear walls, the enclosure members need to be "hung" on the structural members through the connection structure; third, it is as the decorative material of the exterior wall board, the use of concrete plasticity, corrosion resistance characteristics in the factory processing and production of modeling rich exterior wall hanging board, through the arrangement of the combination of hanging on the outside of the envelope members to play a decorative role.

As a composite material of precast reinforced concrete exterior wall panels, steel is mainly used in the following aspects: first, it is used as an enclosure member and precast reinforced concrete exterior wall panels together to form a building facade. The appearance of steel is obviously different from that of concrete, which can enrich the form of building facade. Second, as a decorative plate hanging on the envelope, steel has high strength, good plasticity, and is easy to be processed and formed in the factory. Compared with the concrete member, steel can be processed into a thinner plate, lighter in quality, and more safe and reliable as a decorative plate. The surface of steel can be easily changed color, gloss and other appearance, as a decorative component has innate advantages.

2.2. Connection construction method based on material characteristics of exterior wall panels

The characteristics of concrete and steel are different, and the connection methods when used as enclosure components will inevitably be different. The different connection methods between materials are not only the embodiment of material characteristics, but also the way to realize its characteristics. For prefabricated reinforced concrete exterior wall panel components, the connection structure exists at different levels, including the connection between structural members and enclosure members, the connection between enclosure members, and the connection between enclosure members and decorative members. Can you choose a suitable connection method under the constraints of material properties and various objective conditions and logically complete the connection based on the enclosure components to form a complete and diverse architectural appearance and wonderful architectural details. For prefabricated concrete buildings In terms of it is crucial.

Common connection methods include bolt connection, welding connection, pouring connection, and bonding connection. The corresponding relationship between the connection structure of the precast reinforced concrete external wall panel and the connection structure is shown in Table 1.

| Table 1 Correspondence between the connection structure position and connection structure mode of precast reinforced concrete exterior wall panels |
|---------------------------------|-------------|-------------|-------------|
| Precast reinforced concrete exterior wall panels and main structure | Bolted link | Welding link | Casting link | Binding links |
| | | ✓ | ✓ | ✓ |


Precast reinforced concrete exterior wall panels
between each other

Prefabricated reinforced concrete exterior wall panels
and exterior wall decoration components

The advantages of the bolt link first lie in the convenient construction, detachable, only need simple tools to complete the connection operation, and the bolt specifications in the same project is relatively fixed, can be recycled. Second bolt of low cost, high cost performance, with low cost can obtain the connection structure of safe and reliable. Bolt to use a more flexible, again in the project can choose according to the stress distribution of bolt type, number, diameter and arrangement. Precast reinforced concrete slab and the main structure of the bolt connection belongs to the rigid connection, bolted connection node can force immediately, but the demand is higher, about the quality of the steel fittings and bolt steel fittings directly exposed to the air, in practice, not only need to consider the stress of the fitting problem, but also to do a good job of fire anti-corrosion.

The advantages of welding link are simple processing, the combination of molecules or atoms between the materials makes the connection of good tightness, strong integrity, large stiffness. With the development of welding technology, automation of operation can replace the traditional manual operation mode, welding speed and precision are improved greatly, when the connection parts, more complicated forms and have a high request for waterproof, welding connection advantage is obvious. In precast cladding, welding connection can be used for cladding the component and the main structure of the connection, if the component can also be used for decorative aluminum plate, visor, the connection of air conditioning board, under special circumstances can also be applied to the connection between the cladding. The stress and cost of the outer wall panels are the main factors affecting the selection of welding joints. Welding connection, meanwhile, sealed, and the connection structure depends largely on the quality of spot welding craft level, therefore requires careful application of outer wall plate.

Casting link shape is the advantage of convenient and reliable connection, if the welding connection is through the heating of the pressurized component materials from the level of atoms and molecules connected into a whole, then pouring connection is through the material itself physical and chemical reaction of the component connected into a whole, at the same time the structure of the casting connection have the appearance of the form, can create the appearance of different image. Precast reinforced concrete slab casting connections between components and the main structure belongs to wet connected to the factory production of precast cladding parts reserve on the edge of the component reinforcement, when installation will be reserved and the main structure of the steel binding bar connection or welding connection, and then the joint cast-in-situ concrete material, so that the precast cladding structures and the main structure form the whole. In addition, the problem of plate joints can be solved by casting connection between the exterior wall panels of precast reinforced concrete. At the site construction stage, the outer wall panels are fastened on the main structure first, and then the cracks between the concrete panels and the plates are filled with concrete cast-in-place. Bonded connection has the advantages of simple operation, low technical requirements for construction personnel, reliable and stable connection, at the same time, it can also play a decorative role with the improvement of the process, so it is more and more widely used in the connection of modern building exterior decoration. The exterior panels of precast reinforced concrete are assembled on the facade and the slabs can be filled with binder material for decoration and sealing. As a surface decorative component, the concrete exterior wall hanging board can also be connected with the concrete exterior wall board by structural adhesive when it appears in the image of thin board.

3. Results & discussion
The materials properties of precast reinforced concrete slab are different, connection parts and different stress state, the commonly used several kinds of connection structure process is also different. According to process characteristics of material properties, connecting parts, structure and
construction environment and other aspects of characteristics, such as synthetically evaluation criteria and principles of choosing appropriate connection structure become the important aspect of prefabricated construction. According to the above analysis, the design principle of the outer wall panel connection structure can be divided into the following aspects.

(1) Safe and reasonable, stable and reliable
Safe and reliable connection and tectonic stress have a direct link to the principle. The structure force principle of all kinds of connection modes is clarified, so as to promote advantages and avoid disadvantages in practical application, so that the connection structure can achieve the best comprehensive strength, and at the same time, a variety of connection structures can be used to strengthen the connection. With precast concrete external wall plate wet connection as an example, the steel rebar and the main structure of the slab are reserved for welding or tie bar connection, strengthen the cladding structures and the integrity of the main structure components, and then on the reinforced cast-in-place concrete, and the fluid state of concrete material and the leakage of steel and concrete pouring connection components, to further strengthen the connection between the components. Whether it is a single connection structure or a combination of multiple connection modes, the connection structure should play the maximum role, the force is reasonable, and the path of force transmission should be simple and direct. But the effect of the structure is not connected nodes connected the more the better, is also not connected as closely as possible, proper connections can reach a state of balance, is conducive to the stability of the connection. Precast reinforced concrete slab bolt connection, if the constraint too tight, in case of external force, the cladding materials can occur before the bolt connection cracking of the concrete damage, if add slip in bolt gaskets, when slab are affected by external force is too large, to allow joint tiny displacement or rotation, you can cut part of the energy of the external force, by the way of doing work to avoid the destruction of the rigid.

(2) Apply according to the material, adjust measures to local conditions
Connection structure design is reasonable or not is another important factors affecting the characteristics of the material can be fully play. Material properties such as mechanical properties, machinability, etc., the suitable connection structure is not the same. Adapting measures to local conditions should first adapt to regional materials, but also adapt to regional technology, the same material in different regions have different ways of connection. Such as napa valley wine factory management USES a room in the connecting way of use within the metal basket of gravel; DePraas's new Monte-Rosa Lodge uses prefabricated timber, a combination of prefabricated timber components that are tenon-and-mortise and bolted together.

(3) Efficient connection, universal interchangeable
Connection efficiency refers to the connection structure in satisfies the requirement of stress, to ensure safe and reliable under the premise of should be relatively simple, convenient for construction and installation workers operation, with simple process with advanced tools can easily complete the construction. Because of material application, adjust measures to local conditions is connected to the efficient regional performance, according to the construction of the regional characteristics to choose the appropriate regional materials and connection techniques can have twice the result with half the effort. At the same time, the body of the join operation is a person, the technology level of construction personnel and proficiency is one of the important factors affect the efficiency. Finally, the use of tools and machinery is also an important factor affecting the efficiency of the connection.

Generic interchangeability includes two aspects. General refers to a connection structure of component design should consider the versatility and standardization, convenient production management and quality control, but also to streamline the construction personnel, reduce the error rate in the process of construction. Replaceable means that the connection components should be easily replaced to ensure the safety of the connection structure. As a force, force transmission component, the importance of the connector is self-evident, the need for regular maintenance, timely replacement of problems. This requires connection structure design logic is clear, fittings and connected component a clear logic, force, force between common solution is to use an independent fittings.
(4) Green construction, energy saving and environmental protection
First of all, the material selection and component processing of the connection structure should fully consider the requirements of green energy saving. Secondly, in the construction process, the influence on the surrounding environment should be minimized. For example, physical connection structures such as bolt connection should be adopted as far as possible to complete the processing of highly polluting components in the factory, so as to reduce dust, noise and other pollution in the field construction process. Even in the demolition stage, components can be conveniently disassembled and recycled, and the generation of exhaust building materials can be reduced. Finally, the connection structure is maintainable and replaceable is also a form of energy saving and environmental protection. The longer the life of the building, the less time it needs to be demolished, which effectively reduces the waste of resources. Connection structure and connected component interface clear enough, renovation of buildings are more organized with logic, avoid unnecessary dismantled and prolong the service life of buildings, reduce resource waste.

(5) The unity of technology and artistry
Connection structure embodied in material technical features, construction technology and the connection parts. In particular, the properties of the material can give full play of embodies the connection the rationality of structure design, construction technology limits the implementation of connection structure, the connection of part determines the mechanical characteristics of the connection, the three constitute the technical connection structure. The artistry of connection construction is how to express the architect's design intention with the exposed connection nodes. In short, the technicality of connection construction provides the material basis for artistry, which is the logical manifestation and external expression of technology.

4. Conclusions
This paper first analyzes the material and characteristics of prefabricated reinforced concrete exterior wall board members, and then analyzes and lists the common connection construction mode, analyzes and studies the applicable materials, force principle and connection parts of the connection construction mode, and explains through the prefabricated construction engineering examples. On the basis of theoretical analysis and practical case study, five principles of prefabricated reinforced concrete exterior wall panel connection structure are summarized. These five principles are based on the design principles of precast reinforced concrete exterior wall panels, and combined with the characteristics and importance of connection structure to be refined. They are interrelated and mutually realized, so we need to consider the actual situation of the project comprehensively, and design or select the appropriate connection structure along the general logic principle.

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