

Research Status on Reinforcement Connection Form of Precast Concrete Shear Wall Structure

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Abstract. With the rapid development of Chinese economy and the speeding up the process of urbanization, housing industrialization has been paid more and more attention. And the fabricated structure has been widely used in China. The key of precast concrete shear wall structure is the connection of precast components. The reinforcement connection can directly affect the entirety performance and seismic behavior of the structure. Different reinforcement connections have a great impact on the overall behavior of the structure. By studying the characteristics of the reinforcement connection forms used in the vertical connection and horizontal connection of precast concrete shear wall, it can provide reference for the research and development of the reinforcement connection forms in the future.

1. Introduction

The connection of the precast concrete shear wall mainly includes the connection of the horizontal joints between the upper and lower precast concrete shear walls, and the vertical joints between the adjacent walls. Currently, there is a lot research on the horizontal joints connection form of the precast concrete shear wall, while there is a little research on the vertical joints connection form. The connection of the welded reinforcement ring in the precast concrete shear wall structure was analyzed. The vertical connections are divided into the sleeve connection, constraint grout-filled lap connection of steel bar and the mechanical connection [1-3]. The advantages and the remaining problems of the reinforcement connection are evaluated and summarized.

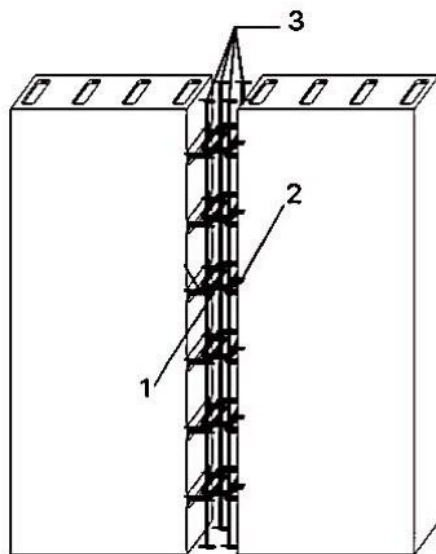
2. Precast concrete shear wall horizontal connection

Precast concrete shear wall structure horizontal connection that uses welded steel ring connection is a relatively new way of connection.

The connection is shown in the Fig.1. Precast concrete components are embedded in semi-circular steel bars and the anchorage length of reinforcement is in accordance with the requirements of seismic codes. The welded ring reinforcement is placed on the upper part of the corresponding embedded semi-circular steel bars. And then lengthwise steel bars are inserted; the concrete are poured from the top. Two precast concrete walls are connected into a whole after curing.

In order to study the seismic performance of the shear wall connected by the welded steel bar, the quasi-static test of six specimens was carried by Yang Yong [4]. It is proved that the precast concrete shear wall with vertical joint has similar hysteresis performance to the cast-in-place wall. And the bearing capacity of cast-in-place wall is slightly lower, but the ductility is better and has better entirety hysteretic energy dissipation performance.





1-welded ring rebar
2-semi-circular horizontal rebar
3-vertical insert rebar



Figure 1. Horizontal connection

Welded steel ring connection has not been mature by now, and there are still some shortcomings. For example, the construction process is complex. The exposed semi-circular steel need to create the relationship between everyone points. It requires a good precision.

3. Precast shear wall vertical connection

3.1. Sleeve connection

The sleeve connection is to embed the sleeve in the bottom of the upper shear wall, and put the vertical reinforced of concrete shear wall into the sleeve. And the reinforcement which is reserved by the lower shear wall was embedded to the sleeve on-site assembly. Then the high strength grouting material without shrinkage composed of cement, expansive agent, fine aggregate and high performance admixture was poured into sleeve by the grouting machine. When the grouting material is hardened, the reinforcement and the sleeve are firmly connected together. The behavior of high strength and non-shrinkage of high strength grouting material can fully ensure the bond, friction and joint strength between the steel and the inner wall of the sleeve, so the stress between the reinforcement and sleeve can be effectively transferred.

There are many kinds of sleeve grouting joints in the domestic and foreign, which can be divided into two categories: full sleeve grouting connection and half sleeve grouting connection [5]. The full sleeve grouting joint grouted at both ends. Its applicability is wide, so it is the most widely used. Half sleeve grouting joints adopts straight thread connection reinforcement in precast end joint and grouting connection on-site assembly. Because of the length of anchor bar anchorage length of reinforcement straight thread connection to connection required less than filling, half sleeve grouting joint size is small. But it has higher requirements on the sleeve material. And the requirements of the prefabricated connecting reinforcement model are strict, so the cost increases.

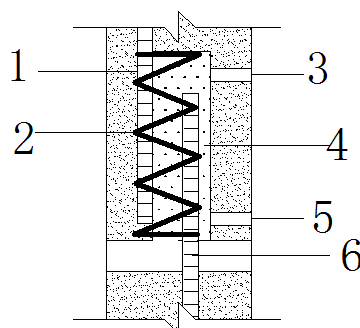
Much experimental research on the sleeve connection has been conducted by many experts and scholars. Peng Yuanyuan and Qian Jiaru [6], with the shear span ratio of 2.25, the vertical reinforcement using the sleeve grouting connection of the precast shear wall specimen as the object of study, the structure of the quasi-static test, the seismic performance of the vertical bar with sleeve grouting was studied. The results showed that vertical grouting sleeve grouting can effectively transmit structural stress, and the failure mode was the buckling of vertical reinforcement and the compression failure of concrete.

Sleeve grouting connection has many advantages in the construction: (1) the requirements on the construction equipment and operator quality are simple and the weather has a little impact on it; (2) the length of the sleeve anchor connector is short, which can effectively reduce the amount of steel reinforcement and on-site grouting work; (3) the construction is green safety with no noise and pollution; (4) it has a high degree of industrialization, and the on-site assembly is simple and quick.

The sleeve connection also has its shortcomings: (1) the reserved reinforcement of sleeve grouting connection specimen is shorted, and the sleeve has a small internal space, so the connection technology requires higher requirements on grouting material and grouting technology; (2) the construction cost will be increased due to the high cost of sleeve.

3.2. Constraint grout-filled lap connection

The constraint grout-filled lap connection (Fig.2) is also called lap anchorage or indirect splicing. The reinforcement is inserted into the rough reserved holes with wavy or spiral shape. Some strengthening measures are adopted for the inner wall of the reserved hole to improve the performance of the reinforcement lap joint. The method of plug-in filling hole for lap joint of steel bar was an invention about reinforced connection method; it was firstly used for production of the PC (Precast Concrete) structures about housing industrialization in China. Besides the steel bar, a hole with spiral-reinforced hoop was reserved. At the time of lifting structure, the lapping steel bar inserted into the hole with a certain degree of lapping length. After the hole was grouted, the steel bars became together when the grouted material was hardened. In order to investigate the reliability and construction method of constraint grout-filled lap connection of steel bars, a total of 144 specimens were designed and tested by Ma Junwei [7]. The experimental results indicate that the constraint grout-filled lap connection for steel bars is simple and reliable construction. Precast concrete shear wall uses grout-filled lap connection by the reserved hole [8]. Compared with other methods, it has many advantages such as simple structure, saving steel, low cost, safe and reliable technology, so it is a main connection form.



1-longitudinal reinforcement 2-spiral stirrup 3-discharge hole
4-grouting material 5-grouting hole 6-connection rebar

Figure 2. Constraint grout-filled lap connection

Pseudo static and pseudo dynamic loading on the three layer full size precast concrete shear wall structures with splice rebar lap connection are carried out by Zhang Jiaqi [9]. The overall seismic performance of the structure is analyzed, and the vertical load test is carried out on the basic members of the structure. The bearing capacity of each component and the connection performance between members are studied. These were no cracks in the structure under the seismic force of seismic fortification intensity. The whole structure is in elastic state and the story drift angle satisfies the limit value of the code. The test results showed that the structure constructed by this connection has good ductility and energy dissipation characteristics. And the stiffness decreases slowly after cracking, which meets the fortification goal of building.

Splice rebar lap connection has many advantages: reinforcement connection is easy to operate; it just need the reserved holes, site insertion, simple pouring process; the complex cost connection like

reinforcement welding sleeve connection is saved; it is more suitable for the industrialization of residential construction of precast concrete structure construction characteristics; the construction process can be more environmental protection, reducing cost, saving construction funds.

The splice rebar lap connection technology is mature, but there are still some shortcomings: (1) for the splice rebar lap, it is difficult to reserve a large number of holes in the not too thick wall; (2) the concrete thickness of the hole edge is very small, and if the hole is damaged during the transportation of the component, the connection performance of the component will be affected; (3) due to the requirement of anchorage length, the retaining length of the grand beam is very long, and the long reserved reinforcement will bring great trouble to the lifting and assembling during the transportation and assembly, and waste the space resources; (4) due to the longer length of the reserved rebar, the length of the grout hole also requires a longer length, so the amount of grouting material consumed will be much more, and the work on the site wet will increase, and because of the longtime of grouting operation, the construction period will have great influence.

3.3. Mechanical connection

Mechanical connection technology is a method that transfers the force from one bar to another by the mechanical joint action between steel bar and connector and the bearing action of reinforcing steel end face. According to the survey from the Japan Welding Society, there are 64 kinds of reinforcement connection methods, 60% of which are mechanical connection method. From 1980s, the mechanical connection of reinforcement began to be studied in China. The common mechanical joints of reinforcement include sleeve extrusion joint, taper thread joint, upsetting straight thread joint, molten metal filling joint. There are provisions for related connection methods and parameters in the new standard -- "technical specification for steel mechanical connection" (JGJ1072010) [10] in our country. For the connection of the vertical component, when the connection is completed, the connection parts need to be poured in second times. But the connection parts are difficult to be vibrated and compacted, so it can result in a horizontal joint. There is no concrete protection in the joint, and the water in the air can touch with the reinforcement, which will affect the durability of the structure.

4. Conclusion

All of the above is the connection of the precast components used in the analysis of the connection. Different steel bars have different advantages, but there are still some shortcomings need to be improved. As one of the key technologies of the connection of precast components, the promotion and application of advanced reinforced connections are of great significance to improve the quality of the project, speed up the construction speed, improve the labor productivity and reduce the cost.

Acknowledgments

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References

- [1] Li Xiaoming. Development and application of key technology for precast concrete structure [J]. Housing Industry, 2011(6):16-18.(in Chinese)
- [2] Qian Jiaru, Yang Xinke, Qin Heng, et al. Tests on Seismic Behaviour of Precast Shear Walls with Various Methods of Vertical Reinforcement Splicing [J]. Journal of Building Structures, 2011, 32(6):51-59. (in Chinese)
- [3] Chen Jianwei, Su Youpo. Precast Concrete Shear Wall Structure and Its Connecting Technology [J]. World Earthquake Engineering, 2013, 29(1):38-48.(in Chinese)
- [4] Yang Yong. Experimental Research on Seismic Performance of Precast Shear Wall with Vertical Joint Surface[D].Harbin: Harbin Institute of Technology, 2011.(in Chinese)
- [5] Khaled A, Soudki, Sami H, et al. Horizontal connection for precast concrete shear walls subjected to cyclic deformations part1:mid steel connections[J].PCI urnal,1995(4):78-96.

- [6] Peng Yuanyuan. Experimental study on seismic behaviour of pre-cast reinforced concrete shear walls [D]. Beijing: Tsinghua University, 2010. (in Chinese)
- [7] Ma Junwei. Experimental study on constraint grout-filled lap connection of steel bar [J]. Building Structure, 2015, 45(2):32-35. (in Chinese)
- [8] Jiang Hongbin. Research and application of precast concrete shear wall structure [J]. Housing industry, 2010, 9:22-27. (in Chinese)
- [9] Zhang Jiaqi. Experimental Research on Seismic Behaviour of Full-scale Precast Shear Wall Substructure [D]. Harbin: Harbin Institute of Technology, 2010. (in Chinese)
- [10] Standard of People's Republic of China, Technical Specification for Mechanical Splicing of Steel Reinforcing Bars (JGJ107-2010). Beijing: China Architecture & Building Press, 2010.