Summary of research and application of prefabricated concrete shear wall in structural seismic resistance

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Abstract

due to the advantages of precast concrete structure, such as high industrialization degree, fast construction progress, high component quality, and favorable for the maintenance of natural environment, it has received people's attention and support, and made great achievements in the direction of structural seismic resistance.In this paper, the seismic principle, the main types of seismic shear walls and the connection forms of prefabricated concrete are classified and summarized.Several kinds of assembled structures with different joints at home and abroad are integrated, such as minified sleeve grouting reinforcement connecting shear wall, high-efficiency reinforced concrete anchor lap connection shear wall, keyway connection shear wall, bolt connection shear wall, and mechanical connection shear wall.In view of the many problems that need to be solved, some Suggestions are put forward.There is still a long way to go for the research of prefabricated concrete shear wall in structural seismic resistance.

Keywords

Prefabricated concrete,Structure aseismic,Connection form,Mechanics principle.

1. Introduction

Green building, industrial building will be the future direction of civil engineering.At present, the construction industrialization is mainly through the prefabricated concrete structure construction, but the prefabricated concrete structure in China's construction industrialization ratio still needs to be vigorously promoted.China every year to increase building area of two billion square meters, nearly 40% cement and steel consumption of the world, extensive use of cast-in-place form, make the construction site wet workload increase, water resource by a large number of consumption, and industrialization level is low, lead to low efficiency, high energy consumption of industry as a whole problem[1], especially in urgent need of a new construction technology to replace the traditional cast-in-situ structures.Therefore, in order to reduce the loss caused by the waste of resources, the research on the earthquake resistance of precast concrete has gradually become a hot topic of many scholars.

1 Seismic principle of prefabricated concrete

In the prefabricated concrete members, the connection position is always the difficult part and the key part of seismic design.And the connection point is just the fragile part of the prefabricated structure, its seismic effect is far less than the cast-in-situ concrete structure.With the passing of time, vibration isolation design has been applied more and more in the construction industry. There are many successful cases in cast-in-situ structure, and its good vibration isolation effect has been recognized by everyone.The vibration isolation capacity can reach over 90%[2].The use of vibration isolation structure in the building can isolate most of the energy transmitted by the earthquake, so that the superstructure will not have a large relative displacement, to ensure the maximum upper components will not be damaged.

Based on the existing deficiencies of assembly structures and the characteristics of vibration isolation structures, the vibration isolation technology can be applied to the assembled structures, which can reduce the displacement between the upper structures and avoid the joints with low seismic performance from being damaged by earthquakes.At the same time, the seismic requirements of the

assembled structure to the joints are reduced, the cost is reduced, and the safety, applicability and durability of the structure meet the standard.

The single-degree-of-freedom system is taken as an example to illustrate the mechanics principle of aseismic structure[3].For a system with one degree of freedom, the structural mechanics equation is

$$m\ddot{x}+c\dot{x}+F\left(x\right)=-m\ddot{x}_0 \tag{1}$$

Type in the: m for quality. x , $\dot{x}$, $\ddot{x}$ are structural displacement, velocity and acceleration respectively, $F\left(x\right)$ is the structural restoring force, $\ddot{x}_0$ is ground acceleration.

Energy balance equation of structure under earthquake action

$$E_K+E_D+E_S=E_{EQ} \tag{2}$$

Type in the: E_{EQ} is the total energy input system, E_K is the kinetic energy of the system, E_D is the damping energy consumption of the system, E_S is the deformation energy of the system.

E_S From structural elasticity to performance E_K ,Plastic deformation energy E_P ,Hysteretic energy dissipation E_H composition,namely

$$E_S=E_E+E_P+E_H \tag{3}$$

When the structure no longer vibrates after the earthquake, the system velocity and acceleration are all zero, and the elastic deformation of the structure is gradually restored. E_K , Elastic deformation energy E_E All is zero. Equation (2) can be rewritten as

$$E_D+E_P+E_H=E_{EQ} \tag{4}$$

This indicates that the energy input to the structure during the earthquake is composed of structural damping energy, plastic deformation energy and hysteretic energy.

It can be seen from equation (4) that, under the action of earthquake, the input energy of earthquake is less than the sum of the damping energy,plastic deformation energy and hysteresis energy of the structure, and the structure can resist the earthquake. One of the methods for E_{EQ} strong structure to resist earthquakes is to reduce the value of A on the right side of equation (4), that is, to reduce the energy lost by earthquakes to the structure. This method corresponds to the technology of isolation and damping (such as setting isolation rubber pads at the base of the structure).

2. The main types of seismic shear walls

Prefabricated shear wall according to the connection process can be divided into wet connection shear wall (miniaturization socket grouting reinforced shear wall and efficient reinforced grouting anchor lap shear walls, etc.), dry connection shear wall (keyway connect, bolt connection, mechanical connection, etc.), with the progress and development of construction in recent years, developed a novel composite material on the basis of the normal concrete (steel fiber reinforced concrete) its good performance and simple manufacturing process, has been used increasingly in engineering.

Among all kinds of connection methods, sleeve grouting connection is the most widely studied and applied because of its advantages of simple structure, better mechanical properties and relatively low cost.On the basis of summarizing previous experience, Ling[4] studied fish-belly grouting connection and steel welded sleeve grouting connection, and compared the mechanical properties of the two. The results showed that the ultimate bond strength of fish-belly grouting connection was 25%~35% higher than that of steel welded sleeve grouting connection due to the tendency of biting steel bars at its end.Existing domestic prefabricated component enterprises mainly use the following kinds of sleeve grouting connection technologies, namely JM sleeve grouting connection technology of a company in shaanxi province, Japanese sleeve grouting connection technology of a company in shenyang and cast iron sleeve grouting connection technology of shenzhen. Domestic scholars have also carried out

relevant researches.At present, the grouting anchor lap connection technology mainly includes two connection technologies, which are insert type reserved hole grouting reinforcement lap connection and bellow pipe grouting anchor lap connection[5].

3. Several typical shear wall connection technologies

3.1 Wet connection mode

3.1.1 Grouting anchor lap connection mode

Grouting anchor lap connection mode (also known as indirect anchorage or indirectly lap) adopted by the way: the bellows in the concrete pouring in advance and wait until meet the concrete strength, reinforcement to wear to the corrugated pipe, finally, the grouting material mixture into corrugated pipe under the condition of standard curing, have the effect of anchoring bar, its characteristic for upper and lower connection steel does not contact, pass shear connection steel padding, then passed to the shear wall around the concrete.The method of grouting anchor lap joint is jointly developed and studied by Harbin Institute of Technology and heilongjiang yuhui construction group co, LTD ,which is applicable to the connection of steel bars with small diameter, relatively convenient for construction and lower than the cost of sleeve grouting connection[6].

Jiang Hongbin in 2008 for the first time put forward the plug hole grouting reinforcement[7] lap connection technology, this technology including longitudinal lap steel two Chambers, the hole is not smooth, used to constraints, longitudinal reinforcement of spiral stirrups and lower into the slurry hole and the top place to vent, etc, and make the plug hole grouting reinforced lap performance tested[8,9], then made the connection method of single direction tensile test and large stress under reciprocating[10] tension and compression experiment, the experimental results shows that the requirements of this connection technique anchorage length can be according to the basic anchorage length I_a values.

3.1.2 Sleeve grouting connection

The sleeve grouting connection mode is to butt the sleeve with internal rib groove with the connecting steel bar, inject grouting material to fill the gap, and form a whole after hardening.The effect of stress transfer between steel bars is good.The friction, bond and occlusal strength between the inner wall of the sleeve and the surface of the steel bar and the high-strength grouting material is mainly guaranteed by its high strength and non-shrinkage.At present, the new type of sleeve connection has been fully tested in practice and has been widely used at home and abroad.

Domestic scientific research institutions and enterprises have also done a lot of research. For example, qian jiaru[11] et al. connected the vertical steel bars of the shear wall with sleeve connection, which was d-16 sleeve produced by ridong industry. They conducted seismic experiments and compared the experimental results with cast-in-situ shear wall.The results show that, in the prefabricated shear wall, this kind of connection mode can meet the requirements of vertical connection of prefabricated shear wall and effectively transfer the vertical reinforcement stress.There is no great difference between the failure state and cast-in-situ structure.However, this kind of connection mode is not ideal for the concrete at the bottom of the shear wall in the later period of the test, so the drop section of skeleton curve is steeper than that of cast-in-situ specimens.In order to facilitate the construction, reduce the construction difficulty and improve the connection efficiency, some enterprises and scientific research institutions, on the basis of the above experiments, have carried on several in-depth exploration and improvement to this kind of connection mode.For example, wang aijun et al.[12] proposed a new connection mode of sleeve, namely, connecting one end with grouting and one end with thread. In addition, epoxy resin-aggregate method was applied to spray into convex grooves of sleeve to enhance the friction between grouting material and inner wall of sleeve, so as to improve the force transfer efficiency between sleeve and connecting steel bar.It is an effective improvement to the traditional sleeve connection mode.

3.2 Dry type connection

3.2.1 Mechanical connection

Mechanical connection technique is to use the compressive capacity of reinforced section and reinforced and connecting sleeve form of mechanical friction, separate the upper and lower two equivalent into a well versed in steel bar connection ways, in our country's existing specifications "reinforced mechanical connection technology regulation (JGJ107-2010)[13], the mechanical coupling of commonly used dry bar connection list illustrates in detail.

3.2.2 Bolt connection

In reinforced mechanical connection, the bolt connection is a common way of reinforcing steel bar connection, this way the conventional bolt and thread rod, in the construction site, the process is: probably the lower shear wall set upper threaded implants reinforcement, as the screw, at the same time, on the lower end of the upper shear wall reserved good steel plates with holes.In this method, the screw reinforcement is made to pass through the steel plate and connected with the upper shear wall with a nut. After fixed, concrete is poured in the splicing area. After the concrete is solidified, the two walls become a whole.The bolt connection method for prefabricated shear wall components has the advantages of simple safety and reliable performance, but the disadvantage is that the connection method has higher precision requirements.Therefore, the application of this method in vertical connection of prefabricated shear wall components is few at home and abroad.

3.3 New connection mode

Steel fiber reinforced concrete[14] has developed rapidly in recent years with the progress of the construction industry.It is a new kind of composite material based on ordinary concrete, which has excellent performance and simple manufacturing process, and is widely used in engineering.Compared with ordinary concrete, steel fiber has a good inhibiting effect on crack development in concrete, which significantly improves its shear, tensile and bending strength, impact resistance, fatigue resistance, grip force between steel bars, post-crack toughness and durability.At present, prefabricated building is developing vigorously in China, especially prefabricated shear wall has been favored by the majority of construction industry practitioners, and steel fiber concrete has been widely used in China.Combining the two, not only the advantages of SFRC and prefabricated shear wall are given full play, but also the unexpected effect may be achieved.Therefore, further explore the mechanical properties of steel fiber reinforced concrete, for steel fiber reinforced concrete in the application of prefabricated shear wall connection provide relevant test data and basic data, and the development of production technology of steel fiber reinforced concrete and the theoretical research of prefabricated shear wall of new type connection mode is of important theoretical significance and practical value.

4. Conclusion

(1) Compared with cast-in-place concrete structure, prefabricated structure has the advantages of saving a lot of resources, improving the engineering efficiency, promoting technological innovation, material innovation and process innovation, and becoming the development direction of anti-seismic modern buildings.

(2) When the earthquake occurs, steel bar connection technology is very critical for precast concrete, and the reliability of the connection between the two is the key to ensure the overall capacity of the structure and seismic performance.

(3) Pulp anchor connection technology to connect the development of technology bring convenience at the same time, it also exists many problems, such as bearing capacity is relatively low, reinforced lap distance, high demand for grouting material consumption is larger, etc., also we can be targeted to improve from these aspects, split hole size and lap length optimization, lower costs, maximize the benefits.

References

[1] Xu yiping. Prefabrication and assembly: an important approach to the transformation and upgrading of the construction industry [J]. Architecture,2013(15):8-9.
[2] Yan lei. Research on construction and seismic performance of prefabricated concrete shear wall structure [D]. Qingdao university of technology,2018.
[3] Han jianqiang, ding zushen, zhang yumin. Review on research and application of energy dissipation and soft steel damper [J]. Journal of building science and engineering, 2008, 35(05) :60-69.
[4] Ling J H, Rahman A B A, Ibrahim I S, et al. Behaviour of Grouted Pipe Splice Under Incremental Tensile Load[J]. Construction & Building Materials, 2012, 33(8): 90-98.
[5] zhang lei. Experimental study on the bond bond performance of precast concrete structure steel bars welded with reserved hole slurry anchor [D]. Xi 'an: chang 'an university,2016.
[6] wu tao, liu quanwei, zhang lei, bai guoliang, xu yaasia. Development prospect of reinforced restraint slurry anchor connection technology for precast concrete components [J]. Journal of xi 'an university of architecture and technology (natural science edition), 2015,47 (06) : 776-780.
[7] Liu wenqing, jiang hongbin, geng yongchang, et al. Insert type reserved hole grouting reinforcement lap joint member [P]. Chinese patent :CN 201217847,2009-04-08.
[8] Jiang hongbin, zhang haishun, liu wenqing, et al. Anchorage behavior of precast concrete reinforced bar grouting with inserted reserved holes [J]. Journal of Harbin Institute of Technology, 2011,43(4):28-31.
[9] Jiang hongbin, zhang haishun, liu wenqing, et al. Lashing test of precast concrete with inserted reserved hole grouting reinforcement [J]. Journal of Harbin Institute of Technology, 2011,43(10):18-23.
[10] Zhao pei. Experimental study on the bond bond of slurry anchor reinforcement [D]. Harbin: Harbin Institute of Technology,2011.
[11] Qian jiaru, peng yuanyuan, zhang jingming, qin heng, li jianshu, liu guo-quan, zhao feng-dong, li lu-rong. Seismic performance test of prefabricated shear wall connected with vertical reinforced concrete sleeve slurry anchor [J]. Building structure,2011,41(02) : 1-6.
[12] Hao min, zhu qinghua, wang aijun, zhou xu. Application of corrosion-resistant full grouting sleeve in steel bar connection construction of cast-in-situ concrete structures [J]. Construction construction, 2017,39 (11) : 1640-1642.
[13] Ministry of housing and urban-rural development of the People's Republic of China, jgj107-2010. Technical specification for steel bar mechanical connections.
[14] Xie li. Experimental study on bending and bonding properties of steel fiber high-strength concrete [D]. Zhengzhou university, 2003.