New Type of Shear Wall and Its Application in Super High-Rise Building
新型剪力墙以及其在超高层建筑中的应用

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With the rapid development of our economy and advancement of urbanization, super high-rise buildings have got rapid development in recent years. Because of the great height of super high-rise building, the high aspect ratio can reach above 7 to 8, which makes the lateral stiffness of structure small, determines the structure’s characteristics of “high, narrow, soft”, and leaves wind and earthquake as the main factors to be controlled in the design and building process.
The Olympic Tower  Shenzhen Jingji 100 building  Green Space in Wangjing center
In the design of super high-rise building, how to fully guarantee strength and ductility of structural members is the basic premise of structural safety. By limiting the inter story drift, the lateral stiffness of the structure can be ensured, the cracking caused by wind and frequent earthquakes can be avoided, and the normal operation of the building can thus be guaranteed.
Because the cast-in-situ concrete shear wall stiffness, good seismic performance, good fireproof performance, low cost, construction technology is mature, so the concrete core tube is still the basic structure of super tall building so far. However, in order to ensure the concrete ductility of shear walls under gravity loads, axial compression ratio should be controlled strictly. At the same time, the wall thickness is large, occupying the using space, leading to the weight of the structure and seismic force increased.
Steel - concrete composite shear wall can effectively increase the strength and ductility of the member, reduce the section size of members, improve the fire performance, and has been used more and more in recent years in super high rise building. The issue need to properly handle during engineering application is how to ensure the steel and concrete work together, avoid structure and construction process complex.
Engineering application of steel reinforced concrete shear wall

Shenzhen Jingji 100

The structure of section steel reinforced concrete shear wall
Characteristic of section steel reinforced concrete shear wall

Section steel reinforced concrete shear wall is usually constructed with steel structure attached to both ends of concrete structure or with steel structure installed as the embedded brace while other parts formed by reinforced concrete wall. The collaboration of concrete structure and steel structure in section steel reinforced concrete shear wall is ensured by the installation of shear key on the surface of the steel. Research on steel reinforced concrete shear wall is mainly concentrated in the seismic performance, to observe influence of the shear span ratio, axial compression ratio.
Usually stud is used as the shear key in the design of section steel reinforced concrete shear wall. However, how to ensure the joint work of steel and concrete, simplify the reinforcement connection, avoid the complexity of construction, and ensure the quality of concrete pouring are still fatal challenges in practical situations. Due to the excellent performance of steel reinforced concrete member under the seismic performance, it has been widely used in super high-rise building areas.
SECTION STEEL REINFORCED CONCRETE SHEAR WALL

Engineering application of steel reinforced concrete shear wall

Shenzhen Jingji 100
Characteristic of steel plate composite shear wall

Steel plate composite shear wall is a steel plate embedded in reinforced concrete wall, by setting shear key on the surface of the steel plate to guarantee the steel and concrete work together.
Characteristic of steel plate composite shear wall

The concrete provide lateral supporting for steel plate, which can avoid steel plate’s premature buckling deformation, thus give full play to characteristic of steel plate. Meanwhile, it also can avoid serious degradation of stiffness and bearing capacity of shear wall under the rare earthquake. Similar to section steel concrete shear wall, steel plate composite shear wall give full play to the advantages of steel and concrete, it has good ductility, good fireproof performance.
Application of composite shear wall

Green Space in Wangjing center

the construction of Steel plate composite shear wall
Application of steel plate composite shear wall

Green Space of Wangjing center is located in Beijing business. The project includes a high-rise tower and a retail podium building, 5 floors underground, 55 on the ground floor, building height 260m.

In order to resist tensile stress of shear wall under earthquake, setting composite shear wall in the first 6 layers to improve the tensile ability. That clearly put forward the construction requirements of shear wall in the design, and the steel plate shear wall test was carried out.
Application of composite shear wall

the construction of steel plate composite shear wall
The Olympic Tower is located in the central area of the Olympic Park in Beijing.

The Olympic Tower

Circle steel plate composite shear wall of Olympic Tower
The Olympic tower consists of 5 single towers, diameter and height of each tower are different, and the maximum height is 248m. Each single tower is composed of cylindrical tower and top crown shaped landscape platform. In order to enhance the integral lateral stiffness of the structure, set up four connected truss between five single tower along the height direction, forming a combination of tower structure.
Characteristic steel plate shear wall

- common steel plate shear wall
- steel plate shear wall with vertical seam
- steel plate shear wall with circle opening
Characteristic steel plate shear wall

- Steel plate shear wall with vertical seam at the end
- Steel plate shear wall with vertical stiffener
- Concrete splint steel plate shear wall
Characteristic steel plate shear wall

Elevation of steel plate shear wall

Cross-section of steel plate shear wall
Steel plate shear wall is a new type of lateral force resisting structure developed in the twentieth century; its main function is to provide the lateral stiffness, shear strength and ductility of the structure. Steel plate shear wall is composed of surrounding frames and embedded steel plate; it has the characteristics of lightweight, convenient installation. Research shows that the characteristics of the steel, good ductility, energy dissipation capacity can be given full play by steel plate shear wall.
The steel plate shear wall with vertical stiffener

In order to improve the stress performance of steel plate shear wall under the control of construction cost, a very practical way is to arrange stiffeners in plate. The main effect of stiffener is reflected in the following aspects:

1. To improve critical load of steel plate shear wall, delay the shear buckling, reduce the out of plane deformation;
2. To improve the vertical buckling critical load of steel plate shear wall, provide a part of vertical bearing capacity, avoid the plate buckling during the installation, meet the construction schedule and the actual demand;
The steel plate shear wall with vertical stiffener

3. To improve the hysteretic behavior of steel plate shear wall, overcome hysteretic curve "pinching" phenomenon of steel without stiffeners, improve the ductility and energy dissipation ability of the component;

4. To prevent the tension area formed by steel plate acting directly on the frame column, thereby protecting columns from tensile failure;

5. Improve the lateral stiffness of steel plate shear wall, and control the lateral deformation of high-rise building structure.
The buckling modes of the steel plate shear wall with vertical stiffener subjected to shear force
Steel plate shear wall with opening

In order to meet the function requirements of open window, open hole and open channel, steel plate shear wall with opening has been used more and more widely in recent years.

The stress state of coupling beam of steel plate shear wall with opening and reinforced concrete structure has a certain degree of similarity.
Steel plate shear wall with opening

The buckling modes of the steel plate shear wall with opening
STEEL PLATE SHEAR WALL

Steel plate shear wall with opening

Steel plate shear wall with opening

Mises stress under the action of horizontal force

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Steel plate shear wall with opening

For the parts of steel plate wall with opening, the frame beam between two holes form coupling beams, the deformation concentrated, member earlier into the yield condition.

In order to ensure the lateral stability of the structure, should set the lateral support beam in the edge of the hole.
Steel plate shear wall with opening

Without column in the middle

With column in the middle
Super high-rise building is an important direction of vertical city development in the future, application of new type of shear wall in super high-rise is of great significance to sustainable development of structure design. Application of section steel concrete shear wall, steel plate composite shear wall and steel plate shear wall, greatly improve the seismic performance and efficiency of structure, also effectively increase the usable space.