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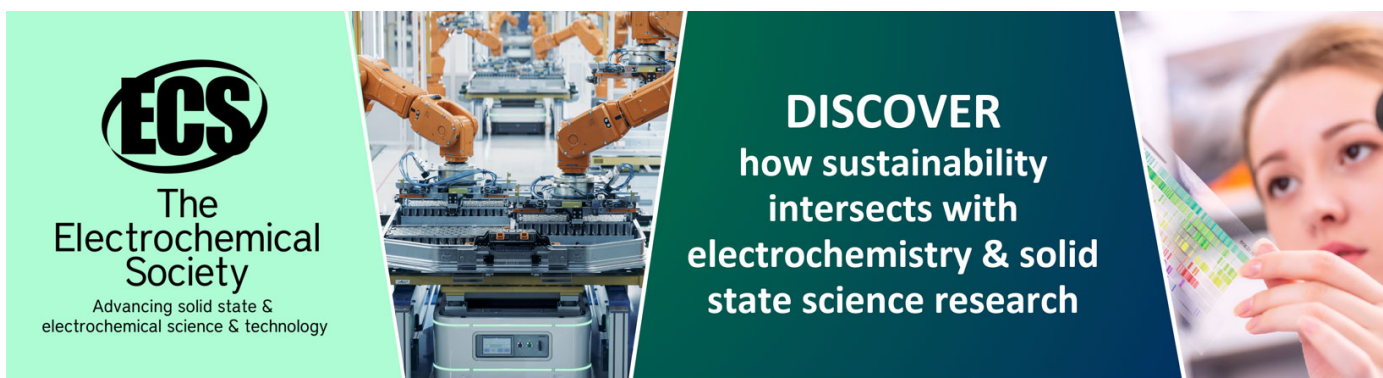
Static elastoplastic analysis of the composite shear wall of the grid -tube- type double steel plate wall with infilled concrete

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Static elastoplastic analysis of the composite shear wall of the grid -tube- type double steel plate wall with infilled concrete

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Abstract: In this paper, the new idea is proposed on the composite shear wall of the grid -tube- type double steel plate wall with infilled concrete, the model test was carried out, and combined with practical engineering, for instance, a 18th floor high-rise building pushover static elastoplastic analysis is discussed. Research shows that the hysteresis curve of the new composite shear wall is relatively full, and has good seismic performance with high bearing capacity, high ductility and high energy consumption capacity. Under the action of rare earthquakes, the interlayer displacement is small on structural system with concrete filled steel tubular column and he composite shear wall of the grid -tube- type double steel plate wall with infilled concrete, and the new composite shear wall is distributed more base shear. Research shows that structural system on composite shear wall with grid -tube- type double steel plate wall with infilled concrete has good seismic performance.

1. Introduction

The shear wall is an important component of the anti-lateral force in the structure of the frame - shear wall. Core tube shear wall under seismic action, not only bear the most earthquake shear force, but also the dissipation of earthquake energy is playing an important role, is the key component super-tall hybrid structure seismic design ^[1-4].

High-rise buildings often use steel frame - reinforced concrete core tube structure, frame column and beam frame adopts excellent seismic performance of steel structure materials, core tube shear wall structure uses the reinforced concrete structure with good sex of can die, mixture of two kinds of building materials. High-rise buildings core tube shear wall structure for most of the seismic shear, reinforced concrete core tube is an important component to resist lateral force, but the seismic ductility of reinforced concrete core tube shear wall energy dissipation is poor, therefore, concrete core tube structure is not suitable for tall building structure ^[5-9].

The combination of the existing steel plate shear wall is in cast-in-place reinforced concrete plate on the side of the two steel shear wall, high structure stiffness big, buckling load, fire prevention performance is good wait for an advantage, but problems existing reinforced concrete wall plate and steel plate are divide-and-conquer, reinforced concrete wall of the lateral early damage, concrete with steel plate separation, after stripping damage caused late manifestation of composite steel plate shear wall close to the stiffening steel plate shear walls, reinforced concrete wall to protect the embedded steel plate is temporary, such combination structure of steel plate shear wall seismic ductility and energy dissipation than ^[10-13].

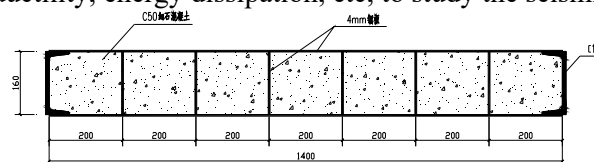


Draw lessons from the advantages of steel concrete composite structure, the lateral set up multi-channel Rachel between double steel plates steel plate, a rectangular grid steel pipe wall, bar grille self-compacting concrete, high strength steel pipe casting to form a rectangular grid type double steel pipe concrete composite shear wall structure and a new type of composite shear wall, high stiffness, high degree industrialization, construction is convenient, buckling resistance is strong, high yield load, good ductility, energy dissipation good performance, low cost advantages.

2. The experimental study

2.1. Test model

The experimental design of three grille type concrete composite shear wall is designed, which is csw-1, csw-2, csw-3, and it is 1400mm width, 160mm thickness and 2800mm. Through this new type of shear wall shear wall subjected to low-cyclic pseudo-static experiment was carried out, from hysteresis curves, skeleton curves, ductility, energy dissipation, etc, to study the seismic performance.



(a) Test section schematic



(b) Test unit figure

Fig.1 Test specimen figure

Three specimens were divided into 2 groups, the first set of CSW - 1, CSW - 2 the do - displacement control load, axial compression ratio comparison test, the second group of CSW - 3 controlled by displacement loading, as a validation test artifacts, such as for the last level load displacement of symmetric cyclic loading, to further explore energy cumulative fatigue damage situation of plastic hinge, the particular case as shown in Table 1.

Table1 Test load condition condition

	Axial compression ratio	Loading way
CSW-1	0.1	Force-dis control
CSW-2	0.6	Force-dis control
CSW-3	0.1	Constant amplitude loading

Three new grille type double steel concrete strength grade of concrete shear wall specimen design of C40, inside all use 4 mm thick steel plate and the outer steel plate Q235B steel, shear wall at both ends for model [16 common channel steel hot rolling, all connections are welding between steel. The loading beam section size is $400 \times 400 \text{ mm}$, ground beam section size is $500 \times 600 \text{ mm}$, in order to ensure the connection between the bottom of the shear wall and ground beam, on top of the ground beam pass long embedded in the hot-rolled H-beam flange $\text{HM } 350 \times 200$.

2.2. Test results analysis

Grille type steel concrete composite shear wall is formed by combining multiple steel tube concrete column, concrete inside three to a state of compression, improved the pipe concrete compressive strength and ductility, effectively avoid the early destruction, makes the new grille type steel concrete composite shear wall can give full play to the seismic resistance of steel and concrete and the energy dissipation capacity.

The concrete composite shear wall of the grid-type steel plate, the concrete in the tube is in three to the pressure state, improves the compressive strength and ductility of the concrete in the tube; Set spacing was Rachel across steel effectively restrict the lateral shear the out-of-plane deformation of steel tube concrete bear all the pressure to avoid the shear steel pressure, lateral plate has high ability to resist out-of-plane buckling

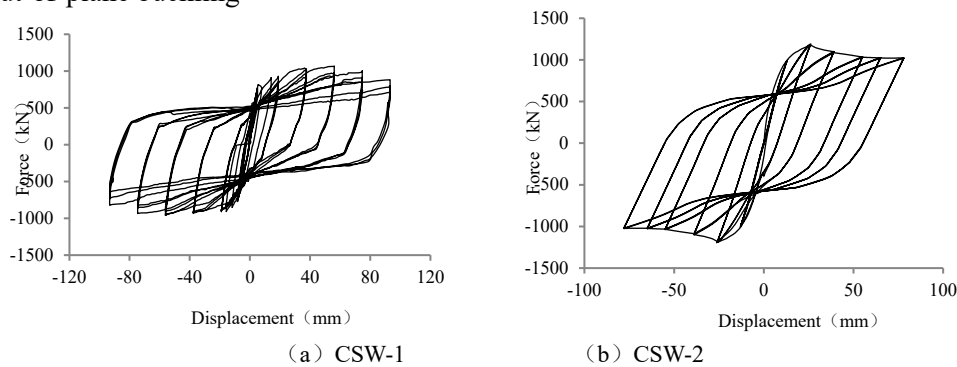


Fig.2 The specimen hysteresis curve

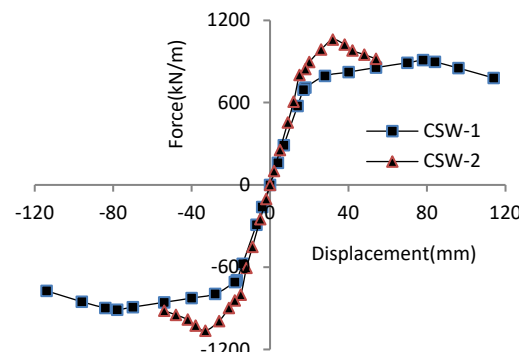


Fig.3 Test skeleton curve

The characteristic value of the skeleton curve of three specimens is shown in Table 2, which determines the yield point using the secant stiffness method. The displacement of the limit displacement is the corresponding displacement of 85% of the peak load. You can see from this table grille type steel concrete composite shear wall in low axial compression ratio has good ductility, ductility coefficient is close to 9, under high axial compression ratio, the ductility coefficient is close to five.

Table2 The characteristic point of the skeleton curve

	yield load (kN)	yield displacement (m m)	Peak load (kN)	peak displacement(mm)	limit displacement(mm)	Ductility coefficient
CSW-1	702.36	12.62	929.84	69.08	114	9.03
CSW-2	811.11	10.78	1082.38	30.90	55	5.10
CSW-3	682.72	12.32	925.17	68.25	114	9.25

This paper designed the three steel concrete composite shear wall specimen grating type, and the test research under low reversed cyclic loading, can draw the following conclusion:

(1) the grille type steel concrete composite shear wall seismic performance is good, under low reversed cyclic loading is a plump hysteresis curve, has advantages of high bearing capacity, ductility and energy dissipation capability is strong, can achieve high axial compression ratio, high ductility and seismic shear walls of the thin wall thickness design requirements.

(2) with the increase of the axial pressure ratio, the load capacity of the concrete composite shear wall of the grille type plate is increased, and the ductility and energy dissipation of the wall is decreasing.

(3) the grille type steel concrete composite shear wall has good stability, bearing capacity under 1/25 displacement Angle, cyclic loading 80 times, the new steel plate shear wall plastic hinge region there is still no obvious damage, in the whole test process without any sound.

3. Pushover analysis

3.1. Engineering background

An office building has 18 stories on the main floor and one floor below. The skirt building has two floors. The floors of the first to third floors of the main building are 4.2 m; the height of the fourth and the above floors is 3.9 m; and the difference height of the indoor and the outdoor is 1.2 m. The total building height is 72.3 m. The standard layer architecture is shown in Figure 2. The project building seismic fortification classified as class c, basic seismic fortification intensity of 8 degrees, design basic earthquake acceleration value of 0.2 g, design earthquake are grouped into the first group, site soil category for II class. The seismic grade of the frame and core barrel is class one.

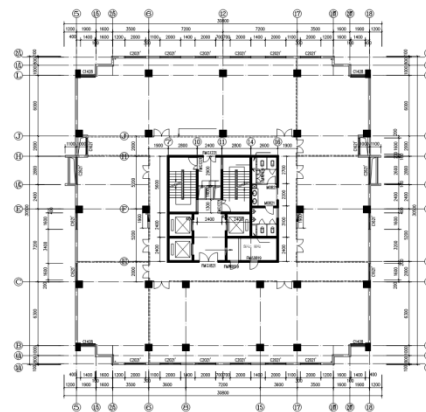
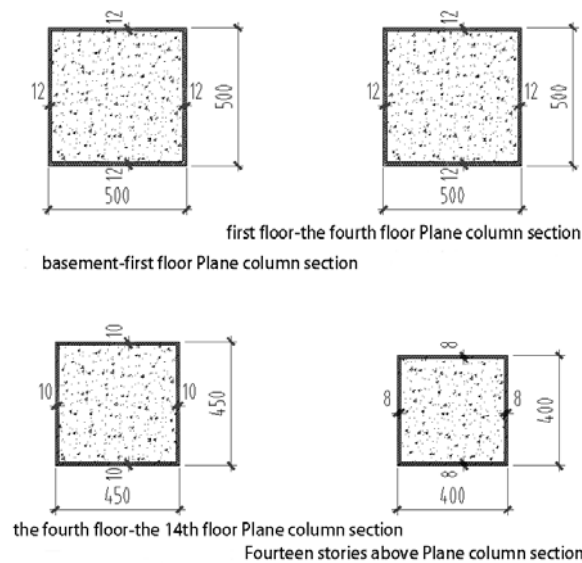
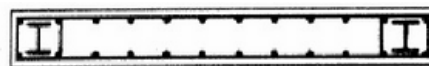


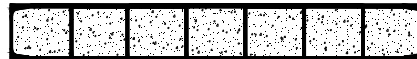
Fig.4 Standard floor building

In this paper, we use two kinds of solutions to analyze the seismic analysis of buildings. Scheme, a steel tube concrete frame column - steel reinforced concrete composite shear wall core barrel, scheme, two concrete filled steel tubular frame column - grille type steel concrete composite shear wall core barrel.

Solution a: concrete filled steel tubular column and steel reinforced concrete shear wall plan one surrounding the structure frame adopts steel pipe concrete column, steel pipe for Q345 steel grade, steel tube concrete inside. The section size of the concrete frame column of the steel tube is shown in Figure 5; The inner wall of the inner tube adopts the steel concrete wall of the concrete composite with a steel concrete wall of 250mm thick, with the steel concrete wall of the concrete and steel, which is built in 200mm thick.

**Fig.5** Steel tube concrete frame column section

(a) Section of the steel concrete composite shear wall



(b) The simplified section of the grid-type steel plate concrete composite shear wall

Fig.6 Composite shear wall section

Scheme 2: concrete filled steel tubular column and grille type double steel concrete composite shear wall core tube, steel tube concrete column arrangement with plan a, choose 8 mm thick lateral double steel plate and 8 mm thick steel plate welded steel grille Rachel type steel concrete composite shear wall instead of steel reinforced concrete composite shear wall, the core tube wall with 250 mm thick, Rachel plate spacing is 320 mm, end in 25 u-steel Settings; The inner wall is of 200mm thick, the span of the steel plate is 320mm and the end of the section is no.20 slot steel, the internal and external shear wall is filled with C40 concrete.

3.2. Contrast of displacement Angle between maximum layer of structure

For whole model by using concrete filled steel tubular frame - grille type steel concrete composite shear wall system combined with the concrete filled steel tubular frame - steel reinforced concrete shear wall system model were analyzed, it is not hard to find: in the role of more severe earthquake, after using grating type steel concrete composite shear wall, structure the largest interlayer displacement Angle compared with steel reinforced concrete composite shear wall has been reduced, structural lateral stiffness is bigger, the reason for the three to the stress of the concrete elastic modulus and strength has a larger increase (Table 3).

Table3 The maximum interlayer displacement Angle

	Steel concrete shear wall		Grid-type double-plate concrete shear wall		Specification limits
	X	Y	X	Y	
Dmax/H	1/1345	1/1256	1/2123	1/1998	1/800

3.3. The Pushover structure static elastoplastic analysis results in contrast

In order to ensure the accuracy of pushover analysis, the lateral thrust load of the two schemes is a nonlinear analysis of step-by-step. In the form of lateral thrust load, a more general form of inverted triangular load is adopted. Through the static elastoplastic analysis, monitoring under horizontal force top horizontal displacement of the structure, when the top horizontal displacement is more than a predetermined level displacement value, ended the static elastoplastic analysis, two solutions are given respectively structure under different level earthquake interlayer displacement Angle and performance point, see Table 4 and Table 5.

The analysis shows that under severe earthquake (level 3) plan a two interlayer displacement Angle decreased, plan a second base shear than, show that second scheme has better ability to resist lateral, and under severe earthquake, grille type steel tube concrete shear wall structure still can bear larger load, reduce the earthquake effect of frame column.

Table4 The corresponding layer displacement Angle and the base shear force (case 1)

Earthquake level	X direction		Y direction	
	Interlayer displacement Angle	Base shear (kN)	Interlayer displacement Angle	Base shear (kN)
Level 1	1/1124	8231.03	1/1184	9274.74
Level 2	1/510	13743.60	1/530	14221.00
Level 3	1/204	25274.30	1/230	25922.30

Table5 The corresponding layer displacement Angle and the base shear force (plan 2)

Earthquake level	X direction		Y direction	
	Interlayer displacement Angle	Base shear (kN)	Interlayer displacement Angle	Base shear (kN)
Level 1	1/1345	9087.78	1/1456	10211.98
Level 2	1/729	18676.00	1/759	19221.10
Level 3	1/342	42095.30	1/378	43082.35

3.4. Structural performance point plastic hinge contrast

Solution with a medium in the performance point of the plastic hinge distribution as shown in Figure 5, most of the coupling beam shear wall cracking, coupling beam models shows that shear wall stiffness significantly degraded, and cracks at the bottom to strengthen relatively concentrated area, other floors are only partial cracks, shows the overall structure in these areas is relatively weak, in the design should be properly adjusted and strengthened. Through the Pushover analysis, found the whole loading process, the beam end first produce plastic hinge, and the deformation of plastic hinge are mainly distributed in larger floor, then local yielding occurs at the bottom of the shear wall, and all of the side frame column concrete filled steel tube column is still in elastic state, did not produce plastic hinge, visible with concrete filled steel tube, steel reinforced concrete composite shear wall with sufficient strength and rigidity, there will be no serious damage, at the same time outside the framework under severe earthquake seismic performance is good, in line with the structure for the general requirements of the earthquake.

Solution two concrete filled steel tubular frame - grille type steel concrete composite shear wall at the performance point corresponding to the plastic hinge distribution is shown in Figure 6 (Y to the largest interlayer displacement Angle corresponding to the plastic hinge distribution is similar to X), the performance points, only part of the coupling beam shear wall cracking, models shows that composite shear wall stiffness coupling beam does not appear obvious degradation phenomenon, through the Pushover analysis, found the whole loading process, is also produce plastic hinge beam end first, basic does not appear to yield and shear wall at the bottom of the phenomenon, all side frame column concrete filled steel tube column is still in the elastic state, did not produce the plastic hinge. Thus can see, in the whole loading process, for the structural system of both grille type steel concrete composite shear wall and concrete frame column, the seismic performance of the under strong

earthquakes are also good, can ensure the structure of the first and second line of defense, work together, to unite combined stiffness increased, achieve the optimum, the most effective seismic performance.

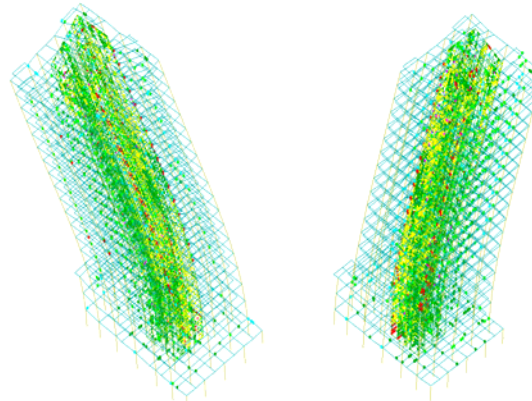


Fig.7 The plastic hinge profile of X and Y to the performance point of the severe earthquake. (case 1)

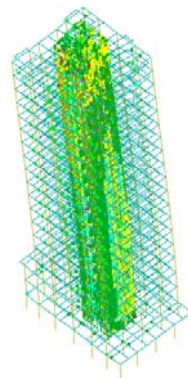


Fig.8 The plastic hinge profile of X to the performance point of the severe earthquake (case 2)

4. Conclusion

This article for the grille type steel concrete composite shear wall for more in-depth research, applied to concrete filled steel tubular column and the structure of the core tube system, from the point of view of static elastoplastic analysis in-depth study the grille type steel concrete composite shear wall seismic performance, and combined with steel reinforced concrete shear wall, the main conclusions are as follows:

(1)The grille type steel concrete composite shear wall seismic performance is good, under low reversed cyclic loading is a plump hysteresis curve, has advantages of high bearing capacity, ductility and energy dissipation capability is strong, can achieve high axial compression ratio, high ductility and seismic shear walls of the thin wall thickness design requirements.

(2)Ander severe earthquake, concrete-filled steel tube column - grille type double steel concrete composite shear wall structure with a small displacement between layers, distribution of shear wall base shear, show that grille type double steel concrete composite shear wall structure has good seismic performance.

(3)Combined with a layer of high-rise building, carry out concrete filled steel tubular frame - grille type steel concrete composite shear wall in the performance points corresponding to the plastic hinge distribution of research, research shows that: the performance points, only part of the coupling beam shear wall cracking, models show that composite shear wall stiffness coupling beam does not appear obvious degradation phenomenon, through the Pushover analysis, found the whole loading process, basic does not appear to yield shear wall at the bottom of the phenomenon, all side frame column concrete filled steel tube column is still in the elastic state, did not produce the plastic hinge.

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