Research Progress of Prefabricated Steel-Concrete Composite Shear Wall

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Abstract. Prefabricated structure is a kind of building structure that has been vigorously promoted and developed in recent years. Steel-concrete composite shear wall is an efficient load-bearing and lateral force resisting member. In order to apply it to prefabricated buildings, the characteristics of different forms of steel-concrete composite shear walls are analyzed, and the result shows that dual steel plate-concrete composite shear wall has good adaptability in prefabricated structure. A kind of prefabricated dual steel plate-concrete composite shear wall (PDSP-CCSW) suitable for prefabricated buildings is proposed, which takes into account the connection between the structural part and the building part. The pseudo-static test of the PDSP-CCSW are carried out and the results show that the PDSP-CCSW has good ductility and energy dissipation capacity, which can provide a basis for the engineering application of the PDSP-CCSW.

Keywords: Prefabricated structure; Steel-concrete composite shear wall; Seismic performance; Pseudo-static test.

1 INTRODUCTION

Prefabricated structure is a kind of building structure that has been vigorously promoted and developed in recent years. Based on the existing research on prefabricated structure, it has been shown that: compared with the traditional construction method that requires a large number of on-site operations, prefabricated structure has the advantages of design standardization, factory production, construction assembly, management informationization, and application intelligence which can reduce the dependence on the labor force in the construction industry.

What's more, based on the existing research on composite structures, it is shown that the steel-concrete composite shear wall can give full play to the respective advantages of steel and concrete to meet the high axial compression and high ductility requirements

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of high-rise building structures for shear walls, while reducing the amount of comprehensive materials and reducing the seismic effect of the structure.

At present, there is no complete design method for prefabricated steel-concrete composite shear wall structure in the current standards, and the theoretical research lags behind the engineering application. This paper adopts the method of combining experiment and theoretical analysis. First, the characteristics of different composite shear walls are analyzed, and then the prefabricated dual steel plate-concrete composite shear wall (PDSP-CCSW) which can be applied to prefabricated buildings is pointed out. Fially, the seismic performance of the PDSP-CCSW is analyzed by quasi-static test.

2 CLASSIFICATION OF STEEL-CONCRETE COMPOSITE SHEAR WALL

2.1 Unilateral Steel Plate-concrete Composite Shear Wall (USP-CCSW)

The USP-CCSW is composed of unilateral steel plate and concrete slab on the other side (**Fig 1**). It has the advantages of simple structure, less steel consumption. However, the asymmetric arrangement makes the wall prone to torsion, which is not conducive to its seismic performance.

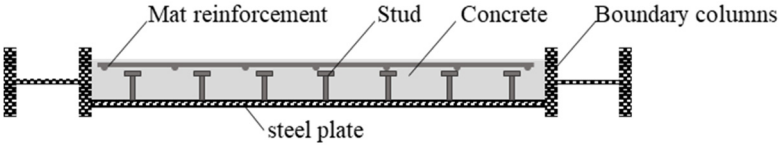

Fig. 1. USP-CCSW

2.2 Embedded Steel Plate-concrete Composite Shear Wall (ESP-CCSW)

The ESP-CCSW is composed of embedded steel plate and concrete slab on both sides (**Fig 2**). The concrete slabs on both sides can effectively restrain the out-of-plane deformation of the steel plate, delay the corrosion of the steel plate and the failure under fire. By setting connectors, the integrity of the wall can be effectively improved, with strong bearing capacity and good ductility. However, its on-site construction is relatively complex, which is not conducive to the application of the ESP-CCSW in prefabricated structures.

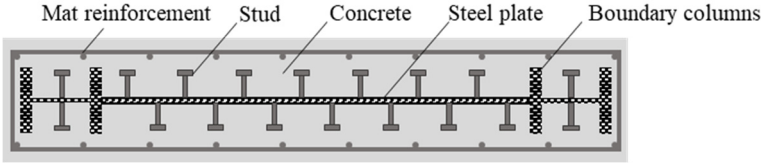

Fig. 2. ESP-CCSW

2.3 Dual Steel Plate-concrete Composite Shear Wall (DSP-CCSW)

The DSP-CCSW is composed of outer steel plate and inner concrete (**Fig 3**). The steel plate can effectively delay the crushing of the inner concrete and the inner concrete can inhibit the inward buckling of the outer steel plate [1]. What's more, the steel plate can be used as a pouring template for the inner concrete, which shortens the construction period and meets the development requirements of building assembly and industrialization.

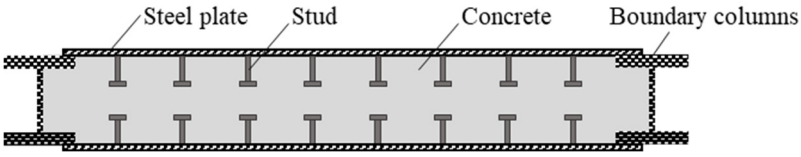

Fig. 3. DSP-CCSW

3 Prefabricated DSP-CCSW

3.1 Research on the DSP-CCSW

According to the characteristics of different types of steel-concrete composite shear wall, it can be concluded that DSP-CCSW is suitable for prefabricated buildings. The experimental and theoretical research on the mechanical properties of steel plate composite shear wall is mainly carried out according to different connector forms (**Fig 4**).

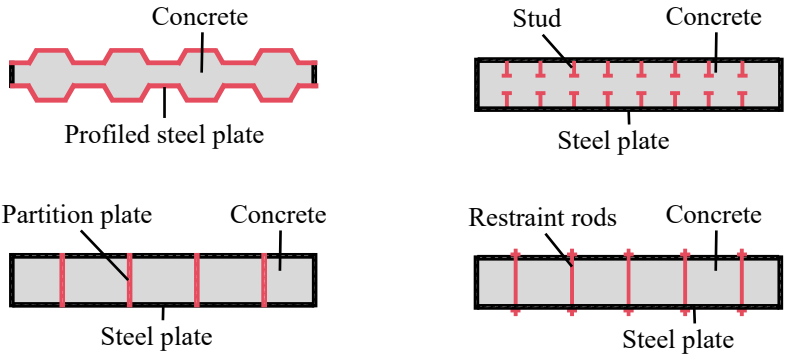

Fig. 4. Different connector forms DSP-CCSW

The profiled DSP-CCSW is the first study of the composite shear wall [2]. However, due to the lack of steel-concrete interface connectors, the bearing capacity of the specimen is quite different from the theoretical calculation value. In addition, the existing connector forms mainly include: welded studs, partition plate, and restraint rods [3,4]. And they all can delay the buckling of the steel plate, enhance the combined effect of

the steel plate and the concrete, and then exert the mechanical properties of the composite shear wall. Among them, the restraint rod DSP-CCSW shows good mechanical properties and economic performance.

3.2 Composition and Characteristics of PDSP-CCSW

The existing research on DSP-CCSW mainly focuses on the influence of different stiffening forms on mechanical properties while does not fully consider the integration of prefabricated decoration and prefabricated structure, which limits the transformation of research results to engineering applications.

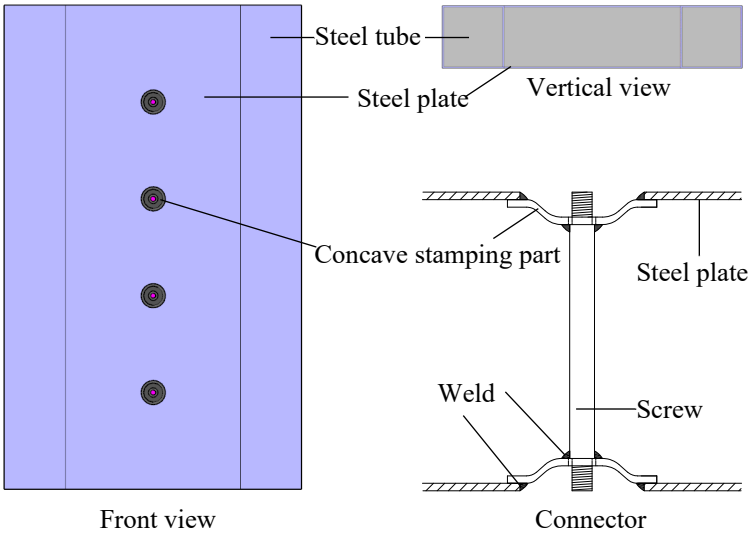

Fig. 5. PDSP-CCSW

In this paper, a kind of prefabricated DSP-CCSW (PDSP-CCSW) is proposed and the seismic performance is studied. Compared with the traditional DSP-CCSW, the PDSP-CCSW adds dumbbell-shaped connectors, which are welded by concave stamping parts and tension screws (**Fig 5**). The concaves on both sides of the connector reserve space for the connection between the shear wall and the decorative insulation board, which can promote the integration of prefabricated structure and fabricated decoration [5].

3.3 Test Results and Performance Evaluation

A quasi-static test was carried out on the PDSP-CCSW. After the test, the bottom of the end column square steel tube bulged, indicating that the failure mode of the specimen was compression-bending failure (**Fig 6**).

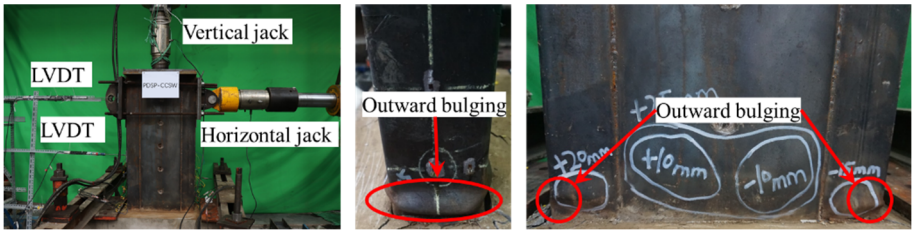

Fig. 6. Test of the PDSP-CCSW

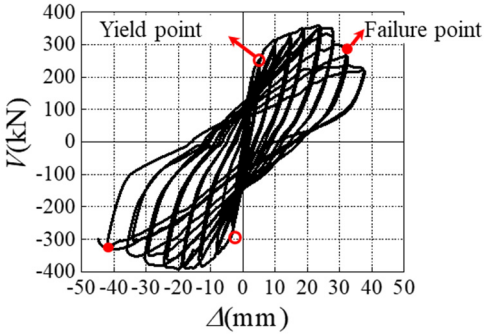

Fig. 7. Hysteresis curve of the PDSP-CCSW

According to the hysteresis curve of the PDSP-CCSW (**Fig 7**), the ultimate inter-story displacement angle of the wall is calculated to be 2.5%, the ductility coefficient is 4.94, and the equivalent viscous damping coefficient is 0.20 [6], indicating that the energy dissipation capacity is lower than that of the steel plate shear wall and higher than that of the reinforced concrete shear wall. What's more, the bearing capacity and stiffness of the wall, the spacing of the connectors are consistent with the calculation results of JGJ 380 [7].

4 CONCLUSION

In this paper, the research progress of prefabricated steel-concrete composite shear wall is studied and the following conclusions are obtained:

1) There are three forms of steel plate-concrete composite shear wall: USP-CCSW, ESP-CCSW, DSP-CCSW. By analyzing the characteristics of three forms of shear walls, it is shown that DSP-CCSW is suitable for prefabricated buildings.

2) Different connectors have a great influence on the mechanical properties of DSP-CCSW. The new connector proposed in this paper can realize the integration of prefabricated structure and fabricated decoration in the actual construction.

3) The results of PDSP-CCSW quasi-static test show that it's failure mode under earthquake is compression-bending failure. And the PDSP-CCSW shows good ductility and energy dissipation capacity.

4) The spacing of the connectors, the bearing capacity and stiffness of the PDSP-CCSW can be designed according to the relevant provisions of JGJ 380.

However, this paper only studies the wall, and does not study the connection between the wall and other structural components. So it is necessary to study the relevant connection joints to ensure the reliability of the structure in the future.

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