A review of the research on the lateral force resistance of cold-formed shear wall

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Abstract. In this paper, the research on the lateral force resistance of the existing cold-formed thin-walled steel shear wall was briefly summarized. The innovation of the new cold-formed thin-walled steel composite wall proposed in recent years and the improvement of the existing structure system were described. According to the research situation of home and abroad, the future prospect and development direction of this system were put forward.

1. Introduction

Cold-formed steel structure is similar to light-weight wood structure frame system in structure form, while cold-formed steel has the advantages of light weight, good anti-seismic performance, safe and reliable structure, good-looking appearance and environmental protection compared with wood. On account of the cold-formed steel structure system has the characteristics of good anti-seismic and anti-wind performance, fast construction speed and high degree of industrialization, the relevant departments of the state have vigorously promoted the new type of system houses in the pilot projects in various places, which have also played an important role in the post-disaster reconstruction.

The cold-formed steel composite wall is the main load-bearing and side-force resisting component of multilayer cold-formed steel building structure. The wall is composed of top track, bottom track, stud, wall panels, support and hold-downs. Among them, the stud, as the main force member of shear wall, can take a variety of cross section forms. The connection between members and members of the cold-formed steel structure composite wall, as well as between the surface material and the steel bones are all made of self-drilling screws, which makes the structure easy to install. A variety of support systems are arranged between the steel bones, and structural plates or decorative gypsum boards are installed on both sides to form a very reliable "plate and rib structure system". Cold-formed steel composite wall is the main load-bearing component of cold-formed steel structure residential buildings, which can well resist lateral horizontal load and various vertical loads such as the dead weight of buildings [1].

2. Present Foreign and Domestic Research

In view of the shear wall members that bear and transmit horizontal and vertical loads in the system, domestic and foreign scholars have conducted a lot of tests and theoretical studies on their shear, seismic and mechanical properties. The shear capacity of composite walls is usually determined by 1:1 wall model test. In recent years, the influence of some factors of the structure system, such as wall panel, connector, connector spacing, steel frame spacing, wall height to width ratio, wall open hole, load types and other factors on the cold-formed steel shear wall about the shear bearing performance
has been extensively studied. The research and application of cold-formed thin-walled steel composite wall has been matured in foreign countries, its design method has been written into the [2, 3] in North America and Europe in the specification. On the basis of existing researches, many scholars have carried out innovative experiments and researches to improve the lateral force resistance of the structures.

2.1. Study on corrugated steel sheet sheathings with slit

System development until now, the structure is mainly used in the three layers and three layers under construction. The limitation of the number of layers seriously restricted the wide application of cold-formed thin-walled steel composite wall. In order to apply it to areas of multilayer and small high-rise building, it is urgent to develop a new type of wall with high lateral stiffness, shear strength and high ductility. Because of the corrugated steel sheet sheathing has the incombustibility and the shear capacity is higher than the steel sheet sheathing, but the shear wall of corrugated steel sheet sheathing surface has poor ductility and other problems. Therefore, Wenying Zhang et al. [4] carried out horizontal monotonic loading and cyclic loading tests on the full-size specimens of cold-formed shear wall on the surface of four corrugated steel sheet sheathings with slit, and it was shown that the loading mode had no significant influence on the shear capacity of slit shear wall. The panel opening makes the shear wall with corrugated steel sheet sheathing cover have higher shear capacity and ductility. In addition, the simplified analysis model of cold-formed steel section building built by using OpenSees program shows that the cold-formed steel shear wall covered by corrugated steel sheet sheathing with slits can improve the collapse resistance of the structure.

2.2. Study on double-sided wall

Most of the experimental studies mainly focused on the composite wall structure form of single-layer cladding on both sides of the framework, which is suitable for low-rise cold-formed steel buildings. In the multi-story cold-formed steel buildings, in order to meet the requirements of seismic action and structural fire protection, the structural measures of at least double wall panels on the same side were adopted in the composite wall frame.

Ye et al. [5] completed the experimental study on full-size shear resistance of conventional composite wall with multiple ipsilateral double-layer sheathing, combining with the characteristics of multilayer buildings seismic requirements, fire prevention and convenience of construction, put forward the sandwich wall plate coated surface enhanced cold bending thin-wall steel composite wall, the full-scale reinforced wall designed and completed 11 pieces [6] low frequency cyclic loading tests, studied the wallboard combinations, the wall height to width ratio, stud section size, wall thickness, loading mode and other factors affect the performance of composite shear wall. The OpenSees numerical calculation model of cold-formed steel composite wall is established in the literature [7], which can accurately simulate the hysteretic behavior of light-steel composite wall covered by double layers and above on the same side under the action of low frequency cyclic load. But so far, there are few engineering examples of this kind of wall applied to the steel structure system. In short, compared with the low-rise cold-formed steel structure system under three floors, the theoretical research and engineering practice of the multilayer cold-formed steel structure system are not mature, and there are still many contents to be improved.
2.3. Study on sandwich panels

Literature [6] composite wall specimens mainly used sandwich panels as the framework with sheathing, the sandwich wallboard was spacing between the two layers of wall panel set up double plasterboard lath and rock wool insulation layer, the test results showed that the shear properties of the composite wall with sandwich panels is better than the composite wall with multiple ipsilateral double-layer sheathing. However, at present, the mechanical test of self-drilling screws joint composed of sandwich plate and cold-formed thin-walled steel framework needs to be improved.

In the literature [6], the influence of different wall panel combinations and wall aspect ratio on the shear performance of composite walls was analyzed. The influence of wall board screw distribution is further investigated by using OpenSees numerical model. It indicated that the spacing of wall board screws at the wall plate edge have a great influence on the shear performance of composite wall, while the spacing of wall board screws which are inside the wall board have a small influence on the shear performance of composite wall, and an improved simplified mechanical model of screws of wall panel is proposed.
3. Prospect
The applicability of the research results of wood structure in the design of cold-formed steel structure needs to be further studied.
Although there have been a lot of studies on light-steel composite walls covered by double layers and above wall panels on the same side, so far there have been few engineering examples of such walls being applied to multilayer cold-formed thin-walled steel structure systems.
The mechanical test of self-drilling screws connector composed of sandwich plate and cold-formed thin-walled steel framework needs to be completed.

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