Experimental Research on the Seismic Capability of new green building materials

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Abstract: It is the development trend of China's housing industry to actively research and develop new green building materials and promote renewable energy. Glass fiber gypsum board concrete frame is green building material, and it has many advantages in building structure, including load-bearing, thermal insulation and so on. Based on the experiments of structure under horizontal low cyclic loading, the seismic capacity of the connecting structure of the fiber-reinforced plasterboard and concrete frame is studied in this paper. Excellent seismic reliability of the two types connection had been shown in this experiment. So the scientific references to the designing and constructing of connection between fiber-reinforced plasterboard and concrete frame were offered.

1. INTRODUCTION

With the insufficient of building materials and structure resources in China. Solid clay bricks are forbidden to use in recent years by some relevant ministries and commissions of China. Therefore, to research and exploit new constructions and new wall-material is urgently.

Fiber-reinforced plasterboard as the reinforcing material, which is a new type of material mainly constituted of plaster with various fibers, also be praised as 'green building material'. It has several advantages: light weight, high strength, thermal insulation, good fire resistance, good moisture proofing, high elasticity, smooth surface, handy to construct and good breathing function etc., it is also popular with many people in recent years[1]. Fiberglass-reinforced plasterboard is constituted of calcined gypsum, the industries’ by-product of plaster and chemistry additive and reinforced by fiberglass. This kind of members usually is prefabricated in factory. It is in Australia where fiberglass-reinforced hollow plasterboard is produced primitively[2]. In general, concrete-filled fiber-reinforced plasterboard can be used as bearing component. On the contrary, empty type can’t be used as main wall. Emphasis is placed on the latter in this paper.

Fiberglass-reinforced light hollow plasterboard as a new type of rapidly produced wall-component, is freshly used in the field of construction in China. But it was researched rarely. Because they are always factory-prefabricated, and installed after transported to the construction spot, how to install them in a certain structure is the most important factor influencing their application and generalizing.

2. DESIGN OF THE CONNECTION STRUCTURES

In recent years, FRP hollow gypsum board has been widely used in concrete structures. In order to study its seismic performance, two connection modes (pre-installation method and post-installation method) between FRP hollow gypsum board and concrete frame have been designed, as shown in fig.1. In the pre-installation method, the C-shaped galvanized steel plate is connected with the fiber
reinforced gypsum board by self-tapping bolts, then the side formwork is supported, and finally the frame concrete is poured. In this structure, the C-shaped galvanized steel plate plays the same role as the end formwork. Post-installation method In the post-installation method, first support the side formwork and pour the frame concrete. Finally, the N-type galvanized steel plate of fiber reinforced gypsum board is connected to the concrete frame by self-tapping bolts. The seismic performance of two connection modes under reciprocating displacement is tested in this paper, including new building materials of glass fiber reinforced hollow gypsum board-concrete frame structure. The whole deformation capacity, characteristics of yield and load-displacement curve of the connectors are mainly studied. The reliability of the two connection modes under earthquake is estimated. It provides technical support for their application in practical engineering. To provide experimental data and theoretical basis for further research.

3. TEST PROGRAM

The size of test block is 3000mm × 2850mm × 180mm (length × width × height). The rectangular section of concrete frame is 400mm × 180mm (or 200mm), and the test equipment is shown in fig. 2. Local dimensions is shown in fig. 3. The horizontal low-cycle load is provided by MTS on the test sample, and the additional displacement controls the loading program during the test \[^{[3, 4]}\]. The loading procedure is shown in fig. 4. In the process of loading, the relative displacement between the center line of the top beam and the bottom beam of the test frame is measured by a displacement sensor, and the changes of the frame and the joint are observed and recorded. Observe the relative displacement between the top and bottom center lines to reach the control value until the structure or connection yields.
4. RESULTS AND DISCUSSION

4.1. Test Specimen of Pre-Installing Test Specimen

4.1.1. the Submit Process of the Test Specimen and the Working Behaviors of the Connection

The deformation of the specimen is in line with the test load. The first slender crack appeared at the joint between gypsum board and concrete frame, and the horizontal displacement was 6mm. This does not affect the normal work of the connecting specimen, and neither the gypsum board nor the frame frame is damaged in appearance.

With the increase of external load, the relationship between deformation and load is no longer linear elastic. When the displacement is increased to 12 mm, the cracks in the upper part of the gypsum board-frame connection increase obviously, near the joints of the frame appeared cracks inclined at about 45°. In the middle of gypsum board, there are three vertical cracks about 50 ~ 80cm long, and its near the inner ribs. The whole specimen is stable and the joints work well at the same time.

The specimen will yield at the time of the displacement is 16mm. Cracks increase at joints around gypsum board and frame, and at the same time, in the middle of gypsum board appeared many vertical cracks. However, it does not affect the normal operation of the connected specimen, and the whole specimen is still stable, it’s shown in fig. 5.
With the increase of test load, the number of cracks in green building materials increases and becomes longer and larger. When some vertical cracks pass through gypsum board, the green building material becomes several parallel vertical strips. When the displacement value is 30mm, the frame joints crack, and with the load increasing, until the frame yields. However, the joint between the two materials had little changes and can still work normally.

4.1.2. Load-Displacement Curve

The curve of the load-displacement is shown in fig.6. From the above curve, the following conclusions can be drawn: under the horizontal reciprocating load, the stiffness of the specimen decreases continuously. The four stages of elasticity, plasticity, hardening and decay can be described by curves [5, 6].

The shape of the ring is arched. It can be seen from fig. 6, which indicated that there is slight slip in the structure, including slip of connectors along joints and opening and closing of cracks, etc. the larger the area, the more energy the specimen absorbs, and the better the seismic performance of the specimen.

4.2. Post-Installing Test Piece

4.2.1. the Submit Process of the Test Specimen and the Working Behaviors of the Connection

Although, both the results of post-installing and the pre-installing one are similar, there are also differences from each other. The cracks throughout the joint between plasterboard and concrete frame appeared when the displacement is 6mm. Both the plasterboard and the frame were not damaged and the connecting specimen worked very well.

When the deformation is 6mm, cracks began to appear in the joint between gypsum board and concrete frame. Both the two materials were not damaged, and the specimens worked very well. When the deformation is 12mm, the cracks increased obviously, both the two materials were not damaged, the specimen was a whole and worked. When the deformation value is 22 mm, inclined cracks appeared in the corner of gypsum board, and the sample began to yield, while others were normal, and a single sample is stable, it was shown in fig.7. When the deformation reached 30mm, two vertical cracks appeared about 50cm in the middle of gypsum board, and the frame joints crack, the displacement increases, the frame were damaged, and the joint didn’t changed.
4.2.2. Load-Displacement Curve
The load-displacement curve is shown in fig. 8. Results show that: Under the horizontal reciprocating load, the stiffness of the specimen does not change obviously in the early stage after installation. The shape of the curve is similar to that of fig. 6, and the process of stiffness reduction of the curve is the same as that of fig. 6. The main reason is that the connection between gypsum board and frame is relatively weak, and the load-displacement curve reflects the characteristics of new green material frame. The transverse stiffness of the specimen before installation is larger than that of the specimen after installation in the early deformation.

4.3. Analysis and comparison to the two types of connection
Facts have proved that this new green building material can meet the seismic requirements. The reasons are as follows: the joint can still work normally when the displacement of the specimen is large, and the seismic resistance of the two connection structures is stronger than that of the whole specimen before connection, and the lateral deformation resistance is proved to be sufficient in the test.

If there is enough space on both sides of gypsum board, because these two types of connections are embedded, the deformability of this new green material will be greatly improved. In many practical projects, the gap between gypsum board and frame is zero. Transverse displacement is directly transmitted to gypsum board through connectors, which leads to the early occurrence of compression cracks of gypsum board, and the connecting specimens slip along the joint between gypsum board and frame. The crack near the joint is only a reflection of the relative displacement of the surface. However, in the post-installation method, the gap between the two is sufficient, so as to meet the construction requirements. Cracks in gypsum board are delayed because the lateral displacement is filled by the initial gap. This is also the reason why the transverse stiffness of the specimen before installation is greater than that post-installation.

5. CONCLUSIONS
According to the above research and analysis, the conclusions are as follows:

(1) The lateral deformation resistance and seismic performance of the new green frame structure are sufficient.

(2) The new green material connection joints can still work normally when the members yield, which indicates that the seismic capacity of the connection joints is greater than that of the frame structure.

Therefore, these two joint connections can be popularized and applied in seismic structures in glass fiber reinforced gypsum board-concrete frame structures. Due to the filling of integral gypsum board in new green materials, the stiffness of concrete frame will be affected. (reflected in the result comparison process).

Due to the limited space, this paper has not made a comparative study. In particular, the designer
should be reminded that this part of comparative experiments should be supplemented in practical engineering research.

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