Shaking table test of earthquake-damaged masonry structure strengthened with external BFRP

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Summary

Externally bonded FRP has been regarded as an effective strengthening technique, but its application in the retrofitting of damaged confined masonry buildings hasn't been studied. This paper conducted a research on a scaled three-story confined masonry structures before and after retrofitted with BFRP. The masonry model was initially tested to failure on a shaking table, from which its cracking development, acceleration responses and displacement were recorded. Strengthening process, including crack repairing, was then carried out on the pre-damaged model in situ. The strengthened model was retested on the shake table to evaluate the effectiveness of BFRP strengthening technique. The test results showed that the seismic performance of damaged masonry structure was significantly enhanced by BFRP strengthening technique.

Keywords: BFRP (Basalt Fiber Reinforced Polymer); strengthening; masonry structure; seismic behavior; shaking table test.

1. Introduction

There is an urgent need of strengthening or repair techniques to enhance the seismic performance of the undamaged or seismically damaged masonry structures for potential earthquakes.

Externally bonded FRP for masonry buildings has the advantages of low weight-strength ratio, short installation periods, and low intervention on the structures. Research on FRP strengthening technique mainly focuses on the strengthening of undamaged masonry walls and columns. The effectiveness of the FRP strengthening technique has been verified through extensive experiments. However, most of these studies focus on the strengthening of undamaged existing or newly-built masonry structures. There are limited publications related to the experimental study of application of the FRP repair method for seismically damaged masonry structures. Research related to BFRP strengthening of masonry structures has not been widely reported.

Based on the shaking table tests of scaled masonry structure before and after retrofitted with BFRP, the objective of this study is to verify the effectiveness of BFRP strengthening technique for the seismically damaged masonry structures. The outcomes of this study are anticipated to promote the application of BFRP composites in post-earthquake rehabilitation.

2. Experimental program

A 1:4 scaled masonry structure was tested on a shaking table (Fig. 1). The total height of the model structure is 1960 mm, and the wall thickness is 60 mm. The floor and roof slab thickness is 40, 80 mm, respectively. The total weight of masonry structure is 182.74 kN , including the foundation of the structure. Confining beams and columns are set surrounding the walls and openings.

The resulting cracks of the structure were used to simulate the damage of real structures during earthquakes. The structural damage concentrated on the first floor, mainly reflecting in the wall

https://doi.org/10.2749/222137813806501498

cracks and concrete crushing caused by the combined shear force and bending(Fig. 2). Strengthening process, including crack repairing, was then carried out on the pre-damaged model in situ (Fig. 3). The strengthened model was retested on the shaking table.

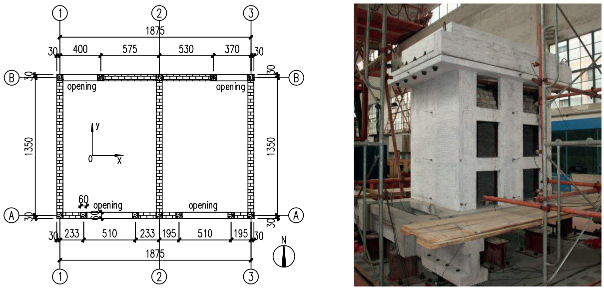

Fig.1: Scaled masonry structure

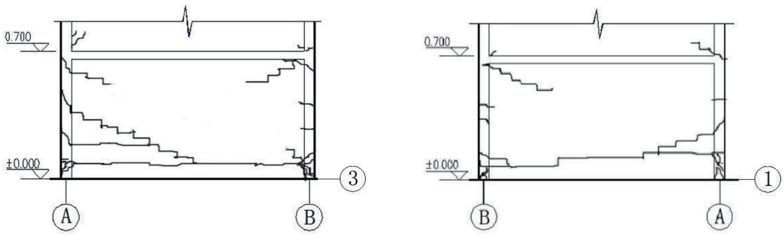

Fig.2: Cracks in transverse walls

Fig.3: BFRP strengthened structure

3. Results and Conclusions

By comparing the performance of the masonry structures during the two shaking table tests, it was found that BFRP strip can effectively prevent the development of cracks in the wall and promote a more smeared crack distribution. BFRP strengthening technique can significantly improve the seismically damaged structure's integrity as well as the whole stiffness. Meanwhile, it also postpones the stiffness degradation of masonry structure. The pre-damaged structure after BFRP strengthening has better ductility and seismic performance.

With the BFRP's excellent physical and mechanical properties as well as its low cost, the BFRP strengthening technique is proven to be one of the promising methods to enhance the seismic performance of the seismically damaged masonry structure. It is worthy to be applied in post-earthquake rehabilitation.