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Improvement of Out-of-Plane Behavior of Masonry Walls Using FRP Fibers

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ABSTRACT

In this research, the finite element modeling method as well as retrofitting of the masonry materials panel under the out-of-plane load was investigated by FRP composite using Abaqus software. In this study, a 1800-mm × 1800-mm wall was placed under an out-of-plane load and then reinforced using FRP sheets. The fibers were placed on the wall in two groups of CFRP and GFRP in four different ways. The wall was placed under a 60 kN out-of-plate load and the modeling results in Abaqus software showed that the wall reinforced with GFRP in Y-shape has 67% maximum performance improvement relative to other layouts, followed by the wall reinforced with CFRP sheet in X-shape with 66%. It is recommended to use these two layouts and fibers in construction.

Key words: Out-of-plane behavior, Masonry walls, FRP fibers, Von Mises, Performance improvements.

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1. INTRODUCTION

The buildings with non-reinforced masonry materials form a wide range of buildings. The statistics of mortality and destruction of buildings shows that masonry buildings have had the most damages from earthquakes (1-5). In addition, these buildings did not have a proper seismic behavior that most likely was due to the lack of proper ductility characteristic. The only structural elements of these buildings are brick shear walls that play the role of gravity and lateral load, which is why the techniques of restoration and reinforcing of walls, as well as the testing of actual samples and scale models, have attracted the attention of the researchers (6-9). The first studies were conducted on reinforcing the masonry wall with FRP fiber in 1994 to 1998 (10-12). Strap et al. (13) studied the out-of-plane FRP-reinforced masonry walls. In this study, they concluded that, in addition to using FRP sheets, they could significantly increase the resistance of the in-plane and out-of-plane masonry walls. When the panel is reinforced, the theory of reinforced concrete bending or reinforced masonry materials can be used to predict the wall's strength. Dimas et al. (14) examined the unprotected walls of non-reinforced masonry walls with FRP sheets under the out-of-plane load. In the presented paper, the behavior of the walls is expressed in three basic steps: the formation of the first visible cracks in the bed, the first separation between the FRP and the wall, and the failure model. In a laboratory study by Sayari (15), seven masonry walls reinforced with a variety of FRP sheets, with different settings and a combination of them on a large scale were made. In this study, walls of different thickness, applied by a simple rack on the four edges on one side and on the other side of the wall, uniformly loaded with an airbag on the wall surface. Now in this study, we investigated the behavior of FRP-reinforced masonry walls under out-of-plane force by modeling in Abaqus software to improve the out-of-plane behavior of the walls.

2. MATERIALS AND METHODS

In order to investigate and find out about the reinforcement of a masonry wall with FRP, a brick wall model with 1350 * 1350 mm dimension and 112.5 mm thickness was used. The wall is reinforced in 8 different modes with GFRP and CFRP sheets and analyzed under the compressive force up to 60 kN / m^2 in the Abaqus software (16), and the results were obtained including changes in the base cut, changes in the amount the maximum displacement outside the wall and the energy absorbed by the wall as well as the plastic strain curvature, which indicates the cracking of the wall,