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Masonry Reinforced with FRP - Walls with Openings

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Abstract

Plain masonry is considered one of the oldest construction materials. It can be traced back to ancient Egyptians who built the pyramids. Since then, a lot of masonry buildings were built with unreinforced masonry all around the world.

Unsatisfactory seismic performance of unreinforced masonry has been observed in earthquake zones around the world. This is attributed to its limited tensile and shear strengths. Unreinforced masonry walls are very stiff and exhibit a brittle response to lateral loads. Innovative methods of repair and seismic upgrading of unreinforced masonry walls are urgently needed. In response to such a need an ongoing comprehensive research program has been initiated at Helwan University to investigate the effectiveness of fiber reinforced plastic (FRP) as small fibers, added to the mortar, or laminates, glued to surface of the wall, to repair and strengthen unreinforced solid masonry walls with openings. The program was divided into two phases as follows:

The first phase was designed to study the improvement in tensile and shear strength of walls with openings when strengthened or repaired by strips of (FRP). The behaviour of model small assemblages, plain and strengthened with FRP, under in-plane joint shear and diagonal tension can represent possible modes of failure for unreinforced shear walls with openings. A total of nine walls are constructed and tested under diagonal splitting tension. The parameters studied are the opening/wall ratio and the method of repair or strengthening with FRP laminates.

The second phase was designed to study the behavior of shear walls with windows and doors under the action of in-plane shear. Thirteen half-scale masonry solid shear walls are constructed to be tested under vertical and lateral loads. The effect of openings, their size and location within the walls will be studied. The strategy of strengthening and repair of these walls is as follows: some of the walls are tested until a certain level of damage is reached then repaired with FRP laminates glued to the walls on both sides at the cracked zones only and retested again. The rest of the walls are strengthened using FRP before testing.

The results of the first phase only are presented in this paper. These results demonstrate that the FRP laminates are very effective in increasing the strength and the deformation ability (ductility) of these walls without significant increase in their stiffness or weight. Although the fiber plastic type is rather cheap and weak, it adds significantly to the wall's strength as the wall is originally very weak in tension and shear. Another advantages of this method of repair are the ease of application of this type of repair (no need for experienced labor) and the fast execution. Hence, this method of repair and strengthening can be considered as an adequate method for seismic upgrading of existing structures and for increasing shear strength and ductility for future structures. The main strength of this method of upgrading is that strips can be glued to zones of weakness or of expected plastic zones without the need of high technology. In the cases that need repair it can be glued to the cracking zones and around opening without the need to evacuate the building.