Seismic Retrofitting of Unreinforced Brick Masonry Panels with Glass Fibre Reinforced Polymers

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ABSTRACT

The out-of-plane performances of brick masonry panels with different retrofitting patterns using glass fibre reinforced polymers (GFRP) have been studied under three-point loading test. The panels were retrofitted on one side and both sides with different geometric configurations. The retrofitted specimens increased the failure load from 19.6 kN (UR) to 79.2 kN. It was observed that the flexural strength of the retrofitted patterns increased from 31.58% to 150% when compared to un-retrofitted specimens. Also, the bending moment of the retrofitted panels increased from 5.94 kNm to 8.96 kNm when retrofitted with one side, while it goes up to 14.88 kNm when retrofitted with both side as compared to un-retrofitted specimens. Further, it also observed that the panel with cross retrofitting showed more efficiency in terms of flexural strength, bending moment, stiffness and deformation capacity.

KEYWORDS
Flexural Strength, GFRP, Masonry Panel, Retrofitting, Three-Point Loading Test

INTRODUCTION

There are innumerable advantages of masonry construction over other of contemporary construction types, namely, reinforced concrete and steel, with respect to thermal comfort, sound control, less formwork, easy and inexpensive repair, use of locally available materials, the need of less skilled labour, less engineering intervention, etc. However, poor seismic withstand capacity is a major hindrance for its use in seismically active regions (Nanda et al, 2012 a, b). The failure of the structure may happen due to the less strength when it is loaded in-plane and out-of-plane directions. In a structure, there may be two types of force, one is vertical forces and other is horizontal forces. The URM walls are very much sensitive to horizontal forces and the walls may damage easily due to the forces and due to the failure of URM walls, there may be human life risk. The history of past earthquakes has shown that masonry buildings have performed the worst, suffered the maximum damage and also accounted for the maximum loss of life. Therefore, it is needed to improve their performance by retrofitting and strengthening to resist earthquake damages. Again, many of this masonry structures are historical buildings that should be preserved as cultural heritage (ASCE 41-13). Structural weakness, overloading, dynamic vibrations, settlements, and in-plane and out-of-plane deformations can cause failure of unreinforced masonry (URM) structures. The seismic capacity of URM buildings depends on the ability of out-of-plane walls to effectively transfer lateral forces to the foundations. In order to avoid out-of-plane flexural failure of URM walls, different retrofitting procedures have been adopted.
by different researchers. The seismic capacity of unreinforced masonry structures can be increased by increasing flexural strength and deformation capacity of masonry walls. Some of the retrofitting methods include the seismic retrofit of URM walls using externally-bonded Fibre Reinforced Polymer (FRP) laminates, bars and fabrics. Experiments on various patterns and layouts of FRP have validated that FRP can significantly increase In-plane and out-of-plane strength of URM walls. Higher strength to weight ratio, ease of application and corrosion resistance is some of the well-known advantages of FRP retrofitting technique over conventional retrofitting. Glass Fibre Reinforced Polymer (GFRP) (Mosallam, 2007) retrofitting can be used for higher strength against the failure of the structure and it can develop the design strength of the URM walls. GFRP gives the very high strength against the load in both out-of-plane and in-plane.

CFRP can significantly increase the bearing capacity of concrete masonry when subjected to out-of-plane loading (Al-Salloum & Almusallam, 2005). To respond to the interest of the engineering community, the American Concrete Institute (ACI) along with the existing masonry committee have formed a joint task group to develop design recommendations for the strengthening of masonry elements with FRP materials. Flexural strengthening of FRP systems has been proven to remarkably increase the flexural capacity (from 2 to 14 times), strength and pseudo-ductility of URM walls (Bui et al, 2010). FRP retrofitted walls were seismically strengthening various magnitude of the earthquake (Li et al, 2005). The effectiveness of the FRP composite strengthening systems in upgrading the out-of-plane flexural structural performance of URM walls (Ismail et al, 2012). However, there are some disadvantages too of FRP strengthening; removal is extremely difficult; the resins used for bonding are flammable and the resin slowly becomes brittle, the long-term reliability of FRPs is largely unproven.

In this present study, the response of brick masonry panels in the out-of-plane flexural test was investigated using GFRP with different patterns experimentally. Masonry panels were made in the casting laboratory with various retrofitting patterns using FRP and responses are compared with standard un-retrofitted masonry panel specimens. Out-of-plane flexural tensile strength perpendicular to bed joints was determined according to ASTM E518.

**EXPERIMENTAL PROGRAMME**

Fourteen solid clay brick masonry panels with a length of 600 mm, height of 600 mm and a thickness of 125 mm were casted for flexural bending test. The masonry panels constructed with brick and mortar joints. The dimension of brick is 250 mm × 125 mm × 75 mm. The thickness of mortar bed joints and head joints were kept 12.5 mm and 10 mm respectively. Each panel is built with 7 courses of brick. The materials used were representative of the materials used in existing masonry buildings in India. Masonry mechanical properties depend on the characteristics of the constituent elements (brick and mortar), as well as on the workmanship. Properties of constituents of masonry were determined experimentally. To determine the average compressive strength of brick, mortar and masonry prism, six replicate specimens were tested for each case according to IS 3495: 1992, ASTM C109/ C109 M and ASTM C1314-16 respectively. Table 1 represents the compressive strength of brick, mortar and masonry prism and the average value obtained to be 9.43 MPa, 4.40 MPa and 3.49 MPa respectively.

Different retrofitting configurations i.e. parallel, diagonal and cross pattern used by using GFRP. GFRP has a very high strength to weight ratio and unaffected by acid rain, salts, and most chemicals. GFRP is an engineered material composed of a polyester or epoxy resin, reinforced with glass fibres. In previous researches, retrofit of FRP was able to reduce the inherent variability of URM. In this study, one specimen was kept unreinforced and six specimens were strengthened, by one layer of
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