ABSTRACT

Masonry structures are prone to extensive damage followed by failure and collapse when subjected to loads resulting from wind, earthquake and other natural or man-made events. Recent earthquakes and terrorist acts have clearly demonstrated the need for the development of effective and affordable strategies for the strengthening of masonry. As a response to these challenges, fiber reinforced polymer (FRP) composites are found to offer technically and economically viable solutions. In the context of research undertaken worldwide, this thesis presents an overview of the studies and field applications of masonry strengthening with FRP composites as conducted in the last few decades.

In particular, the thesis covers basic materials and installation techniques, namely: externally bonded laminates, experimental test programs dealing with the out-of-plane behaviour of walls with discussion of failure modes and applications including historical structures. Without providing full details, an effort has been made to address issues related to design so that practicing engineers can immediately appreciate the potential of this technology and understand the key parameters affecting performance and the areas that need further experimentation. The objective of the research is to study the failure pattern of simple masonry elements with and without GFRP wrapping subjected to base shock vibrations for out-of-plane loadings, the behaviour of GFRP wrapped masonry elements were compared with conventional masonry elements in terms of first crack load, energy absorption, velocity of impact, cumulative energy, Peak Base Acceleration (PBA), and Peak Response Acceleration (PRA).
Further, to critically analyze the effectiveness of different GFRP layouts subjected to base shock excitation and to observe the response of the wall by changing different impact actions. Also, to assess the accuracy and performance of available analytical formulations from masonry standards of masonry walls and to compare the experimental results with the values obtained from numerical and analytical study was made to understand the failure modes. This thesis starts with a brief review of the existing rehabilitation methods available and explains that the use of FRP is a possible alternative. Results of material tests performed on the masonry and fiber materials are then presented.

The overall results show that externally applied FRP greatly increases the strength and energy absorption capacity of un-reinforced masonry walls. This thesis reports on finite element models which are developed to predict the response of masonry walls in the case of out-of-plane loading. The wall panels made of clay bricks were investigated and the effectiveness of different types of FRP elements used for strengthening is analysed. The behaviour of FRP strengthened masonry walls subject to out-of-plane loading is examined and then both experimental and numerical results compared and found to be in close agreement.

In this investigation, an un-plastered and plastered masonry panel of size 1 m x 1 m x 0.15 m was installed on a specially developed shock table for this occasion and tested. Under the base impact, using pendulum of varying masses and height of fall, collection of details of time history of vibration, acceleration, energy absorption, and failure pattern of panels is possible. The panels were repaired using three different types of GFRP wrappings, namely, vertical, diagonal and inner diagonal patterns.
They were later tested in the same manner and corresponding quantities were collected. The frequency of unrepaired panel was 10 Hz and that of repaired panel was 17.5 Hz.

The energy absorption of the plastered wall panel was greater than that of unplastered one by 2.75 times. In the case of unplastered and strengthened panel with GFRP, the energy absorption was 65 times higher than that of un-strengthened and un-plastered panel. In the case of plastered and strengthened panel, energy absorption was 34.45 times higher than that of plastered panel without GFRP wrapping.

Among the GFRP strengthened and plastered wall panels, those provided with diagonal inner wrappings behaved well and sustained a greater number of impacts and absorbed more energy.

The conclusion drawn from this experimental and numerical investigation is that panel strengthen with GFRP behaved monolithically by preserving its integrity, enhancing higher energy absorption and sustaining more numbers of impacts over virgin panel.