Masters Thesis

OUT-OF-PLANE STRENGTHENING OF UNREINFORCED MASONRY WALLS USING FRP TECHNIQUES

BY

QI YANG

B.E., Civil/Structural

School of Civil and Environmental Engineering

The University of Adelaide

May 2007

ABSTRACT

Unreinforced masonry (URM) structures comprise a significant proportion of the building stock in many countries worldwide, however they do not behave well under out-of-plane loading, such as that experienced during seismic events. Consequently, many existing masonry structures require some form of retrofit to comply with existing codes. Moreover, retrofit solutions of historical structures must also consider the impact on aesthetics. Hence, research is being directed to developing quick and efficient retrofitting techniques with negligible aesthetic impact.

As part of ongoing research at The University of Adelaide on the out-of-plane behaviour of URM walls, this study was carried out to develop and test innovative fibre reinforced polymer (FRP) strengthening techniques for retrofitting of masonry walls in order to sustain out-of-plane bending. Both externally bonded (EB) and near-surface mounted (NSM) techniques were applied. Twenty-seven push-pull tests were conducted to study the FRP-to-masonry bond behaviour with the variables including: masonry surface preparation; bonding agent of masonry bed joints; location of FRP strips; FRP materials; and, geometric properties. An FRP-to-masonry bond model was developed by modifying an existing FRP-to-concrete bond strength model. Four severely damaged URM full-scale walls (with window openings), previously tested under reversed-cyclic loading, were repaired with either glass FRP (GFRP) or carbon FRP (CFRP) EB vertical strips (3 walls) and CFRP NSM vertical strips (1 wall) and tested under two-way monotonic out-of-plane bending to quantify the increase in strength and ductility relative to the original and residual capacities of the URM walls. Air bags were used to apply lateral pressure onto the FRP strengthened URM wall specimens to simulate out-of-plane load induced by earthquakes. Based on these tests, a lower bound mechanics based analysis approach was developed to predict the failure mode and out-of-plane capacity of URM walls repaired with adhesively bonded vertical strips.

It is anticipated that the results of this study will lead to the development of FRP strengthening techniques for URM structures in practical use, upgrading existing masonry buildings for seismic loading and also to extend their service life. The implementation of this innovative technique could have a significant economic impact in addition to the cultural and social impacts on conservation of the architectural heritage.

CONTENTS