In-plane Shear Behaviour of Unreinforced Masonry Panels Strengthened with Fibre Reinforced Polymer Strips

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I hereby certify that the work embodied in this thesis is the result of original research and has not been submitted for a higher degree to any other University or Institution.

I hereby certify that the work embodied in this thesis contains a published paper of which I am a joint author. The research work presented in Chapter 3 of this thesis has been published in the Journal of Composites for Construction:

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I am solely responsible for the research presented in this joint publication, under the supervision of Mark Masia and Rudi Seracino.

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Mark Masia (supervisor)

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CONTENTS

ABSTRACT

Inserting fibre reinforced polymer (FRP) strips into pre-cut grooves in the surface of masonry walls is an emerging technique for the retrofit of unreinforced masonry (URM) structures. This method, known as near surface mounting (NSM), provides significant advantages over externally bonded FRP strips in that it has less of an effect on the aesthetics of a structure and can sustain higher loading before debonding. As this technique is relatively new, few studies into the behaviour of masonry walls strengthened using this technique have been conducted.

A combined experimental and numerical program was conducted as part of this research project to study the in-plane shear behaviour of masonry wall panels strengthened with NSM carbon FRP (CFRP) strips. In this project the FRP strips were designed to resist sliding along mortar bed joints and diagonal cracking (through mortar joints and brick units). Both of these failure modes are common to masonry shear walls. Different reinforcement orientations were used, including: vertical; horizontal; and a combination of both.

The first stage of the project involved characterising the bond between the FRP and the masonry using experimental pull tests (18 in total). From these tests the bond strength, the critical bond length and the local bond-slip relationship of the debonding interface was determined.

The second stage of the project involved conducting diagonal tension/shear tests on masonry panels. A total of four URM wall panels and seven strengthened wall panels were tested. These tests were used to determine: the effectiveness of the reinforcement; the failure modes; the reinforcement mechanisms; and the behaviour of the bond between the masonry and the FRP in the case of a panel.

The third stage of the project involved developing a finite element model to help understand the experimental results. The masonry was modelled using the micro-modelling approach, and the FRP was attached to the masonry model using the bond-slip relationships determined from the pull tests.

Reinforcement schemes in which vertical FRP strips were used improved the strength and ductility of the masonry wall panels. When only horizontal strips were used to reinforce a wall panel, failure occurred along an un-strengthened bed joint and the increase in strength and ductility was negligible. The vertical reinforcement prevented URM sliding failure by restraining the opening (dilation) of the sliding cracks that developed through the mortar bed joints.

The finite element model reproduced the key behaviours observed in the experiments for both the unreinforced and FRP strengthened wall panels. This model would potentially be useful for the development of design equations.