FIBRE REINFORCED POLYMER PLATES AND ANCHORS FOR STRENGTHENING OF MASONRY WALLS

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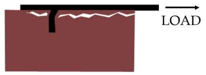
THE PROBLEM

Unreinforced masonry (URM) buildings are particularly vulnerable under earthquake loads. Typical damage includes out-of-plane wall failure as well as fallen chimneys and parapets.

Due to their heritage value and the cost of rebuilding structures, many of these URM buildings still exist today. It is estimated that URM buildings make up 35% of buildings in the Adelaide CBD, likely to be well below current design standards (Griffith et al. 2013).

There is great need to strengthen and rehabilitate existing masonry structures. Seismic retrofitting using fibre reinforced polymer (FRP) plates is popular due to its lightweight, ease of application and durability. The most common type of failure is debonding of the FRP (where the plate detaches from the brick). This is a sudden failure mechanism and means that the strength and strain capacity of the FRP are often underutilised.

THE SOLUTION



The simple addition of FRP anchors can improve both the strength and ductility of the system. Ductility allows structures to absorb energy and undergo larger deformations before permanent damage.

This is achieved through additional transfer of load at the location of the anchor. With appropriate design techniques, anchored retrofits can withstand load after debonding of the plate.

THE RESEARCH GAPS

Practical application of FRP anchors is limited by little understanding of combined reinforcement behaviour and lack of specific design guidelines. There is limited knowledge of how an anchor effects the strain distribution of the plate. It has simply been assumed that there is a transfer of load at a discrete location. Without a simplified design approach, FRP anchorage has been superseded by other forms of retrofitting. To develop such guidelines, a simplified model of the system must first be created.

ACKNOWLEDGEMENTS

We thank Dr Jaroslav Vaculik and Dr Phillip Visintin for their guidance through the project. Also to Scott Letton and Simon Golding for assisting in the lab. We also acknowledge the support of Jaya Kashyap for providing past data, allowing the validation of the final member load-displacement model.

REFERENCES

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AIM 1 — MODELLING THE BEHAVIOUR OF MASONRY RETROFITS WITH ANCHORS

AN ANCHORED SPECIMEN

OBJECTIVE To develop a model for the load displacement relationship of a combined FRP bonded plate and anchor prism using numerical techniques.

APPROACH

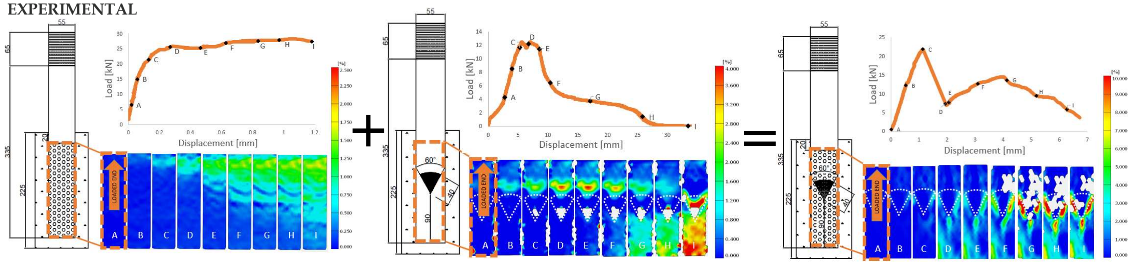
EXPERIMENTAL
Attain local bond-slip relationships for plate and anchor separately. Record and compare global load-slip behaviour of a combined specimen.

MODELLING
Predict global load-slip behaviour for a combined specimen and compare/validate with experimental data using a partial interaction model.

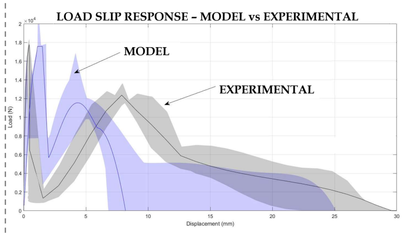
RESULTS

The load deflection relationship of the FRP plate and anchor system followed an effective superposition of the load deflection relationship of the plate and anchor separately.

EXPERIMENTAL



MODELLING



STRAIN BEHAVIOUR – Distribution of strain was dependent on propagation of cracks in substrate caused by the anchor. Points of high strain generally occurred at the boundary between the plate and the perimeter of the anchor or at the insertion point of the anchor. In addition, the strain in the anchor fan was observed to be lower due to a higher stiffness.

GLOBAL RESPONSE – The model provided a good approximation of plate peak load along with the residual anchor peak loads. However, the model was unable to capture the displacement capacity of the experimental series due to variation in failure modes and the unconfined nature of the brick specimens.

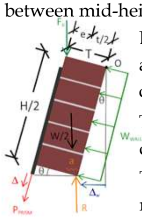
AIM 2 — DEVELOP A LOAD DISPLACEMENT MODEL FOR A RETROFITTED WALL

OBJECTIVE - To develop a simplified method to FRP retrofit design for out of plane loading on a unreinforced masonry wall.

APPROACH

It was assumed that the wall would develop a horizontal crack at the centre and that the two sections of wall would pivot about the crack. One of these sections is shown below.

Principles of rigid body motion, geometry and statics were used to determine the relationship between mid-height deflection and applied out of plane loading on a wall.



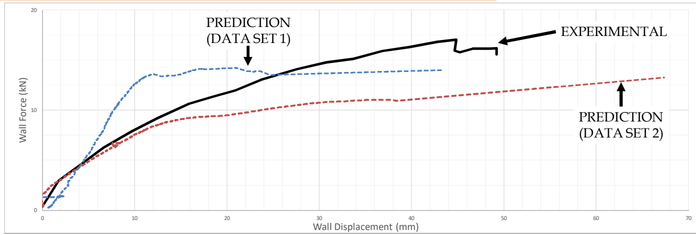
Load-displacement data from a pull test (P_{PRISM}) and (Δ) was used to calculate the applied load on the wall (W_{WALL}) and the mid-height displacement (Δ_W) (this data can be sourced from experimental tests or analytic/numerical models).

The displacement of the wall (Δ_W) was calculated by summing the wall displacement due to elastic deformation and deflection under rigid body motion.

The out of plane force on the wall (W_{WALL}) was calculated by summing the moments about point O.

OUTCOME

The model was validated using the input of two experimental pull-test data sets obtained from Kashyap et al. (2012) to predict wall behaviour. The predictions were then compared to experimental wall test data by Griffith, Kashyap & Ali (2013). The model provided an accurate prediction of the load-displacement curve considering the variability of masonry.



CONCLUSIONS & FUTURE RESEARCH

The combined effect of the anchor and plate system was modelled using a numerical approach (partial interaction model). The model prediction was comparable to the experimental results. Future research could consider validating these results with an analytically based approach.

It was found that there was an increased region of strain around the anchor and not simply at the insertion point, as has been assumed in previous studies. It was also found that strain in the anchor fan was lower due to it having a higher stiffness.

A simplified approach was developed for the analysis of a wall for a 1 strip FRP retrofit. Future research could focus on developing the robustness of the model for walls retrofitted with more FRP strips.