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Department of Structural Engineering

Seismic Behavior of Confined Masonry Walls Retrofitted by Fiber Reinforced Polymers

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Civil Engineering (Structural Eng.)

The work included in this thesis was carried out by the author in the Department of Structural Engineering, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis has been submitted for a degree or qualification at any other university or institution.

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ABSTRACT

TITLE : "Seismic Behavior of Confined Masonry Walls Retrofitted by Fiber Reinforced Polymers"

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Confined masonry building is a common kind of construction found in many parts of the world. It represents one of the cheap and economic forms of construction. With the lack of codified design provisions in addition to experience base construction of such buildings, the issue of retrofitting existing confined masonry structures surface as the primary aim of the thesis at hand. The primary aim of thesis was to conduct an extensive experimental – analytical investigation of confined masonry wall assemblies retrofitted with CFRP sheets subjected to lateral loads. In this respect, the experimental phase of the research included the testing of three full-scale wall assemblies, consisting of a clay masonry panel, two confining columns and a tie beam retrofitted by CFRP under a combination of vertical load and monotonic pushover up to failure. Wall assemblies had various configurations, namely solid, perforated with window and door openings. The retrofitting scheme relied on using epoxy bonded CFRP sheets applied to untested walls in configurations tracking the principal tension fields. Experimental results showed that the wall assemblies experience a shear failure at the ends of the lightly reinforced confining elements after the failure of the diagonal struts formed in the masonry wall due to transversal diagonal tension. The application of CFRP sheets enhanced the lateral load capacity and displacement ductility significantly. Wall specimens' results were compared with unretrofittted walls tested by other researchers in the research program.

In the analytical phase of the research program, a numerical model based on nonlinear finite element analysis was developed and validated in light of the experimental program. The analytical results from the finite element analysis of both retrofitted and unretrofitted walls shows

that the developed models are capable with high accuracy to capture the ultimate load and displacement capacities of the tested walls
Key experimental and analytical findings indicate that using Fiber Reinforced Polymer to retrofit confined masonry walls enhance the lateral load behavior of confined masonry walls significantly. A parametric study was carried to expand results database for multiple design variations including CFRP amount, CFRP configuration, eccentric openings and opening location. By increasing the amount of Fiber Reinforcement Polymers, the lateral load capacity for both solid wall and wall with window opening as well as ultimate displacement capacity increased significantly. The increase was significantly lower for walls with door opening.
The parametric study also shed some light on different CFRP configurations that showed either economic or response merits over the experimentally tested configurations. The analyses of perforated walls with eccentric openings showed that the effect of CFRP sheets on the increase of ultimate lateral load and ultimate displacement capacities decreases as the amount of perforation in the confined panel increases. For opening location for retrofitting perforated walls, CFRP sheets showed a similar enhancement for panels with eccentric perforations when compared to concentric ones.

Keywords: Confined Masonry, Seismic Behavior, Lateral Loads, Shear Failure, Retrofitting, Composite Material, CFRP.

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