REHABILITATION OF EXISTING UN-REINFORCED MASONRY (URM) STRUCTURES USING CFRP FABRICS

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1 INTRODUCTION

The most important recent earthquakes have produced extensive damage in a large number of existing un-reinforced masonry (URM) buildings, showing the need of rehabilitation techniques for masonry structures. There are many paper that be written on the rehabilitation of existing reinforced concrete structures using cfrp fabrics, but the article for usage of this technology for masonry structure is very low. Trying for rehabilitation of existing un-reinforced masonry structures using cfrp fabrics is very importance. Not many investigations on the use of externally bonded FRP laminates or fabric as in-plane shear reinforcement of masonry walls has been reported. This case is caused in this search. Under diagonal compression, twelve URM panels masonry with externally bonded carbon fiber reinforced polymer (CFRP) laminates and sheets are tested. Panels with three configurations of the reinforcement were subjected to monotonic and cyclic loading.

2 REVIEVE OF LITERATURE AND RELEVANT TOPICS

Experimental results reported by Schwegler, Priestley and Sieble and Laursen [1]show that masonry walls externally reinforced with FRP and subjected to in-plane shear have large increase of strength and load deformation capacity. Valluzi [2] reported that 24 externally reinforced masonry panels subjected to diagonal compression had between 15 and 70% increase of strength. This search completes Santa-Maria's paper [1]. An experimental study was initiated at the METU (university in Ankara) Structural Mechanics Laboratory, which aimed to develop such strengthening techniques [3]. The arrangement of the CFRP layers, the amount of CFRP used the anchorage of CFRP fabric to the wall and the frame elements were the major parameters investigated. Effect of cross-sectional shapes, vertical applied loads and horizontal wall reinforcement on seismic behavior of walls is studied by koji [4].

3 Aims and Hypothesizes

This research reports the results of the tests in terms of strength, mechanism of failure, stiffness, and energy dissipation. Relationships between most important parameters as the number of wrap layers are obtained. External CFRP reinforcement decreases the thickness of the cracks and increases the shear strength and stiffness of the panels. The contribution of two configurations of CFRP reinforcement on the shear behavior of hollow clay brick panels will be experimentally investigated. Monotonic and cyclic loadings are be considered.

4 Methodology

All of the tests did under diagonal compression twelve URM panels masonry with externally bonded carbon fiber reinforce polymer (CFRP) laminates and sheets. Panels with three configurations of the reinforcement were subjected to monotonic and cyclic loading. 17 specimens constructed with low strength masonry, without bars and without adequate transverse reinforcement were tested under constant axial and reversed cyclic lateral loads. Three URM panels and fourteen URM panels with externally bonded CFRP will be loaded to failure under diagonal compression: 11 panels will be subjected to monotonic loading and 6 to cyclic loading. Two reinforcement configurations were used: diagonal and horizontal. The objective of these tests will be to simulate the in-plane shear phenomenon to quantify the improvement in shear resistance, stiffness, and energy dissipation of the brittle masonry elements, and to study the effect of the load reversal on the efficiency of the reinforcement and the behavior of the panels.

5 EXPERIMENTAL PROGRAM

5.1 Materials

Two types of FRP reinforcement with unidirectional fibers will be used in this investigation. Their dimensions and main mechanical characteristics, according to the fabricator, are shown in Table 1.

Table 1 Nominal dimensions and mechanical properties of the FRP reinforcement

Fabric(mm)	Laminate (mm)	Type of Fibber
0.17	0.9	Thickness (mm)
370	250	Characteristic tensile strength(MPa)
231	165	Tensile modulus of elasticity (GPa)
0.017	0.017	Ultimate tensile strain

Pull-off tests will be performed to both reinforcement types. Rupture will be occurred at the bricks or between the adhesive and the fabric. Mechanism of Rupture will be discussed. The panels were fabricated using hollow clay bricks (140x290x112 mm), with approximately 12-mm-thick mortar joints. The average prismatic strength & the bond strength are measured . Commercially available premixed mortar will be used. The monotonically loaded panels had cylinder compressive strength of (18~22) MPa and tensile strength equal to (5~6) MPa, while in the rest of the panels the cylinder compressive strength and the tensile strength will be equal to (9~10) MPa and (3.1~3.6) MPa, respectively.

5.2 Test Specimens

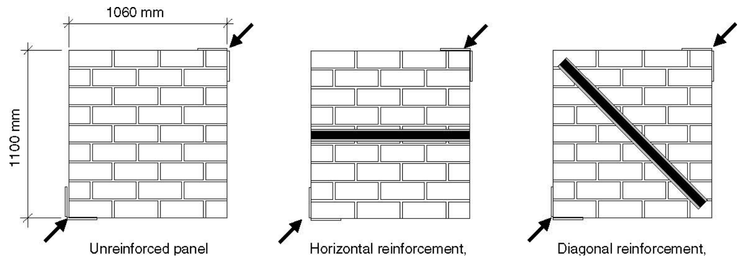
A series of 17 masonry panels with nominal dimensions of 1060x1100x140 mm will build. Fourteen panels will be reinforced with one strip of laminate or fabric sheet on each side and 3 panels will not reinforced. The specimens with diagonal reinforcement tested under monotonic loading will be reinforced only along the diagonal in tension.The characters of the alphanumeric code used to identify the specimens indicate the type of reinforcement and load scheme as follows: the first character indicates if it is a monotonic (M) or cyclic (C) test; the second shows if it is a panel un-reinforced (U), with diagonal reinforcement (D), or with horizontal reinforcement (H); the third character indicates if the reinforcement is CFRP laminate (L) or fabric (F); and the last one is the number of the specimen. four panels will be reinforced with CFRP laminates, two with 100 mm-wide fabric sheets, and two with a 200 mm-wide fabric sheet. ten panels will be reinforced with CFRP fabrics, five with 100 mm-wide fabric sheets, and five with a 200 mm-wide fabric sheet. Twelve panels will reinforced diagonally and the rest horizontally. Any panel will be reinforced on one side. The average strength of the un-reinforced panels will be ~140 kN, with a coefficient of variation of 21%. It is interesting to notice that the coefficient of variation of the strength of the reinforced panels will be decreased to less than 12%.

5.3 Testing Procedure

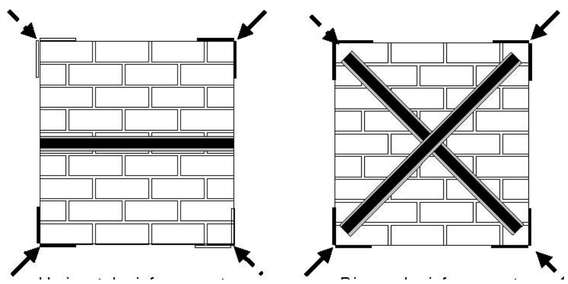
In the monotonic tests the load is increased up to failure. The cycle testing consisted of the following steps: diagonal compression up to a certain load level; unloading of the diagonal; compression of the second diagonal; and un-loading of this diagonal. Two cycles were performed at each load level, in increments of 24 kN. Average deformations were measured along the two diagonals of the panels and at 3 points along the reinforcement. The behaviour of the panels with different reinforcement layouts is discussed in the following sections. The different configurations of the reinforcement are shown in Fig 1.

5.4 Un-reinforced Panels

All the panels had a brittle failure, with a single wide diagonal splitting crack.



Monotonic and cyclic loading (MU, CU) . monotonic loading. (MHL, MHF) monotonic loading. (MDL, MDF)



Horizontal reinforcement cyclic loading. (CHL, CHF) Diagonal reinforcement, cyclic loading. (CDL, CDF)

Fig. 1 Dimensions of the panels and configurations of the reinforcement

5.5 Two sides diagonal reinforcement

The panels reinforced with laminates had slightly larger increase of maximum load than the panels reinforced with fabric sheets. This will be explained by the failure mode that occurred with each type of reinforcement

5.6 Two sides horizontal reinforcement

The failure mode of the panels will similar, irrespective of the type of reinforcement: delaminating started at one end of the reinforcement and propagated to the center, producing failure of the panels by splitting crack. Delaminating of the laminates started at lower loads than in the fabric because the contact surface was smaller in the former. Cyclic loading compared to monotonic loading

.The panels with diagonal laminates subjected to cyclic loading are suffered slight delaminating at the ends of the laminates.

5.7 Shear Modulus

Shear modulus of each specimen and average value for each reinforcement configuration are calculated. Even though the results show large dispersion, it can be concluded that the horizontal reinforcement slightly increases the shear stiffness of the panels, while the diagonal reinforcement increases up to 54% the average value of the modulus. This is independent of the type of reinforcement and the reinforcement ratio. Energy Dissipation The energy dissipation, expressed as the equivalent viscous damp coefficient, is calculated as[1]:

$$\zeta = \frac{W_d}{4\pi W_S} \tag{1}$$

Wd and Ws are the work in a hysteretic loop and the static work, respectively. Damping coefficients will be calculated for both cycles at each load level. Because of low improve strengthening at the One side reinforcement ,any panel are reinforced on one side. All of the CFRP sheets will have two widens & we can compare our results with other work simply

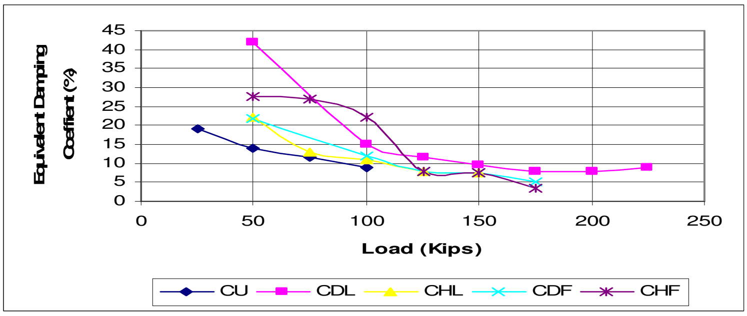


Fig.2 Equivalent damping coefficient at various load levels

6 CONCLUSIONS

- Diagonal reinforcement is more effective in terms of shear strength than horizontal reinforcement. The strength of the un-reinforced masonry panels can be increased up to 80%.
- Diagonal reinforcement increases the stiffness of the panels, while horizontal reinforcement has no effect on the stiffness.
- The CFRP reinforcement produces a slight increase of the equivalent damping coefficient of clay brick panels. The horizontal reinforcement is more effective in increasing the damping properties of the masonry panels.
- The panels reinforced will be showed cracks with small thickness, spread cracks, and a less brittle failure than the un-reinforced panels. The horizontal reinforcement is more effective in spreading the cracks.
- Panels subjected to monotonic and cyclic loading show similar behavior.
- High compressive stresses in the masonry produce de-bonding of CFRP fabrics.
- The results from diagonal compression tests are not representative of the behavior of full-scale walls, but give a general idea of the response of walls reinforced with CFRP.
- In the case of un-reinforced panels the damping coefficient in the first cycle was approximately 22% larger than in the second cycle due to internal damage of the masonry. The coefficient will be decrease approximately from 22% to 8% as the load increased. At a given load level the value of the damping coefficient of the reinforced panels will almost the same in both cycles. The damping coefficient will larger than in un-reinforced panels for low load levels, but it will be decreased from approximately 25% to 10% as the load increased up to failure.
- The panels reinforced with fabric have slightly larger damping coefficients than those reinforced with laminates. But the equivalent damping coefficient of all the reinforced panels tend to approximately 9%, the same value found for the un-reinforced panels.
- The diagonal configuration produces larger increase of strength and stiffness than the horizontal configuration.

ACKNOWLEDGEMENTS

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