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OUT-OF-PLANE SHEAR STRENGTH ASSISMENT OF TYPICAL AND GEOMATRICALY MODIFIED BRICKS

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ABSTRACT

Masonry walls are subjected to various loading like settlements, earthquakes, and wind loadings and other loadings, these loadings may cause in plane as well as out of plane shear stress in the wall which lead to masonry joints failures. The failures caused by various loading may affect the strength as well as the esthetics of masonry walls. Many researches have been performed to improve the shear strengths of masonry walls and many of them achieved the improved strengths.

In this research two types of bricks masonry are tested for the out of plane shear strength namely typical brick masonry and modified brick masonry. Typical brick masonry wall specimen are prepared from bricks typically available while that of modified brick masonry special bricks were prepared and then samples were prepared. The only difference between typical and modified bricks is that the modified bricks have groove on its header face which are filled with mortar to form a key. The dimensions of the both bricks are 9'' length 4.5'' width 3'' height.

In this research study three samples of each typical and modified bricks masonry wall are tested for out of plane shear strength. The dimension of the specimens are two feet length two feet height (2"×2") and the thickness of the wall is that of the thickness of the bricks.

KeyWords Out-of-plane shear strength, grove, Geometrically Modified Bricks, typical Bricks, Retrofiting

INTRODUCTION

Masonry walls are subjected to different loading which can cause in-plane and out-of-plane stresses in masonry walls. The masonry behavior is unpredictable during these loadings however many researches have been done to evaluate the performance of masonry under different loading conditions. As brick masonry is considered to be a nonstructural element mostly used for portioning due to small or sometime negligible effect on the design. The masonry is taken as dead load in many instances. The effect on masonry could be adverse consequences if measurement are not taken using standard methods. Masonry wall can take lateral loads due to its stiffness property. The seismic effect is enhanced by the wall as it increases the time period of the building. [1]
Bricks masonry failure are mainly caused by stresses causing cracks. The stresses overall impact of should be such a way that it does not cause serious failures and problems in the structures and the stress should be control and distributed over the area. Researches have been performed to increase the shear strengths of bricks masonry by using high strength materials, cements and reinforcement. Many retrofitting techniques are being used by researchers in which they have used steel to reduce the stress on masonry walls and to enhance shear strengths of masonry walls.in this study instead of reinforcement material or retrofitting technique only the geometry of the brick is changed to increase out of plane shear strength of the masonry wall.

RESEARCH OBJECTIVE

The primary objective is to enhance the out-of-plane shear capacity of brick masonry and to examine out of plane shear strength of brick masonry prepared from modified bricks.

LITERATURE REVIEW

Brick masonry is one of the oldest construction industry material used form thousands of years. Many researches are done for investigation of various parameters of brick masonry. The in-plane and out-plane shear stress of masonry are of major importance, which represent the overall strength of brick masonry.
A research work performed in which fiber-reinforcement composite was overplayed on an existing unreinforced masonry and was tested for the out-of-plane static load. Fifteen panels specimen with dimension of [1,200 3 1,800 3 200 mm (4 ft. 3 6 ft. 3 8 in.)] were investigated in the out-of-plane test which include 3 control sample and 12 strengthen samples. By Using ASTM E-72 standard testing procedure a uniform distributed load through air bag was applied to every masonry specimen. The mode of failure, ultimate loads, strain in the steel used as a reinforcement (FRP) and deformations of out of plane were noted. Shear failure is controlled. The flexural strength of unreinforced masonry wall increased by using retrofitting technique of externally bonded composite overlays. Though, the ultimate flexural strength is not attainable if the premature failure by shear at the support is measured and controlled. [2]
Carbon fiber-reinforced polymer laminate strips have been used in a research as a strengthening material. Five specimen of masonry block panels were investigated for shear strength. Masonry wall used in the research work having various arrangements. Both strengthen and unstrengthen specimen were subjected to a uniform load and were tested. The test setup was such a way that a cyclic out-of-plane spread pressure was applied to the specimens. The specimen were established in an upright frame and distributed pressure were applied through airbag. The Failure mode shown by the strengthened block wall was such that the failure was along the mortar joints. As compare to the unstrengthen wall the strengthen wall showed failure through both mortar joints and block at the carbon strip. The strengthen wall specimen's results showed high lateral load caring capability then strengthened. The strengthen wall specimen also showed more high ductility performance. [3]
One of the research work performed on masonry include a wall subjected to earthquake loading which applies both in-plane and out-of-plane loading on the wall. Different level of concurrent in-plane and out-of-plane loads on brick walls are represented. From the experimental result interaction between in plane and out-of-plane can be seen. A circular trend appear in the interaction curve of in plane and out of plane. For evaluating in plane and out of plane bending interaction a modest analytical method is presented. [4]

Various technique used for retrofitting or strengthening includes near surface mounted fiber reinforced polymer strips. As many masonry walls failure occur during earthquake therefore a minimally invasive earthquake strengthening method is need to be developed. As the typically clay brick showed poor performance in earthquakes. In the research study nine samples of masonry beam and five samples of masonry wall were tested. The test were performed on near-surface mounted (NSM) carbon fiber reinforced polymer (CFRP) strips retrofitted specimen for the evaluation of seismic resistance performance. By providing retrofitting to improve the shear strength performance of common bricks masonry panels. From the results it can be decided that NMS CFRP retrofitting technique is minimally warlike.
The consequences of the experimental tests established that for seismic strengthening of masonry wall the NSM CFRP retrofit method is an economical option which improved the out-of-plane shear strength capacity. For earthquake loading solidification of unreinforced masonry walls to counterattack out-of-plane earthquake tempted lateral forces. From the results we can see that CFRP strips expressively augmented equally the post-cracking wall flexural strength (stuck between 3.05 and 6.21 times the as-built wall strength) and the ductility capability of the unreinforced masonry walls. [5]
One of the all-inclusive researches study was reported in which 100 plus samples were tested samples are tested for the evaluation of dif-

ferent properties of bricks. From the experimental result the average Compressive strength (COV 22.89%) of the brick was 2.45 kips. [6] Another research was reported in which IRA and the 24-hours water absorption was evaluated. From the result IRA was founded to be 82.20 gm/min/30inch2 and the 24-hour water absorption is 19.3%. As the 24 hours water absorption is not under 20% therefore the bricks are desirable for the strength of brick masonry. If the pores are more in the brick then the water absorption could be more than 20% and the strength of brick get reduced. [6]

METHODOLOGY

BRICKS PREPARATION

The objective is the valuation and improvement of the out-of-plane shear strength of brick masonry. Therefore it was decided to change the shape of brick rather than changing the mortar or chemical properties of materials. For this perseverance, it was desirable to plan a geometrically modified shape brick. A geometrically modified shape of brick with voids on both headers was designated. The selected geometric mold can be used in the brick developing industry for preparation of bricks. Mold was made of Steel and for shear keys the keys which were also made of steel were mounted on the side of the mold (perpend). The dimensions of the mold are as that of the typical bricks mold (9''×4.5" ×3"). The keys dimensions were 2 inch length and 1 inch radius. Both the typical and modified bricks were prepared in the same kiln using the same material properties.
The diagram of mold for modified bricks is shown in Figure 1. And Figure 2 shows the finally modified bricks prepared in kiln after all the manufacturing process as for the typical bricks.

Figure 1 Modified bricks mold

Figure 2 Modified bricks

SAMPLE CASTING

A total of six panel of walls were prepared which consist of three typical and three modified bricks masonry wall panels with a two feet by two feet (2''×2'') length and width. Same mortar ratio of 1:6 was used while preparing the both the typical bricks walls and modified bricks walls panels. The casted sample and preparation of both typical and modified bricks are shown in Figure 3 and Figure 4.

Figure 3 preparation of specimen

Figure 4 casted samples of typical and modified bricks

TEST SETUPS

The test setup for the individual brick unit is as far ASTM C 140 03v[7], for IRA and 24 hours water absorption test were performed according to ASTM C 67v[8], for mortar cub test setup were as far ASTM C 109 [9]. and the test setup for the out-of-plane were such a way that support and hollow button was created by placing bricks under boundary of the sample and center load was applied through load cell with loading machine and the test setup are shown in Figure 5

Figure 5 Test setup for out-of-plane shear

RESULTS

Tests on masonry constituent material

Test on masonry unit bricks

The research study focus on the comparison of typical and modified clay fired bricks masonry which is commonly available in south Asian countries like Pakistan, India and other south Asian countries. The tests performed on both typical and modified bricks in this research study include brick unit compression test the results are shown in Table 1 and Table 2 test were performed as per ASTM C 140 03 [7].

Table 1 Typical bricks compressive strength

Typical bricks					
S No.	Brick Length (in)	Brick Width (in)	Brick Area (in^2)	Brick Maximum Load (lb.)	Brick Compression Strength(psi)
1	9	4.5	40.50	45,402.4	1121.36
2	9	4.5	40.50	71,409.6	1763.69
3	9	4.5	40.50	66,781.2	1649.38
Average					1,511.47

Table 2 Modified Bricks compressive strength

Modified Bricks					
S No.	Brick Length (in)	Brick Width (in)	Brick Area (in^2)	Brick Maximum Load (lb.)	Compression Strength(psi)
1	9	4.5	3	70,924.72	1751.34
2	9	4.5	3	55,055.92	1359.78
3	9	4.5	3	49,124.95	1218.89
average					1,443.33

The results of compressive strength of typical and modified bricks are 1.51 Ksi and 1.44 Ksi which are close to each other because the material used for both the types of bricks are same. There is a negligible difference in the average compressive strengths of typical and modified bricks.

The tests on brick unite also have water absorption tests IRA and 24-hours water absorption tests which are performed as far ASTM C 67 [8] the results are shown in Table 3,Table 4, Table 5 and Table.6.

Table 3 Typical brick IRA

Typical brick IRA				
S No.	Brick Wet weight (Kg)	Brick Dry weight (Kg)	Brick Contact area (in²)	Brick IRA gm/min/30in²
1	2.74	2.71	40.5	32.41
2	2.66	2.63	40.5	31.74
3	2.80	2.76	40.5	33.84
Average				32.66

Table 4 Modified brick IRA

Modified brick IRA				
S No.	Brick Wet weight (Kg)	Brick Dry weight (Kg)	Brick Contact area (in²)	Brick IRA gm/min/30in²
1	2.67	2.65	40.5	30.16
2	2.60	2.57	40.5	31.97
3	2.72	2.41	40.5	34.16
Average				32.09

Table 5 Typical brick water absorption

Typical brick 24-hour water absorption			
S No.	Brick Wet weight (Kg)	Brick Dry weight (Kg)	Percentage water absorption
1	3.18	2.71	17.34
2	3.17	2.63	20.53
3	3.20	2.70	18.51
Average			18.78

Table 6 Modified brick water absorption

Modified brick 24-hour water absorption			
S No.	Brick Wet weight (Kg)	Brick Dry weight (Kg)	Percentage water absorption
1	2.89	2.45	17.95
2	3.12	2.62	19.08
3	3.11	2.64	17.80
Average			18.27

From the test results of IRA and 24-hours water absorption it can be seen that the average IRA of typical bricks are 32.66 and IRA of modified bricks is 32.09. The results of IRA for typical bricks are near to the results of that of the results of modified bricks IRA because of same material were used for both types of bricks, similarly from result of the result of 24-hours water absorption it can be seen that the average results for typical and modified bricks are close to each other which are 18.78% for typical and 18.27% for modified.

MORTAR TEST

In this research only one type of mortar was used for all the masonry panel. The proportion of mortar were keep 1:6 which were workable at the site. The mortar samples were taken with dimension of two inch by two inch (2"×2") and were tested as per ASTM C 109 [9]. Six samples were taken from the mortar at the time of specimen construction. The results of 28 days compressive strength are shown in Table 1.6 and Figure 1.1

Table 7 Compressive strength of mortar

S NO.	Failure load (lb.)	Length (in)	Width (in)	Area (in^2)	Compressive strength (Psi)
1	5884.76	2	2	4	1471.19
2	6268.84	2	2	4	1567.21
3	5549.12	2	2	4	1387.28
4	6304.44	2	2	4	1576.11
5	6307.24	2	2	4	1576.81
6	5674.88	2	2	4	1418.72
Average					1499.53

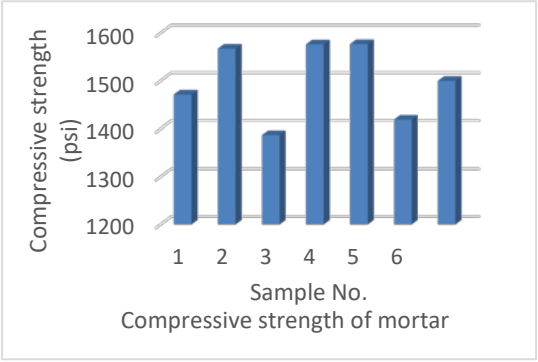

Figure 6 Bar graph of mortar strength.

From the experiment result of mortar compression test it was concluded that the average compressive strength of mortar used in the research is 1.499ksi.

TEST ON ASSEMBLAGE OF MASONRY

Out-of-plane test was performed on a masonry walls (masonry panels) the samples dimensions were two feet by two feet (2'×2') three specimens of the typical and three specimen of modified bricks were tested for the out-of-plane shear test. The tests were performed on masonry panels to evaluate the peak out-of-plane load caring capacity of each masonry specimens of typical as well as modified brick masonry panels. The results of peak load values of both typical and modified bricks masonry were compared. The samples were loaded till cracking of specimen and the failure load was the peak load caring capacity of the masonry specimens. The cracked sample is shown in figure 1.6

Figure 7 cracked specimen of masonry panel.

From test result it can be seen that the peak load capacity of modified bricks masonry is more than that of the typical bricks masonry. The results of out-of-plane shear test for typical and modified bricks specimens are shown Table 8 and Figure 8

Table 8 Comparison of typical and modified bricks

Comparison of Shear Capacities of Modified and Typical Bricks		
S No.	Typical brick peak load capacity(lb.)	Modified brick peak load capacity(lb.)
1	0.330	0.570
2	0.410	0.287
3	0.250	0.439
Average	0.333	0.432

Figure 8 Comparison of typical and modified brick masonry

From the results it can be determined that the out-of-plane peak of modified bricks masonry panel 23% is more than typical bricks masonry panels.

Conclusion

From the experimental results it can be concluded that the peak load caring capacity of the modified bricks masonry panel is more than that of the typical bricks masonry. The strength of modified brick masonry was found to be 23% more than that of the typical bricks masonry wallet. The hollow space provided to form a key has contributed in the out-of-plane shear strength of modified bricks masonry specimens.
The failure pattern of the sample also change due to the shear key the failure pattern showed by modified brick masonry was not a sliding but a joint breaking failure while that of typical bricks masonry showed a sliding failure. Both the typical and modified bricks showed a sudden failures.

Recommendations

Due to limited resources the scope of the research work is also limited. The research work showed improvement in the out-of-plane shear strength but yet to investigate other parameters like cyclic testing on the modified bricks are recommended to be tested.
The hollow space in the brick have provided sufficient strengthening hence further studies are recommended to develop empirical relationships and also in-plane shear strength evaluation are needed to be measure.

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References

[1] Maheri, M. R., & Najafgholipour, M. A. (2012, September). In-plane shear and out-of-plane bending capacity Interaction in brick masonry walls. In Proceedings of 15th world conference on earthquake engineering, Lisbon, Portugal.
[2] Hamoush, S. A., McGinley, M. W., Mlakar, P., Scott, D., & Murray, K. (2001). Out-of-plane strengthening of masonry walls with reinforced composites. Journal of Composites for Construction, 5(3), 139-145.
[3] Ghobarah, A., & El Mandooh Galal, K. (2004). Out-of-plane strengthening of unreinforced masonry walls with openings. Journal of Composites for Construction, 8(4), 298-305
[4] Maheri, M. R., & Najafgholipour, M. A. (2012, September). In-plane shear and out-of-plane bending capacity interaction in brick masonry walls. In Proceedings of 15th world conference on earthquake engineering, Lisbon, Portugal.
[5] Dizhur, D., Griffith, M., & Ingham, J. (2014). Out-of-plane strengthening of unreinforced masonry walls using near surface mounted fibre reinforced polymer strips. Engineering structures, 59, 330-343.
[6] Ali, Q., Badrashi, Y. I., Ahmad, N., Alam, B., Rehman, S., & Banori, F. A. S. (2012). Experimental investigation on the characterization of solid clay brick masonry for lateral shear strength evaluation. International Journal of Earth Sciences and Engineering, 5(04), 782-791.
[7] ASTM C 140 03 Standard test method for compressive strength of unit brick. American Society for Testing and Materials International (ASTM) Committee, West Conshohocken, PA, USA.
[8] ASTM C-67-06 (2006). Standard test methods for sampling and testing brick and structural clay tile. American Society for Testing and Materials International (ASTM) Committee, West Conshohocken, PA, USA
[9] ASTM C109/C109M-08 (2008). Standard test method for compressive strength of hydraulic cement mortars (using 2-in. or [50-mm] cube specimens). American Society for Testing and Materials International (ASTM) Committee, West Conshohocken, PA, USA.