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SHEAR AND TENSILE TEST OF BRICK MASONRY UNIT FOR EARTHQUAKE SAFETY

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Abstract---**Brick masonry is one of the earliest types of structures erected by man. Masonry has been used as a load bearing material for centuries. It is the most common type of structures in many countries. It is very weak in resisting earthquake hence the parameters of masonry unit to resist lateral load needs to be known.**

To find shear and tensile properties of brick masonry unit no standard procedures are introduced in ASTM and ACI. The shear and tensile properties between brick and mortar interface are closely presented in this paper. The objective of this paper is not to develop standard procedure of finding shear and tensile properties of masonry unit rather to develop a preliminary method to find the shear and tensile properties of masonry unit.

Various works have been done about compressive strength of mortar. But few works are done about tensile and shear strength of mortar. The shear and tensile strength of mortar between three brick masonry unit are closely studied at various loading conditions were parameters of mortars are varied. A total of 60 specimens were prepared. By applying compressive force on masonry the failure shear force and corresponding deflection have been measured. By varying the parameters of masonry the tensile strength of mortar is also measured. This study is an initial step to prepare numerical model by finite element of shear and tensile strength of mortar.

Keywords--- **Shear test, Tensile Test, Brick masonry**

I. INTRODUCTION

Masonry is one of the oldest construction materials, which was used for all kind of structures during the last millennium.

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With the introduction of skeleton frames of wrought and cast iron buildings the use of brick masonry in high rise buildings was practically abandoned.

These framed buildings infilled with brick masonry seemed the ideal structural system. The frames being a means of carrying gravity loads, the infills are a means of providing a building envelop or partitioning. In high rise structures the frames have been generally well engineered in accordance with the state of knowledge of the day, whereas the infill panels were invariably considered to be nonstructural. It was not until the 1950s the investigations began on the interaction between infill panels and the frames of buildings [12].

II. EARLY RESEARCH ON BRICK MASONRY INFILL

Early research that investigated the seismic performance of infilled frame specimens using reversed cyclic loading mostly focused on developing improved seismically resistant design analysis and construction techniques for new structures [2], [4], [9]). Little research was done to investigate the seismic performance of existing structures with nonductile detailing. Although some studies have been conducted on infilled frames with deficient detailing([8],[7],[10], [11], [13]). The first study in the United States that investigated the lateral load behavior of infilled frames, using specimens typical of US construction practice (steel frames with brick infills) was reported by Benjamin and Williams (1958)[3]. Equivalent strut methods starting with Stafford smith (1966)[14] used an equivalent single strut to represent infill behavior. It was later realized that such a simplification did not accurately capture all facets of frame interaction. Therefore several multiple strut methods of analysis have been proposed by Chrysostomou et al., 1988 [5]; Thiruvengadam, 1985 [15]. Mortars are accepted of the basis of laboratory tests using the materials in the proportions specified for a particular job. It should be noted that laboratory mortars are mixed to a lower flow value than field mortars (i.e. laboratory mortars have lower water content). The result is that mortars sampled on a construction site will have lower strength values than mortars prepared in the laboratory.

A. *ASTM C 270 Standard specified for mortar masonry*

ASTM C 270 [1] provides three categories of mortar: cement-lime, mortar cement and masonry cement. Cement-lime mortars are a blend of cement lime and sand, without any additives. Masonry cements and mortar cements are proprietary products, consisting of cement, ground limestone and admixtures which enhance the plastic properties.

B. Intrusive in Situ Testing-in Place Shear

The shear strength of unreinforced masonry construction depends largely on the strength of the mortar used in the wall. An in plane shear test Eilbeck et al. (1996) [6] is the preferred method for determining the strength of existing mortar. The results of these tests are used to determine the shear strength of the wall.

C. Test by Earthquake Engineering Research Centers Program of the National Science Foundation

Masonry shear strength was evaluated according to ASTM C 270 [1]. This test method covers the determination of the diagonal tensile shear strength of 4 ft by 4 ft masonry assemblages by loading them in compression along one diagonal. The given loading causes a diagonal tension failure with the specimen splitting apart along an axis parallel to the direction of the compressive load.

III. LABORATORY INVESTIGATIONS

The test and investigations were conducted in the Concrete Laboratory and Structures and Materials Laboratory of Bangladesh University of Engineering and Technology, Dhaka.

After collecting all the constituent materials the specimens were first constructed and then cured. After 28 days curing the masonry specimens attain their full strength and they were ready for test. The material ratio followed to construct test specimens were according to ACI standard.

A. Experimental Procedure

After construction of the specimens each was marked properly according to their respective sample no. a total of 60 specimens were prepared of which 48 specimens were for shear test and 12 specimens were for tensile test. The bricks were kept in the water tank for 24 hours. After soaking those were wiped properly and then cast according to the structure described here. After 24 hours of casting those were again put in the tank for curing. After curing of 7 days the shear specimens were capped and cured for 21 more days. After a total of 28 days curing the specimens were brought out from the tank and wiped, air dried and the specimens were ready for test.

B. Machines Used for Testing

Universal testing machine- capacity 400,000 pound

Hydraulic jack—to provide side pressure

Dial Gauge—with a gauge constant 0.001 inch

Pressure Gauge – capacity up to 25 Kg

C. Mix ratio for preparation of specimens

All the constituent materials were mixed in different ratio for different specimen and the test is performed. An average result was used to plot the graph and to investigate the result. ACI code is followed and also field situation for building masonry wall was kept in mind for construction of the sample. During casting proper care is taken to maintain the correctly.

Table I Different mix ratio for different samples

Sample No.	Cement: Aggregate	W/C	Mortar Thickness	Total Specimen for Shear Test	Total Specimen for Tensile Test
Sample 1	1:4	0.4	3/4"	12	3
Sample 2	1:4	0.4	1/2"	12	3
Sample 3	1:3	0.4	3/4"	12	3
Sample 4	1:4	0.5	3/4"	12	3

D. Fabrication for Test Specimen

Three bricks were joined in the long face by mortar. The middle one was 3″ above than the other two. Lateral force was given by a clamp and hydraulic pump. Shear force was applied on the top of the middle brick as in Fig.1. and Fig. 2. Lateral force is considered assuming the load of 10′ wall and this load is also varied to check shear stress at different compressive stress.

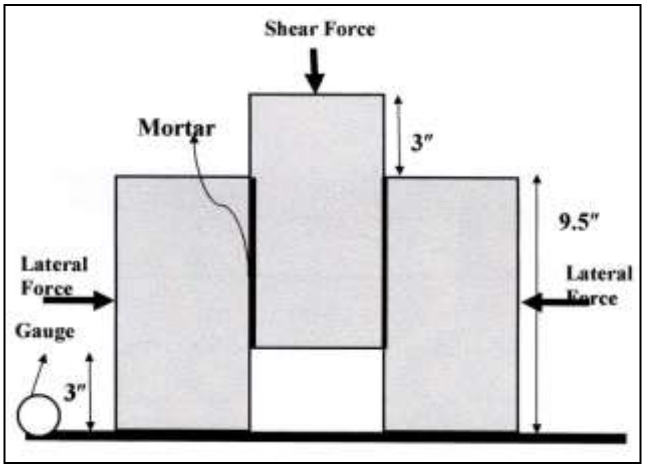

Figure 1. Experimental Setup for shear test of mortar

Figure 2. Shear test Setup

Parameters were varied and four types of samples were prepared to compare between the results.

For shear test, the capped cylinders were set vertically and centrally within the loading plate of the testing machine. The uniform loading rate of 1 ton, 0.75 ton and 0.5 ton was maintained according to ACI specification until the specimen was failed.

For tensile strength test, according to standard test methods, the test specimens were placed horizontally as in Fig. 3 and 4. The standard loading rate was maintained until the specimen was broken. Accurate centering of the specimen within the loading plate of the testing machine was done to avoid compound stress effects.

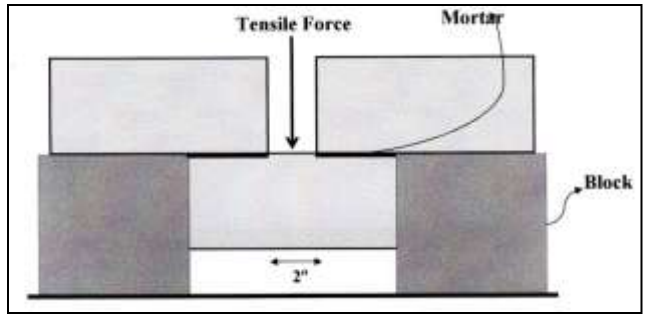

Figure 3. Experimental setup for tensile test of mortar

Figure 4. Mortar tensile test setup

IV. FINDINGS FROM THIS STUDY

In this paper lateral load on masonry structure is presented. Average failure deflection on average failure load is plotted in Fig. 5.

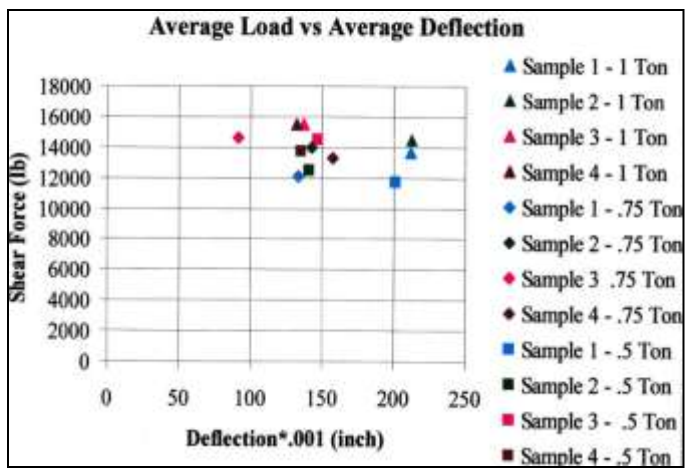

Figure 5. Average failure load vs. Average Failure deflection for all samples

Average failure deflection found here was nearly about 140×10-3 inch. At this deflection most of the specimens failed in shear force.

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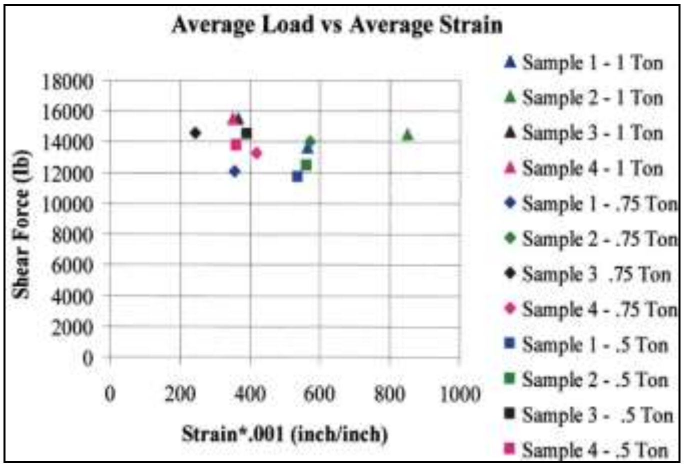

Figure 6. Average load vs. average strain for all samples

Shear force (lb) vs. shear strain×10-3 inch is plotted for all sample in Fig 6. Most of the sample fails at a strain of 375×10-3 to 400×10-3 inch/inch. Mortar thickness for sample 1,3,4 was 0.75 inch and mortar thickness of sample 2 was 0.5 inch.

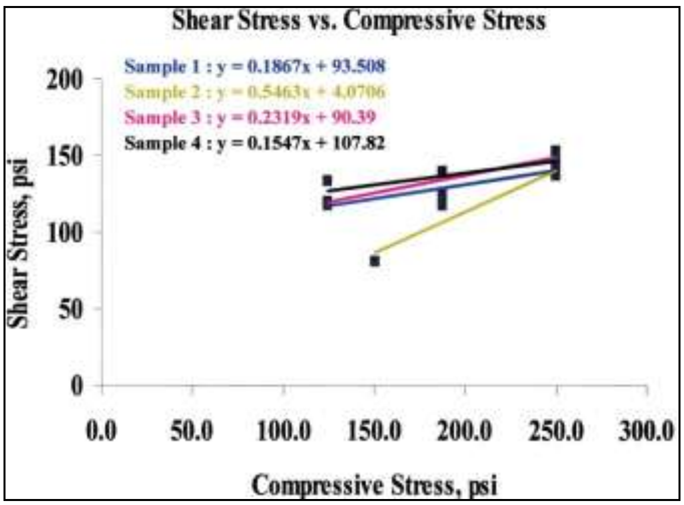

Figure 7. Shear Stress vs. Compressive stress for all samples

In Fig 7 shear stress vs. compressive stress graph is plotted for all samples. Sample 1,3,4 shows almost same criteria except for sample 2 with different mortar thickness. The results found in tensile test are shown in Fig 8. The average tensile stress found here was 14.83 psi. Sample 2 has the lower mortar thickness and it shows lower tensile stress. In sample 3 cement ratio is the highest and hence it can be predicted from the analysis that the higher the cement ratio the higher the tensile strength.

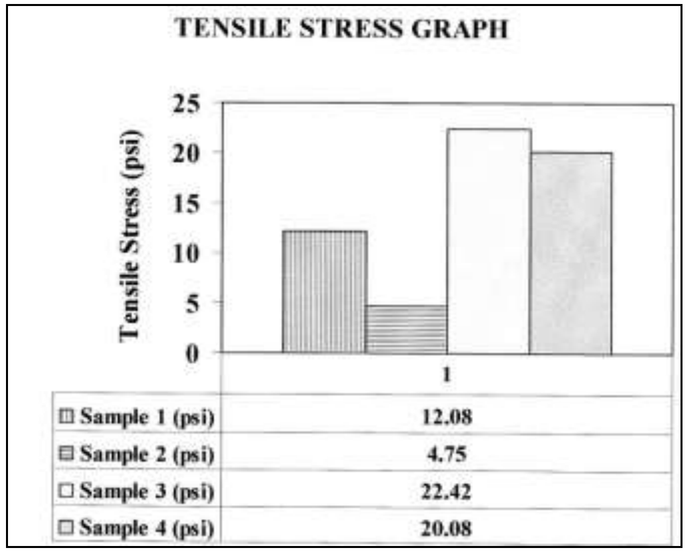

Figure 8. Shear stress vs. Compressive stress for all samples

V. CONCLUSIONS AND FUTURE RECOMMENDATIONS

Brick masonry is weak in resisting lateral forces like earthquake. During earthquake wall failure cause a large damage. For this reason brick masonry compressive, shear and tensile stress is analyzed. For compressive strength literature is adequate. But for shear and tensile stress literature is not enough. Here in the study a methodology is formed to get data to prepare finite element model. This is not an aim to develop a standard method rather it is a proposal how this study can be done. Better accuracy is expected with more sample using varying parameters and different types of load combinations.

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