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Experimental Investigation of Shear Strength of Rat-Trap Bonded Masonry

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ABSTRACT:- *Rat-trap bonded masonry is an attractive construction technique because of its economic and environmental advantages over conventional masonry. It is adopted for construction in most of the Asian countries. Various studies show that different researchers have studied the compressive strength where as limited or no research work has been reported regarding the diagonal shear and direct shear behavior of the bond. To cover this deficiency an experimental study was carried out where triplets were tested for direct shear and prisms were tested for diagonal shear strength of RTB. The results show that the direct and diagonal shear strength of rat-trap masonry are somehow less than the results of conventional masonry.*

***Key words**: Diagonal shear strength, direct shear strength, triplets, coefficient of friction cohesion, Rat-trap bond,*

I. INTRODUCTION

Rat-trap masonry is a cavity type masonry in which the nominal bricks are laid on the 3-inch face instead of 4.5-inch face as generally used in conventional masonry. Two bricks lied in the direction of the with 3 inch cavity between them are called shiners. The shiners are followed by the rowlocks, which are laid perpendicularly to the wall. The cavity can also be reinforced. The bond is used in construction worldwide especially in Asian countries. It is adopted as a cost effective construction technique with other benefits of cost optimization, thermal insulation, and dead load reduction[1]–[3]. The typical layout of the bond is showing Figure 1.

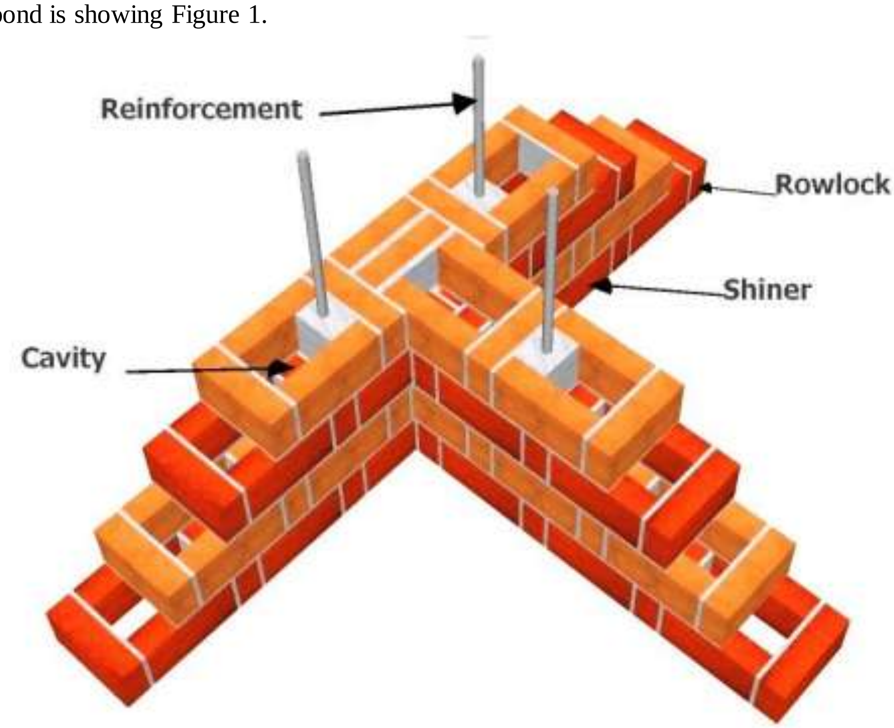

Figure 1.Typical view of RTB-masonry

1.1 Construction steps in RTB masonry

The steps followed in its construction are a bit different from those of the conventional masonry and it is mandatory to guide the mason for its construction. The cavity makes it difficult to arrange the bricks properly in T-joints (Figure 2) and L –joints

(Figure 3) of alternative courses, without dodging the bond symmetry. The first and top or last course should be laid solid made up of rowlocks. The courses below the sill level and above lintel level should be laid as solid bricks in rowlocks.

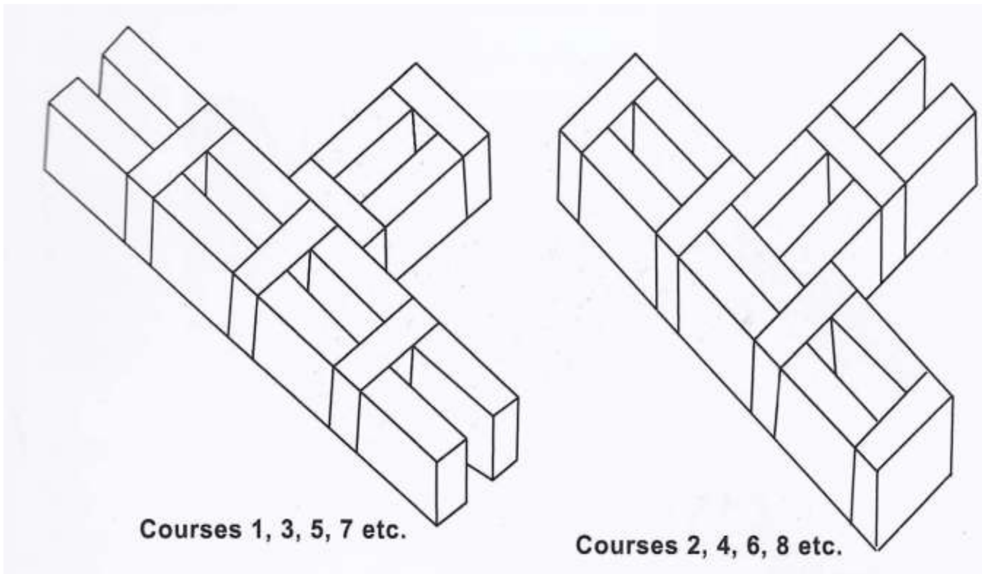

Figure 2. Typical layout of T-junction of RTB masonry

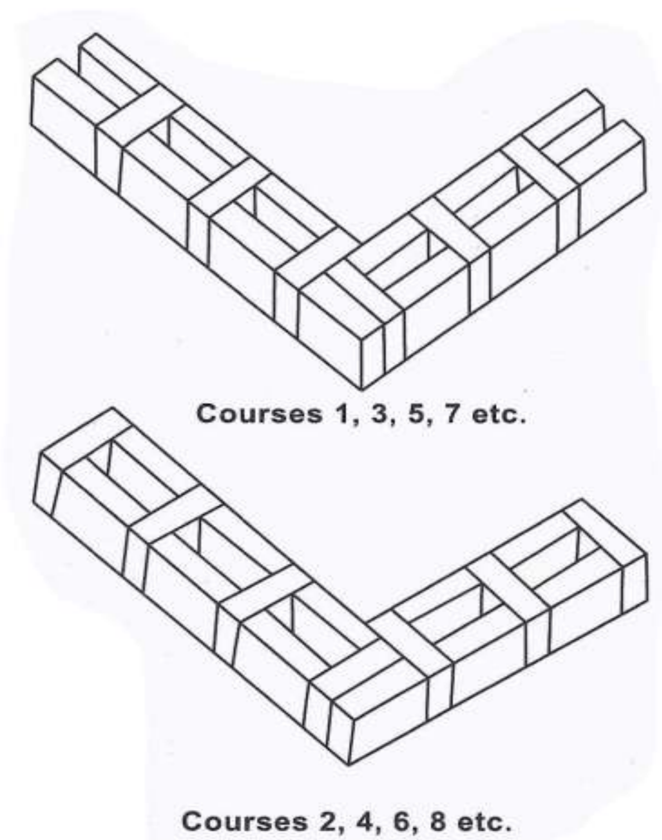

Figure 3. Typical layout of L-junction of RTB masonry

1.2 Literature survey

Khan and Thaheem[4] attempted to Study the performance of rat-trap bond in comparison with conventional English bond. The parameters of performance were cost, energy use (Electricity) and thermal comfort. The test results reported by the authors show that the strength of English bond masonry varies from 1.34 to 1.96 MPa. While in case of rat-trap bond masonry, bricks with low strength has strength ranging from 0.6-0.9MPa. While for bricks of greater strength, it varies between 1.67-1.68 MPa. In addition, samples made up of bricks with various compressive strength and varying ratio of mortar for both conventional bond and rat-trap bond.It was found that the average strength of English bond varies from 1.34 - 1.98 MPa while that of rat-trap bond varies from 0.6- 1.68 MPa. Sivaraja and Thandavamoorthy[5], [6] prepared prism for testing purpose in mortar of ratio C:M 1:4 and ,1:5 .The compressive strength of rat-trap bond prism of C.M. 1:5 is 0.87 MPa and that of C:M 1:4 is 1.30 MPa. Richer mortar sample were 49% stronger than the leaner. They also studied the energy capacity and reported that the energy capacity in the case of the model with roof slab (44.5-3582 MPa) is 13.66 percent more than that of the model without roof slab (58-4069MPa). It can be stated that model with roof slab behaves the best in out-of-plan box type shear building.Santhakumar and , A.Sivakumar n.d. [7]compared full scale, samples for English and rat-trap bond. The key parameters of comparison were compressive strength, failure behavior assisted by stress-strain curve and computer analysis. They found that bricks having a compressive strength of 5.69 MPa were used to prepare three specimens (1^{st}set) in English bond pattern. Similarly bricks having compressive strength of 5.69 MPa, were used to prepare three specimens (2nd set) in rat-trap bond pattern. Another set of three specimens (3^{rd} set) were prepared in rat-trap bond pattern where the bricks strength was 4.02 MPa. In all the cases, mortar strength was kept constant having strength 17.02 N/mm^2. Two specimens were prepared in RTB bond in which FAL-G and wire tied bricks was used as rowlocks. Specimenswere tested for compressive strength until crushing. It was reported that the 3^{rd} set of rattrap could bear a load of about 50% of that of set 2.

RTB is being used for construction of various buildings now days; therefore, it is necessary to study its properties for design purpose. Form the literature survey it was also noticed that plenty of work is reported in compressive strength while there is little or no work reported regarding its shear strength. Therefore, this study was carried out to study the direct shear and diagonal shear behavior of the RTB masonry.

II. EXPERIMENTAL PROCEDURE

2.1 Materials

The bricks generally used in construction were selected for prism testing. The bricks were tested for their compression as per specifications of ASTM C-67[8]. The specimens were constructed in in lime mortar. The mortar cubes of size 3 x 3 were also tested for compression as per guidelines of ASTM C 109[9]. The compressive strength of brick and mortar was 2066 psi and 644 psi respectively.

2.2 Construction and geometry of the specimens

To study the direct shear strength parameters, twelve triplets were prepared simulating RTB wall. Where the bricks were laid on the 3 x 9 in face of the bricks as shown in Figure 4. In order to study the diagonal shear strength parameters prisms of size 27 x 9 x 27 inch were constructed in RTB as shown in Figure 4. As the ASTM standard says that smaller size if specimens can be used where there arelaboratory constrains so smaller size prism were constructed. The bearing shoe was adjusted accordingly.

2.3 Testing of triplets.

Triplets were tested in such a way that each three specimens were tested for various magnitude of normal stress. the testing arrangements are shown in Figure 5 where the triplets is supported by rollers in the bottom similar to simply supported beam, while a point load is also applied at the top of middle brick using a roller. The test was conducted in accordance with EN-1052-3 [10].

Figure 4. RTB testing Specimens Triplet and diagonal prism

Figure 5. testing arrangements of triplets testing

2.4 Diagonal shear test

The diagonal shear test was performed on five specimens such that the specimens were placed on a wooden plank, which rests on steel roller rods providing a frictionless environment. The two bearing shoes were placed to the corners of the diagonal. To apply the load smoothly, rubber bands were place between the wall and the bearing shoe. The one diagonal corner was fixed on a girder beam and the load was applied on the opposite diagonal corner. The load was applied through a hydraulic jack until failure of the specimens. The arrangements are shown in Figure 6. The test was conducted in compliance with ASTM E 519-02 [11]

Figure 6. Testing arrangements for diagonal shear strength test

III. RESULTS AND DISCUSSION

3.1 Direct shear strength

This test is performed to find out the cohesion (C) and co-efficient of friction (μ) of the masonry. The normal stress applied and the shear stress calculated were plotted against each other for all the twelve samples. The plot is shown in Figure 7. The linear trend line with equation of the format (Y= M.x + C) was fitted on the curve where Y, M and C represent direct shear strength, co-efficient of friction and cohesion respectively. Also the intercept of the line represent the cohesion and the slope of the line is the co-efficient of friction.

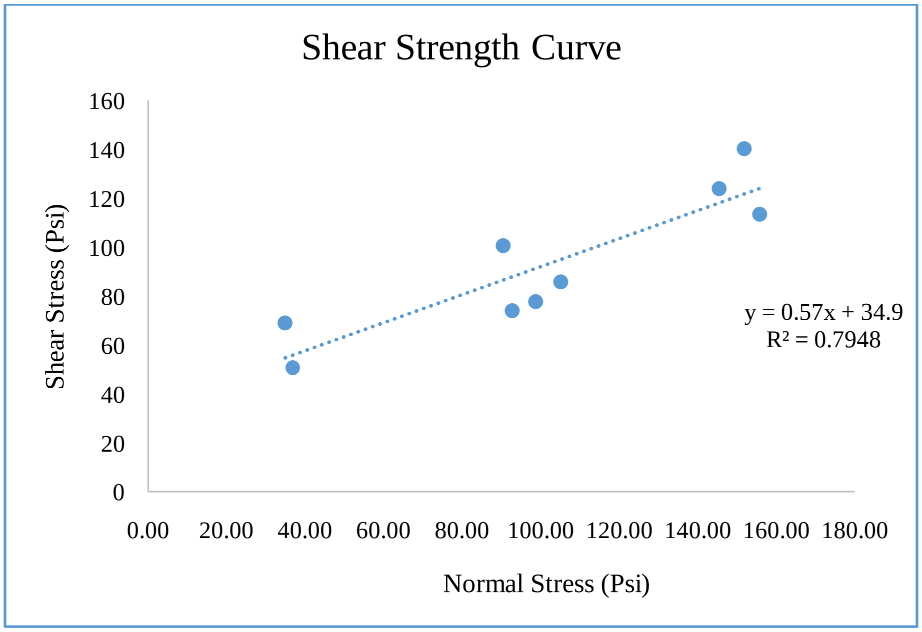

Figure 7. Normal strength vs shear strength curve

3.2 Diagonal shear strength

The test results are presented in Table 1. The stress was calculated based on net-effective area that is 2/3rd of the gross cross sectional area of the prism. Both the diagonal shear strength and diagonal tensile strength was calculated using the following ASTM equations.

$$Diagonal\ tensile\ strnegth = 0.5 * \frac{\mathrm{P}}{\mathrm{An}}$$

$$Diagonal\ shear\ strnegth = 0.707 * \frac{\mathrm{P}}{\mathrm{An}}$$

Where.
P= ultimate load
A_n= Net area

Table 1. Diagonal shear and tensile strength of RTB

Prism Label	Gross Area in^2	Ultimate Load (lbs.)	Diagonal Shear Strength (psi)	Diagonal Tensile Strength (psi)
1A	256.73	5,763.46	24	17
2A	256.47	3,771.04	16	11
3A	253.59	12,657.57	53	37
4A	253.96	4,147.93	17	12
5A	247.87	9,838.66	42	30
Average			30	21

IV. CONCLUSIONS

This study was carried out to study the diagonal shear and direct strength of RTB masonry. The conclusions drawn from the study are listed below.

- The coefficient of friction of RTB masonry is 0.57.
- The cohesion of RTB masonry was 34.9 psi.
- The diagonal shear strength of RTB masonry is 30 psi.
- The diagonal tensile strength of RTB is 21 psi.

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