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Comparitive Analysis on Reinforced and Unreinforced Brick Masonry Walls

Akkinapalli Vishal kumar, Shaik Mohammad Ali, Marri Bharath Kumar, Koncherla Harsha Kiran, Lingeshwaran Nagarathinam,

Abstract

Brick masonry is widely used for building construction throughout the world. In today scenario the standards were reduced due to increase in pollution & poor structural design. The reinforcement sustains at higher loads and can reduce the crack in the wall. This helps strengthen the brickwork and prevent cracking, especially in areas susceptible to earthquake zones. In this research we are also going to deal with the crack patterns for different reinforced, unreinforced masonry walls and comparing the both. In order to find the strength of the brick's compression, diagonal shear, masonry prism, water absorption, mortar, tensile tests are being carried out. I did the experimental analysis of reinforced & unreinforced brick masonry walls with a specified dimensions and different properties. The equipment that is used to test the brick specimen is loading frame.

Index Terms: Crack Patterns, Compression test, Diagonal Shear Test, Reinforced Brick Masonry.

1. INTRODUCTION

Masonry walls are mostly used in different parts of construction around the world because it is economically affordable also for its good sound and heat insulating properties and most durable part of building structure. It consists of bricks and mortar, for different types of masonry walls different types of materials are used like stones for stone masonry etc. There are different types of masonry walls in building construction.

1) ***Load bearing masonry walls***
2) ***Reinforced masonry walls***
3) Hallow masonry walls
4) Composite masonry walls.

Load bearing walls are unreinforced masonry walls constructed as both exterior as well as interior walls. They directly transfer the load from roof to the foundation. The thickness of wall depends upon the load that acts on it.

Reinforced brick masonry (RBM) comprises of brick work which consolidates steel installed in mortar or grout. This workmanship has incredibly expanded protection from powers that create **elastic and shear stresses**. The Reinforcement gives extra rigidity, permitting better utilization of brick work's inalienable compressive quality. The two materials supplement one another, subsequent in a phenomenal auxiliary material. The standards of Reinforced brick work configuration are the equivalent as those normally acknowledged for strengthened cement, and comparative formulae are utilized**.**

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Akkinapalli Vishal kumar, B.Tech, 4th Year, Department of Civil Engineering,K L E F, Vaddeswaram, India.522502.

Shaik Mohammad Ali, B.Tech, 4th Year, Department of Civil Engineering,K L E F, Vaddeswaram, India.522502.

Marri Bharath Kumar, B.Tech, 4th Year, Department of Civil Engineering,K L E F, Vaddeswaram, India.522502.

Koncherla Harsha Kiran, B.Tech, 4th Year, Department of Civil Engineering,K L E F, Vaddeswaram, India.522502.

Lingeshwaran Nagarathinam, Assistant Profressor, Department of Civil Engineering,K L E F, Vaddeswaram, India.522502.

This type of construction increases the forces that **produce the tensile and shear stresses**. The reinforcement provides additional tensile strength, allowing the better use of brick masonry's inherent compression strength. Two materials complement each other, **resulting in an excellent structural material.**

2. EXPERIMENTAL PROGRAM

In the present study, we are going to deal with the compressive behavior and other characteristics of local hand molded burnt clay bricks, mortar, unreinforced and reinforced masonry walls.

In the comprehensive experimental study, tests were performed

- Wall specimens (Reinforced & Unreinforced)
- Mortar cube specimens
- Specimens of masonry prisms.

In addition, water absorption of bricks will be determined by standard tests. Along with water absorption test, laboratory tests are conducted.

2.1 Compression test on masonry brick wall

A vertical load is applied on the specimen to know the compressive strength of it. The test is conducted on specimens using loading frame. Reference **IS 3495 Part 1 (1992)**. Total 3 unreinforced specimens are constructed,

- First specimen is tested after 7 days of curing.
- Second specimen is tested after 14 days of curing.
- Third specimen is tested after 28 days of curing.

Dimensions of specimens are **(0.75m X 0.5m X 0.23m)** with an average water cement ratio of 0.5(Generally Used). The model is prepared by using English bond.

For the reinforced wall specimens, the reinforcement is placed for every 3rd course. Then after curing process is started and it should be cured for specified time period. Testing is carried out on 5 reinforced specimens with three (Parallel i.e. un joint) reinforcement and two with Ladder type reinforcement. Dimensions are same as unreinforced specimens. Fig. 2.1 shows the model of masonry brick wall.

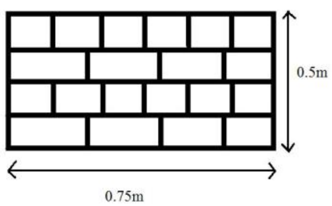

Fig. 2.1 (a) Unreinforced wall for compression test

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2.2 Diagonal shear test on masonry brick wall

Similar to compression test, here the load is vertically applied on specimen, but the specimen is placed diagonally. The load applied on it will affect on bonded mortar & bricks, so that its shear strength is obtained. Dimensions of specimens are **(0.5m X 0.5m X 0.23m).**

Total 3 unreinforced & 5 reinforced specimens are constructed, reinforcement is provided in 3rd course. Two types of reinforcement are provided, 3 of them as same (Parallel reinforcement) & remaining 2 as same (Ladder type) reinforcement.

The dimensions of specimens for compression & shear test are shown in table 1.

RESULTS

Table (i) – Dimensions of specimens

Testing	Length (mm)	Breadth (mm)	Thickness (mm)
Compression test (Reinforced & Unreinforced)	750	500	230
Diagonal shear test (Reinforced & Unreinforced)	500	500	230

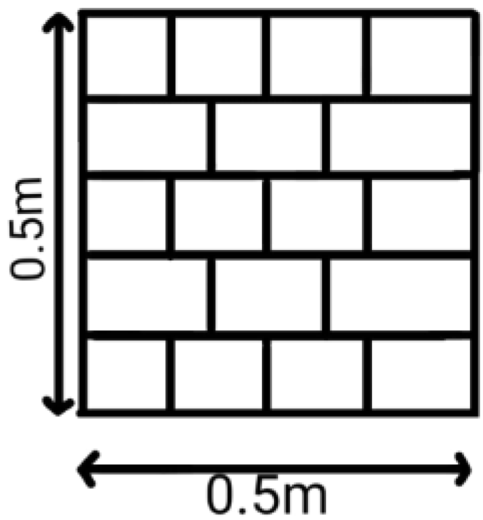

Fig 2.2 Test for Diagonal Shear

2.3 Masonry prism test

The specimen is constructed by alternate alignment of mortar & cement on 'one on one' systematically.

Assembled specimen shall be at least 40 cm high and shall have a height to thickness ratio (h/r) of at least 2 but not more than 5.

By performing compression test on this specimen, we get the assemblage strength of units & mortar bond. Referred IS 1905-1987. In these phenomena when the load is applied, the mortar at bed joint under goes more compressive forces. Total 3 specimens are constructed,

- First specimen is tested after 7 days of watering.
- Second specimen is tested after 14 days of watering.
- Third specimen is tested after 28 days watering.

The test is conducted on UTM. The sample of specimen is figure 2.3(a).

2.4 Reinforcement details

The longitudinal reinforcement for all specimens was not same, 3 specimens are provided with plane reinforcement and & 2 as ladder type reinforcement. Reinforcement details for specimens shown in table (ii) respectively. Fig.2.4 (a) shows the reinforcement details of parallel placing, which has no connection in it. Fig.2.4 (b) shows the reinforcement details of ladder type reinforcement, which has connection between the longitudinal bars. 8mm bars are used as reinforcement.

Table (ii) – Dimensions of reinforcement

Testing	Reinforcement type	Length (mm)	Diameter (mm)
Compression test	Plane reinforcement	750	8
	Ladder type reinforcement	750	8
Diagonal shear test	Plane reinforcement	500	8
	Ladder type reinforcement	500	8

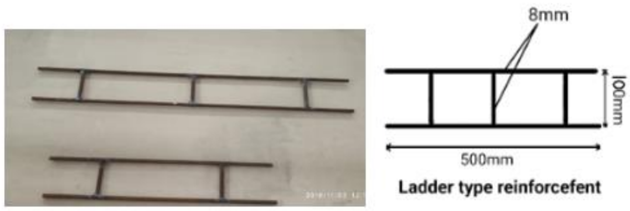

Fig 2.4 Reinforcement Bars

2.5 Water absorption test

Total water absorption capability of the brick material is given by the water absorption test. The moisture absorption by capillarity within the bricks produces suction phenomena to observe water from mortar and this characteristic is defined by IRA. The rate of absorption can have a major effect on the interaction between freshly arranged mortar and the brick units. IRA is measured in order to assist in choosing mortar choice and material handling within construction method. Referred IS 3495 part 2 (1992).

This test is useful to know the standard of bricks. Three bricks are taken for testing, kept in oven for an hour and taken its dry weight. Later the bricks are placed in water for 24hrs. After 24hrs time bricks are taken out and noted its wet weight. Now using dry weight and wet weight water absorption value is obtained. Fig 2.5 shows the brick specimens.

Water absorption = $[(W_2 - W_1) / W_1] \times 100$

- W_1 = Weight of dry specimen
- W_2 = Weight of wet specimen

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Fig 2.5 Specimens for water absorption test

3. RESULTS AND DISCUSSION

3.1) 7 Days Compression Test results.

Fig 3.1.1 Compressive Test

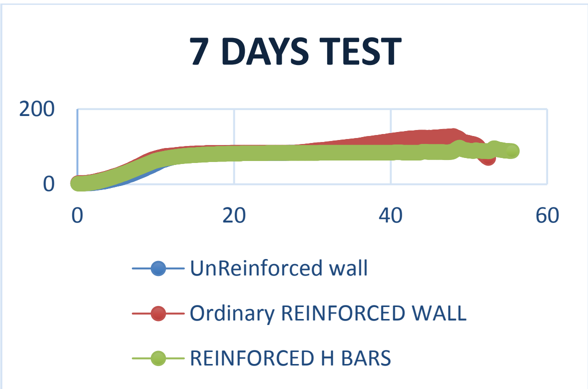

Fig 3.1.2 load vs deflection curves

The unreinforced wall has failed at a load of 114.9 KN. whereas reinforced and ladder reinforced walls failed at 128 KN and 112 KN respectively. This graph is drawn between the load and deflection. The load vs deflection curves are shown in the figure 3.1.

3.2) 14 Days Compression Test Results

The unreinforced wall has failed at a load of 117.1 KN. whereas reinforced and ladder reinforced walls failed at 131.4 KN and 156.2 KN respectively.

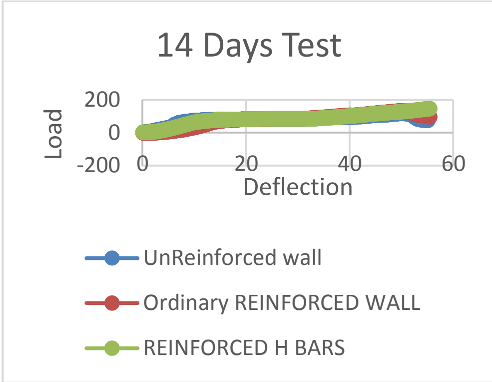

Fig 3.2.1

3.3) 28 Days Compression Test Results

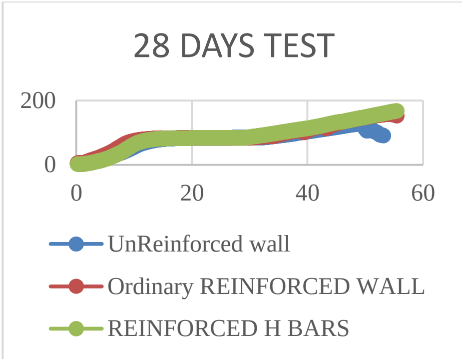

Fig 3.3.1

The unreinforced wall has failed at a load of 128.7 KN. Whereas reinforced and ladder reinforced walls failed at 156.6 KN and 175.9 KN respectively. Through this analysis the Ladder reinforcement gives higher load bearing capacity.

COMPRESSIVE TEST OF THE SPECIMENS (MPa)

No. of days	Unreinforced	Joint Reinforcement	Ladder Reinforcement
7 days	0.666	0.742	0.649
14 days	0.678	0.761	0.905
28 days	0.746	0.907	1.019

Table 3.3.2 Compressive strength in MPa

3.4 Masonry Prism Test

Place the specimen in the test setup and load the specimen at a convenient rate

At the time of failure match it from the fig

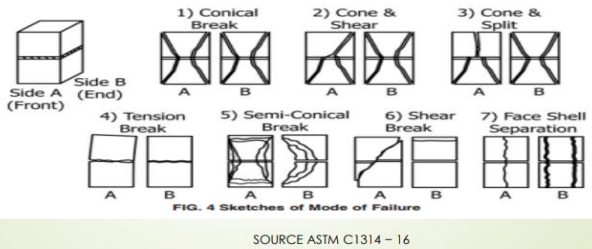

Fig 3.4.1 Modes of Failure

Fig 3.4.2 Masonry Prism Test

The strength of the masonry is obtained as

f_m= Correction Factor X Strength of Prism

Correction factor can be obtained by from the figure 3.2.2.

TABLE 12 CORRECTION FACTORS FOR DIFFERENT h/t RATIOS

(*Clause* B-1.1)

Ratio of height to thickness (h/t)	2·0	2·5	3·0	3·5	4·0	5·0
Correction factors for brickwork*	0·73	0·80	0·86	0·91	0·95	1·00
Correction factors for blockwork*	1·00	—	1·20	—	1·30	1·37

*Interpolation is valid for intermediate values.

Fig 3.4.2 Correction Factor Values

Masonry Prism Strength Calculation

f_{ms}= Correction Factor X Strength of Prism

h/t Ratio = 500/220 = 2.272

Correction Factor = 0.768; through Interpolation.

Sample	**No. of Days**	**Compressive Strength (Kgf/cm^2)**
1	**7**	**3800**
2	**14**	**4000**
3	**28**	**4200**

Table 3.2.3 Compressive strength of prism

i.e., f_{ms}= 0.768 X 411.8793

= 316.323 N/mm^2.

= 0.316 MPa.

3.5 Diagonal Shear Test

Load carried by wall in the in-plane direction depends on the shear strength of masonry and needs to be simulated.

Following the ASTM [ASTM, 2002] standard, the shear stress τ for specimens are calculated from the experimental test. We can calculate the shear strength by fallowing equation (3.3.1)

$$\tau = \frac{0.707\ X\ p}{A_n} \qquad (3.3.1)$$

Where, p is the maximum applied Load

A_n is the net Area of the specimen.

A_n can be calculated by the fallowing equation 3.3.2.

$$A_n = \left(\frac{w+h}{2}\right) \text{X} t \qquad (3.3.2)$$

Where, w is the specimen **width**, h is the specimen height, t is the specimen thickness.

Calculation

Sample 1: (Reinforced)

$$A_n = \left(\frac{w+h}{2}\right) \text{X t}$$
$$= \left(\frac{0.5+0.5}{2}\right) \text{X } 0.23$$
$$= 0.115\ m^2.$$
$$\tau = \frac{0.707\ X\ p}{A_n} = \frac{0.707\ X\ 37.5}{0.115}$$
$$= 230.543 \text{ KN}/m^2$$
$$= 0.230 \text{ MPa.}$$

Sample 2: (Unreinforced)

$$\tau = \frac{0.707\ X\ p}{A_n} = \frac{0.707\ X\ 28.4}{0.115}$$
$$= 174.598 \text{ KN}/m^2$$
$$= 0.174 \text{ MPa.}$$

Shear Strength for the reinforced and Unreinforced brick masonry is obtained through Diagonal Shear test as 0.230 MPa and 0.174 MPa and Force vs deflection was obtained as shown below

Fig 3.5.1 Diagonal test

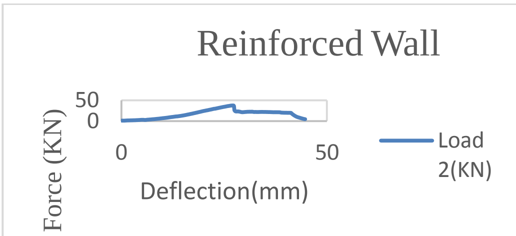

Fig 3.5.2 Load vs Deflection Graph

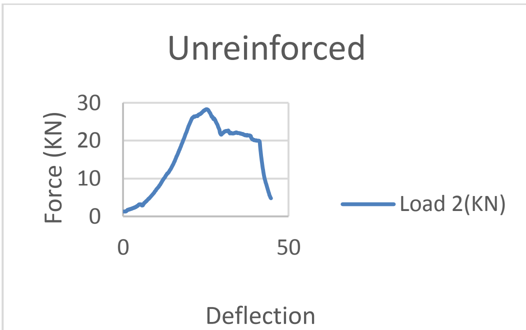

Fig 3.5.3

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Through this experiment, we can able to find the shear strength of the wall and the diagonal compressive strength.

Fig 3.5.4 Diagonal Shear Failure

4. CONCLUSION

Experimental Investigations on compressive strength using compression test and masonry prism test for both Reinforced and unreinforced masonry walls. Through diagonal shear test we obtain a shear strength of 0.23MPa for reinforced masonry and 0.174 MPa for unreinforced Masonry Respectively. Average compressive strength obtained for a masonry prism test is 0.316 MPa. The load vs deflection graphs were drawn for all the specimens and are calculated.

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Authors Profile

Akkinapalli Vishal kumar is pursuing B. Tech at Koneru Lakshmaiah Education Foundation (Deemed to be University), Vaddeswaram, Guntur district, Andhra Pradesh, India

Shaik Mohammad Ali is pursuing B. Tech at Koneru Lakshmaiah Education Foundation (Deemed to be University), Vaddeswaram, Guntur district, Andhra Pradesh, India.

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