Performance Study on Reinforced Brick Masonry for Earthquake Resistance

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Abstract— *Brick masonry is one of the oldest forms of building construction. Brick wall construction is commonly used for low-cost dwellings in developing nations. This system, being extremely brittle, performs poorly during earthquakes. From the experience of Bhuj (2001) earthquakes major damages occurred in the masonry structures. To overcome the immediate failure of brick against earthquake reinforcement was introduced in the brick. The diagonal test was conducted on the specimen size of 450mm x450mmx105mm with 6mm dia bar. Based on the Diagonal test results, the average Collapse load of the Reinforced Brick Masonry is 26.47KN which is 170% more than the ordinary Brick Masonry. And displacement due to shear force in the Reinforced Brick Masonry is 275% more than the ordinary Brick Masonry.*

Keywords—Earthquake resistance, Reinforced brick, Brick masonry, Diagonal test, Collapse load.

1.INTRODUCTION

Brick wall construction is commonly used for low-cost dwellings in developing nations. This system, being extremely brittle, performs poorly during earthquakes. The Reinforcement embedded brick masonry demonstrates the practically and economy of construction, and their performance confirms the soundness of the design principles. Reinforcement embedded bricks in brick masonry consists of brick masonry which incorporates steel reinforcement horizontally embedded in bricks through mortar. This masonry has greatly increased resistance to forces that produce shear and compressive stresses. The reinforcement provides additional tensile strength allowing better use of brick masonry's inherent compressive strength. The two materials complement each other, resulting in an excellent structural material. Reinforcement has been used to strengthen masonry to withstand the seismic forces.

2. METHODS AND MATERIALS

2.1. Materials

The materials required for the manufacture of reinforcement embedded bricks are 6 mm dia HYSD bar, clay and mould.

2.1.1. Manufacture of reinforcement embedded brick

Preparation of clay:

The clay for bricks is prepared in the following order:

a) Unsoiling

The top layer of soil about 200 mm in depth is taken out and thrown away. The clay in top soil is full of impurities. Hence it is to be rejected for the purpose of preparing bricks.

The clay is dug out from the ground. It is spread on the leveled ground. The height of heaps of clay is about 600 mm to 1200 mm. The clay as obtained from the process of digging should be cleaned of stones, pebbles, vegetable matter etc. The clay is then exposed to atmosphere for softening or mellowing for some weeks.

The clay is made loose and spread out at its top. The blending indicates intimate mixing. The blending makes clay fit for the next stage of tempering. In the process of tempering, the clay is brought to a proper degree of hardness and it made for the next operation of moulding.

The clay which is prepared as above is then sent for the next operation of moulding. We used hand moulding for reinforcement embedded bricks. In hand moulding

the bricks are molded manually**.** The mould is a rectangular box which is open at top and bottom. It is made up of plastic.

Specification of mould for Reinforcement embedded bricks:

The size of brick mould is 220 mm X 105 mm X 80 mm. For position of steel reinforcement rod we made a hole of 12mm dia which is placed 25.4mm from bottom and 25.4mm longitudinally insertion in both sides of the plastic mould.A hollow bolt of 12 mm dia and 25.4 mm length also required.

Drying:

The bricks are laid longitudinally in stacks of width equal to two bricks. A stack consists of ten tiers. The bricks are laid along andacross the stack in alternative layers. All bricks are placed on edge. The bricks are allowed to dry till they become lather hard.

Burning:

The burning of bricks is done in **clamps.** When burning of bricks, the particles of two important constituents of clay, namely, alumina and silica bind themselves together resulting in the increase of strength and density of bricks

Fig.2.1 Insertion of 6 mm dia rod while moulding of bricks

Fig.2.2 Finish of Moulding

2.2.1. Construction of reinforcement embedded brick masonry

The Platform should be cleaned, leveled and watered. Non permeable sheet is placed on the prepared platform. Bricks are placed on sheet and mortar is used to fill the joints for ordinary masonry specimen. In the case of Reinforcement embedded brick specimen, connecting rod of length 60.8 mm is used to interlock the bricks. The gaps between the bricks are filled with mortar. Both specimens are cured for 14 days as per BIS codes, to attain the strength.

2.2.3. COMPRESSION TEST ON BRICKS

The capacity of compression testing machine is 200 tonnes. The compression strength of concrete cube, brick and timber can be found in this equipment.

FORMULA USED:

Compressive Strength = F / A

F = Compressive load in KN

A = Plan Area of Brick in m^2

Each 3 samples are taken from ordinary and reinforcement embedded brick. By grinding unevenness in the bed faces is removed to provide two smooth parallel faces. They are immersed in water at room temperature for 24 hours. The specimens are removed and the surplus moisture is dried out at room temperature. The frog and all loads in bed faces are filled flush with the cement mortar. They are immersed in water for 3 days. They are moved and wiped for any

traces of moisture. The specimen is placed with flat faces horizontal and mortar filled faces. This is carefully centered between the plates of compression testing machine. Load is applied at the uniform rate of 14 N / mm^2 per minute till cracks are noticed first. The loading is continued till the specimen failed or crushed completely. The load at failure is the maximum load at which the specimen failed. The above procedure is repeated on a number of specimens and the observations are tabulated and the average compressive strength is computed.

2.2.4. Diagonal compression test

Determination of the diagonal compression or shear strength masonry assemblages by loading them in compression along one diagonal, thus causing a diagonal tension failure with the specimen splitting apart parallel to the direction of load. The diagonal test is carried out in universal testing machine.

The capacity of universal testing machine is 1000 KN. The Compression strength, tensile strength, shear strength, flexural strength and split tensile strength of concrete cube, steel, concrete prism, concrete cylinder, timber, brick and masonry can be found in this equipment.

Compressive Strength = F / tl

F = Diagonal Compressive load in KN

t = Thickness of Wall specimen in metre

l = Length of side of a Square specimen in metre

DETAILS OF SPECIMEN:

- Specimen size : 450 mm x 450 mm x 105 mm
- Mortar : 1:5 cement and sand mortar
- Mortar thickness: 10 mm
- Connecting rod: 6 mm dia , 60.8mm length

TESTING OF BRICK MASONRY SPECIMEN:

150 X 150 X 10 mm Angle is used for distributing the compression load at 1/3 distance in the specimen. Angle is welded with 16 mm dia rod for to clamp it in the Universal testing machine. Specimen is placed on the angle which is fixed in Universal testing machine diagonally. Gradually load is applied on specimen assemblages by loading them in compression along one diagonal. For particular loading, the corresponding displacement readings are recorded in the computer which is attached with UTM. Load is applied up to collapse the specimen. Graph is plotted between Load vs Displacement and the Shear strength is calculated.

3. RESULTS AND DISCUSSIONS

3.1. Water absorption test on bricks:

Ordinary brick:

Table 3.1: Water absorption test

DRY WEIGHT (kg)	AFTER WATER ABS. (kg)	% OF WATER ABS.
3.260	3.65	11.96
3.305	3.64	10.14
3.26	3.69	13.19
AVERAGE % OF WATER ABSORPTION		**11.76**

The average water absorption for the ordinary brick was found as 11.76 %

Table 3.2: Reinforcement embedded brick

DRY WEIGHT (kg)	AFTER WATER ABS. (kg)	% OF WATER ABS.
3.310	3.680	11.18
3.290	3.670	11.55
3.320	3.700	11.45
	AVERAGE % OF WATER ABSORPTION	**11.39**

The results of water absorption shows that, both the specimens have almost same absorption and there is no much difference between the specimens as for water absorption is concerned.

3.2. Compression test on bricks

Table 3.3: Ordinary brick

BRICK SAMPLE	ULTIMATE LOAD (KN)	COMP.STRENGTH (N/MM²)
1	102	4.420
2	90	3.900
3	94	4.070
AVERAGE	**95.33**	**4.126**

Table 3.4: Reinforcement embedded brick

BRICK SAMPLE	ULTIMATE LOAD (KN)	COMP.STRENGTH (N/MM²)
1	100	4.400
2	98	4.350
3	90	3.900
AVERAGE	**96**	**4.156**

Compressive Strength (Ordinary Brick)= F / A

= (95.33 x 1000) / (220 x 105)

= 4.126 N/mm²

Compressive Strength (R/F Embedded Brick) = F / A

= (96 x 1000) / (220 x 105)

= 4.156 N/mm²

3.3. Diagonal compression test

3.3.1 Ordinary Brick

SPECIMEN	ULTIMATE LOAD IN KN
1	15.45
2	16.90
3	14.50
AVERAGE	**15.62**

FIG.3.1.ORDINARY SPECIMEN – SUDDEN FAILURE The performance of ordinary specimen during diagonal test is not safe. Since the after reaching the ultimate load immediately the collapse is happened. Hence it is very poor performance against shear force as well as earthquake force

Table 3.3: Diagonal Test on Ordinary brick

Shear Stress (For Ordinary Brick),

V_m = 0.707F/ tl

= (0.707 x 15.68) / (0.105 x 0.45)

V_m = 234.62 KN/m²

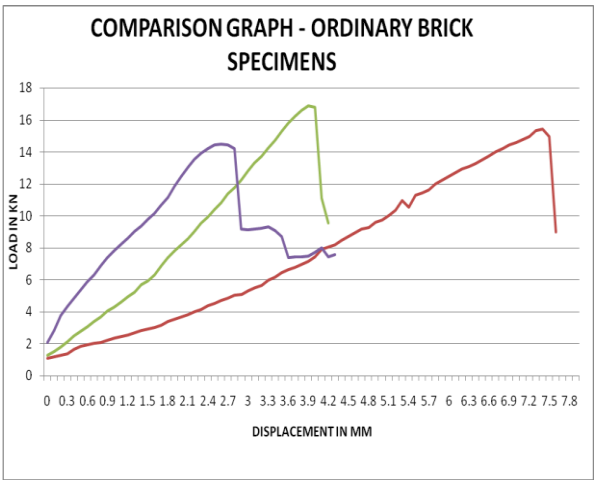

FIG.3.2. ORDINARY SPECIMEN

3.3.2 Reinforced brick

FIG.3.3.REINFORCED SPECIMEN – DUCTILE FAILURE

The performance of reinforced brick specimen during diagonal test is very good . Since after reaching the ultimate load the structure not failed immediately and also collapse was not happened. Hence it had very good performance against shear force as well as earthquake force

Table 3.3: Diagonal Test on Ordinary brick

SPECIMEN	ULTIMATE LOAD IN KN
1	30.45
2	26.00
3	24.80
AVERAGE	**27.08**

Shear Stress (For R/F Embedded Brick),

V_m = 0.707F/ tl

= (0.707 x 26.47) / (0.105 x 0.45)

V_m = 396.07 KN/m²

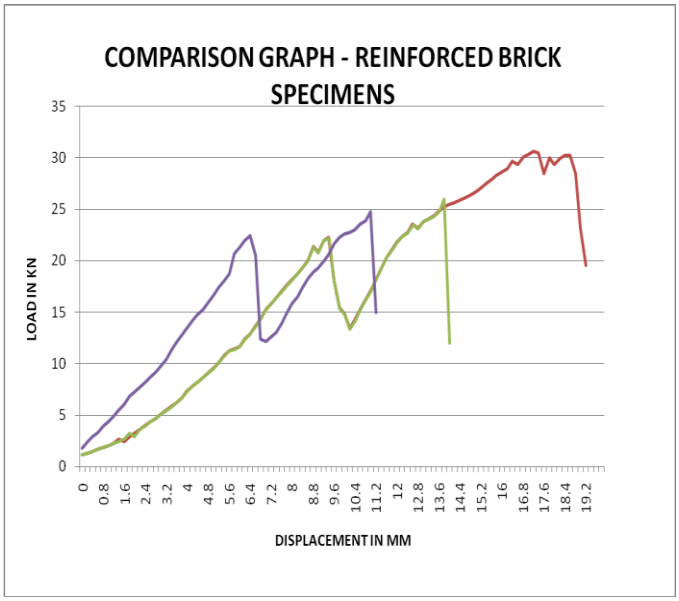

FIG.3.4 REINFORCED SPECIMEN

Comparison of the ordinary and reinforcement embedded brick masonry shows, that the sudden failure is occurred in ordinary brick masonry whereas ductile failure in Reinforcement embedded Brick Masonry.

Average Ultimate load taken by ordinary brick masonry is 15.62 KN whereas Reinforcement embedded brick is 27.08 KN.

Improvements in both compressive and shear strength have shown by comparison with a similar un-reinforced specimen.

4. Conclusion

Based on Water absorption and Compression test results, there is no major variations in the performance of both ordinary and Reinforcement embedded Bricks. Based on the Diagonal test results, the average Collapse load of the Reinforced Brick Masonry is 27.08KN which is 170% more than the ordinary Brick Masonry. And displacement due to shear force in the Reinforced Brick Masonry is 275% more than the ordinary Brick Masonry. Hence reinforced brick masonry can perform better than ordinary brick masonry and also it will give time for escape.

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