Experiemental Investigation on Reinforced Masonry Walls Under Axial Load

V.V.L. Dinesh sai, N. Lingeshwaran

Abstract: ***India is one of the most prominent country for earthquakes and masonry walls are considered as Non-Structural elements of structure. In order to resist the structures from earthquakes different techniques been used such as base isolation, shear wall, Reinforced masonry. Reinforced masonry walls are used to increase lateral resistance in both In-Plane and Out-Of-Plane of the structure. Reinforcement in masonry walls can be provided in both bed-joint and perpend joint. This paper deals with the Bed-joint reinforcement of masonry wall and the kind of reinforcement used is ladder type bed joint reinforcement. This reinforcement been placed in alternative course of masonry walls and the type of masonry used is burnt clay bricks of Class-B with the kind of bond used is English. The mortar been used in between coarse is MM 7.5 confirmed according to IS:2250. The observation of this experiment stats that the inclusion of reinforcement in wall increases the Displacement capacity and the crack pattern of the wall can be observed.***

Index Terms: Reinforced Masonry, In-Plane, Out-Of-Plane, Bed-Joint Reinforcement, Perpend Joint, STAAD.Pro.

I. INTRODUCTION

Experimental test was done with Burnt Clay Brick that is obtained when the clay is burnt in kilns. Mortar that is used in masonry is taken such that to produce more compressive strength and to propagate less cracks after hardening of mortar, while Steel reinforcement is placed in alternative courses of masonry with reinforcement as shown in (fig1.) to improve the lateral strength to the wall. Reinforcement used is mild steel and different kinds of welding can be done, but in this paper the comparison between unreinforced masonry wall and ladder type reinforcement been used and these are manufactured by connecting two longitudinal wires and welded with cross wires in the form of ladder type of bed-joint reinforcement. Advantages by placing the reinforcement are

- The reinforcement helps in resisting the Out-Of-Plane forces that are coming on to the wall.
- Mortar thickness may vary between 6-15mm and 12mm been used.
- These welded connections which are provided will distribute the load equally up to certain extent to provide strength.

[1] During the process of developing this study, several literature works been studied and known that the placing of horizontal reinforcement increases the shear strength of wall comparing with unreinforced masonry walls. [2] The availability of data for provision of horizontal reinforcement is limited and it is considered to be as limit state of serviceability and [3] by adding the minor part of reinforcement to the masonry wall will helps in altering the pattern of crack [4] to which the mortar joint helps in improving the bond between the block and reinforcement placed [5] with specimens being dealt with bed joint reinforcement.

In particular, two specimens were experimented under axial load and the results of these were compared to know the placing of bed joint reinforcement will increase the axial strength and analytical study was also done and this stat that provision of bed-joint reinforcement increases the shear capacity and material being used to their maximum extent. The crack patterns which were developed in both Unreinforced and Reinforced masonry under same dimensions and aspect ratio.

This study mainly focuses on investigating the effect of ladder type reinforcement in wall and comparing it with the unreinforced wall in both axial and shear development.

II. OBJECTIVE OF STUDY

1. Comparison between bed joint Reinforced and non-reinforced walls.
2. Stress development in walls.
3. Crack pattern development in walls.
4. Development of deflection due to load in walls.

III. EXPERIMENTAL TEST ON REINFORCED MASONRY WALLS

A. Test Setup

An experimental test was done to assess the load bearing of the reinforced masonry wall in which material used is burnt clay bricks and comparison is done between unreinforced and bed-joint reinforced masonry wall with the test setup used is loading frame and the specimens are loaded axially. The loading is applied constantly on the top of the specimen by using single hydraulic actuator as shown in fig1.

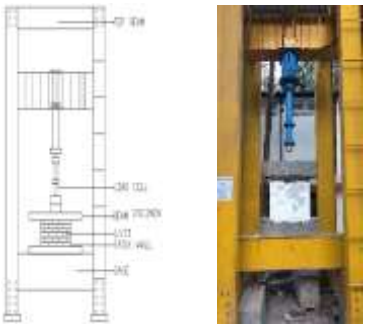

Fig. 1: Test Setup

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B. Wall Specification

The three walls were given codes URW (Unreinforced wall) and RW (Reinforced wall) 1 and 2. URW has no reinforcement in it and RW1 and RW2 were provided with bed-joint reinforcement of ladder type respectively. The dimensional details of the three wall specimens are described in table 1 and the cross-sections of the specimen are drawn in fig 2 and fig 3.

Table I: Dimensions of specimen.

	wall			beam		
Specimen	Length (l)	Height (h)	Thickness (t)	Length (l)	Width (b)	Height (h)
URW	1.0	0.5		1.5	0.23	0.23
RW	1.0	0.6	0.23	1.5	0.23	0.23
RW	1.0	0.6	0.23	1.5	0.23	0.23

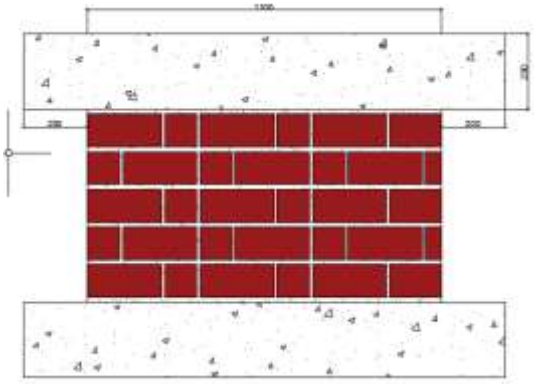

Fig. 2: Cross-Section of unreinforced masonry specimen

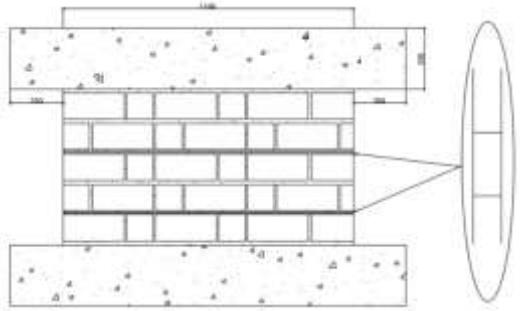

Fig. 3: Cross-section of reinforced masonry specimen

C. Reinforcement details

Bed-Joint reinforcement for the specimen used is ladder type and these are placed for two specimens as I specified them as RW1 and RW2. Cross-section of the reinforcement is provided in figure 4. Size of bar used is 6mm and it is mild steel and the beam cross sections where shown in fig 5.

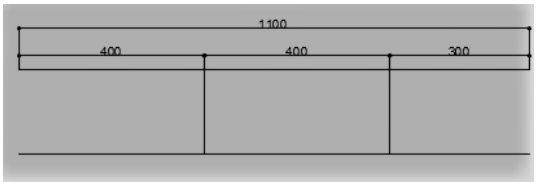

Fig. 4: Ladder type bed-joint reinforcement

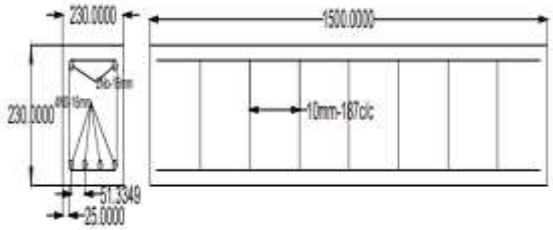

Fig. 5: Cross-sectional details of beam

D. Concrete

Type of concrete used is M30 and the procedure used to design is IS10262:2009 and tests done during trial mix are provided in the below table 2 and cubes were casted in knowing the compressive strength and relative tests for Fine aggregate are described in table 3. Concrete mix is used in casting the beams.

Table II: Compressive strength of concrete.

Specimen	Beam 1&2	Beam 3&4	Beam 5&6
Load (KN)	730	725	730
Load (KN)	750	705	710
Load (KN)	770	730	725
Average strength (N/mm^2)	33.33	32	32.07

Table III: Properties of Fine aggregate

S. No	Property	Value
1	Specific Gravity	2.61
2	Fineness	II

E. Mortar

To make the bond between the brick to brick. Mortar is placed and for reinforced masonry walls the strength of mortar should be high. In that case the mortar specifications were chosen from IS 2250:1981 and the MM7.5 been used and the properties were shown in below table 4.

Table IV: Mechanical properties

Property	Standard Reference	Average Value
compressive strength of 1:3 mortar (f_c)	ASTM C109-11	2.5 N/mm^2
Compressive strength of brick (f_b)	ASTM C67-11	10 N/mm^2

IV. ANALYSIS OF WALLS USING STAAD.PRO

In this analysis of masonry walls is done by using STAAD.PRO software which is used for analysis of structures. Results obtained in this are in form of stress. Maximum displacements, maximum Nodal displacements and Maximum bending moment are obtained from the wall.

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A. Wall Data

Initially a beam of dimensions 1.5x0.23x0.23 was designed and the brick blocks are created using plate mesh to a height of 0.6m and another beam of same dimensions mentioned above were placed again on top. In Y-Axis a point load of 200kN was applied at the center of wall and combination of load was taken according to IS 456:2000 with a bed-joint reinforcement was placed with results are obtained by analysis of the specimen and specified in the below ffig. 6 and fig. 7.

Fig 6: Modelling of Specimen

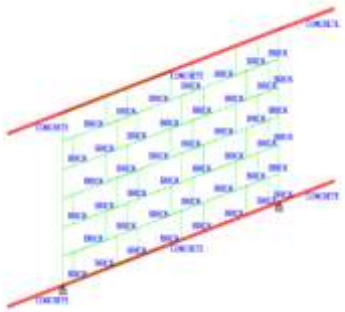

Fig. 7: Complete Specimen

V. RESULTS

5.1. Crack Pattern:

Specimen **RW1** was placed under the loading frame in which the cracks were developed mostly at the joints and it is shown in fig 8. Out-of-plane action was developed in the specimen.

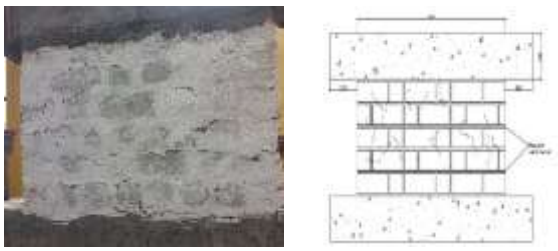

Fig 8: Crack patterns of URW and RW specimens.

5.2. Load vs Deflection:

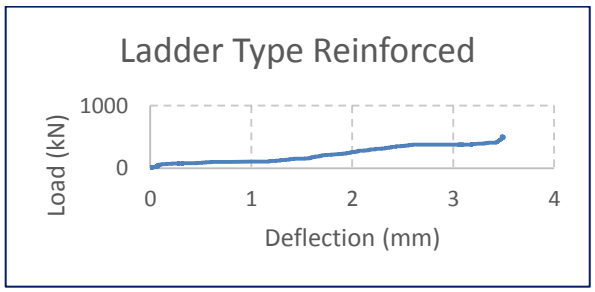

Fig. 9: Ladder Reinforced masonry

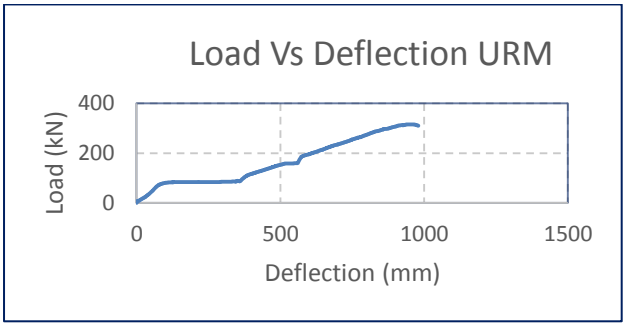

Fig. 10: Un Reinforced masonry

Table V: stresses in URM and RM (N/mm2) for Axial load

S.No	Stresses	URM	RM
1	Max. absolute	13.7	22
2	Max.Tresca	21.9	36.5
3	Max. Von mises	19.1	31.9

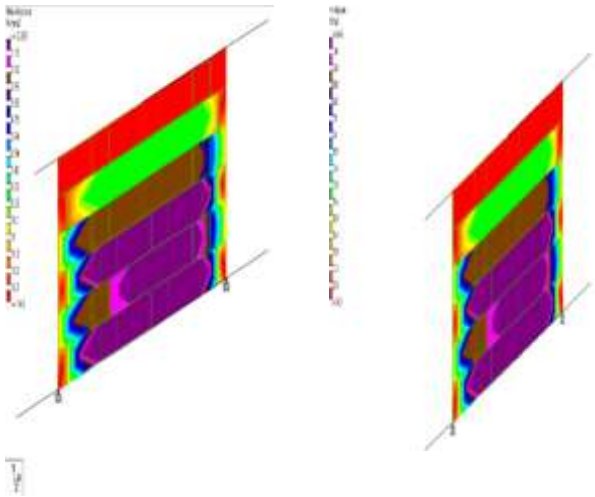

Fig 11: Max absolute stress contours for URM and RM with point load

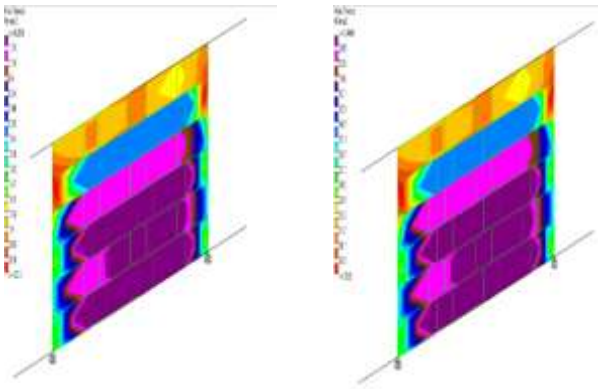

Fig 12: Max Tresca stress contours for URM and RM with point load

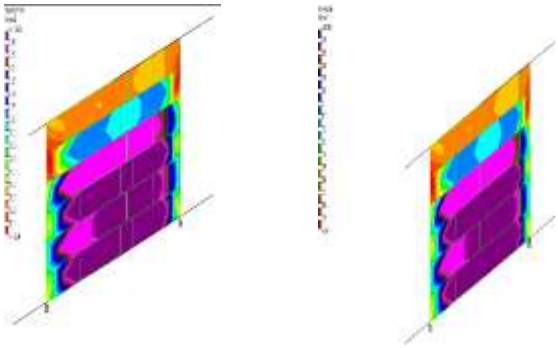

Fig 13: Max von mises stress contours for URM and RM with point load

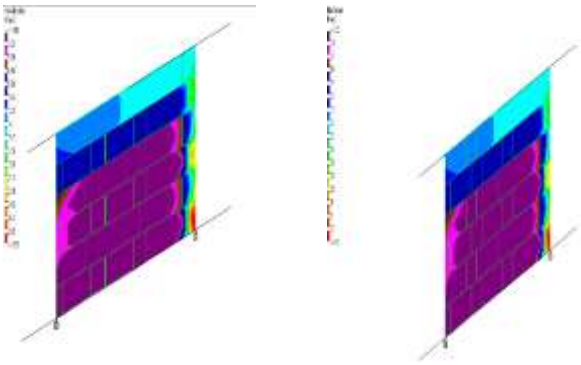

Fig 14: Max absolute stress contour for URM and RM with both lateral and point load

Table VI: stresses in URM and RM (N/mm2) for lateral load

S.No	Stresses	URM	RM
1	Max. absolute	28.2	46.9
2	Max.Tresca	28.7	47.8
3	Max. Von mises	28.4	47.4

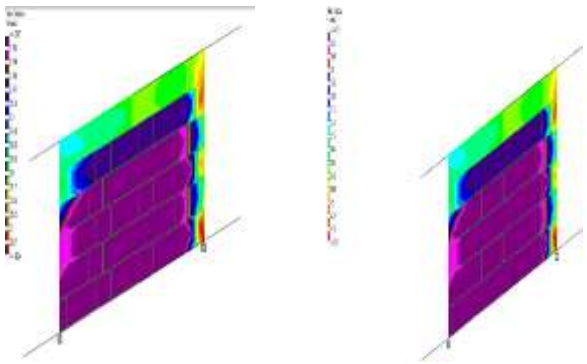

Fig 15: Max Tresca stress contours for URM and RM with both lateral and point load

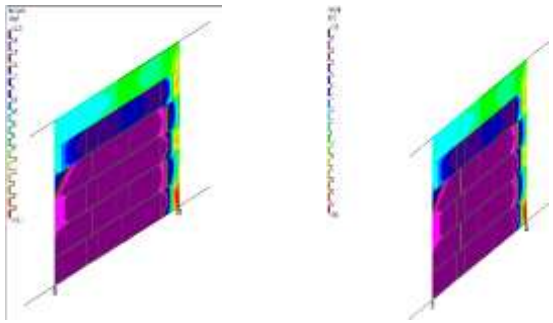

Fig 16: Max von mises stress contour for URM and RM with both lateral and point load

VI. CONCLUSION

Behavior of reinforced masonry in which reinforcement is provided to enhance the strength of the masonry is provided, but due to lack of knowledge available on reinforced masonry and only bed joint reinforcement, complete investigation based on this can't be determined. Particularly there is no detailed report on the behavior of specimens on different kinds of loading.

1. There are no particular design procedures for reinforced masonry walls.
2. The failure in walls under axial loading is sudden.
3. URM is weak in taking load and failure was happened all sudden but when compared to RM the load carrying capacity is high.
4. Bed joint Ladder reinforcement is designed based on the European code and there is not available standard code for the reinforced masonry walls.
5. Addition of bed joint reinforcement to the masonry wall increases in the load carrying capacity of the walls and the development of crack was propagated in URM at joints.

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