Sesimic Behaviour of Brick And Hollow Block Masonry Walls With Fibre Composites

J.Soundharajan[1], S.Gayathri[2]
[1]Dept of M.E-Structural Engineering
[2]Assitant Professor ,Dept of Civil Engineering
[1, 2] Paavai Engineering College Namakkal-637018, India

Abstract- *In India, 60% of land is vulnerable to seismic excitation. In the past Bhuj Earthquake, it was learned that most of the collapse has been happened in the non-engineered constructions. They include both R.C.C and Masonry buildings. Recent research works in Earthquake resistant design focus on the energy absorption in critical locations of the structure.So here an attempt has been made to enhance the energy absorption capacity of the different masonry walls such as Brick masonry and Hollow block masonry using Nylon fibre composites of 1% volume fraction.The aim of the project is to study the seismic behavior of hollow block and brick masonry wall with and without fibre reinforcement. Energy absorption capacity parameter is compared by drawing the load –deflection curves. This project consists of two stages. One is finite element analysis using commercial software ANSYS 10. PLANE 42 elements have been chosen for modeling the brick masonry. One of the input parameters of ANSYS is Young's Modulus. It has been obtained from the test results of Brick pillars under compressive loading. The remaining parameter namely Poisson's ratio has been assumed as 0.25 for all the models. Finally both the finite element and experimental analysis results have been compared.*

I. INTRODUCTION

Brick masonry is the oldest building material. In spite of this, the technological development of masonry in earthquake engineering has lagged behind compared to other structural materials like concrete and steel. The paucity of knowledge on the subject has led to a lack of confidence by engineers with regard to use in seismic environment. The last three decades have bestowed on a significant knowledge of earthquake engineering regarding seismic analysis, design and experimental testing facility. Advances in servo-hydraulic technology and computer simulation are making actual shaking more feasible in earthquake engineering, but fundamentally, such researches are being concentrated principally on steel and concrete structures whereas majority of population in India lives in low-strength masonry houses constructed with stone, brick, mud, adobe, etc. Research work has often been carried out on small scale models either under horizontal the behaviour of masonry walls and buildings (Krishna and chandra, 1965; Qamaruddin et all, 1978; Arya and kumar, 1982; Clough et al., 1979; Tomazevic and Velechorsky, 1992). These investigative programmes have led to the results regarding development of methods for seismic resistance, analysis and design as well as new seismic resistant technology and construction techniques. It is not yet known; to what extent the observations from static test can be correlated with dynamic test in terms of strength, stiffness and mode of failure. An attempt has been made here to study the behavior of two masonry and two hollow brick masonry models constructed with identical features under quasi-static testing.

II. SCOPE OF THE INVESTIGATION

- More than 60% of land in India is vulnerable to Earthquake.
- In past Earthquake, most of the collapse was happened in non-engineered constructions.
- Among the Non-Engineered Constructions, masonry buildings are contributed more.
- The suggested procedure to prevent the Earth quake is
- But the cost of steel reinforcement is increasing day by day. So, people living in rural areas could not use this methodology. Hence alternate method which is based on local material and methodology is required.
- So, here an attempt is made to utilize the concept of fibre reinforcement in cement mortar to enhance the seismic performance of the masonry walls.

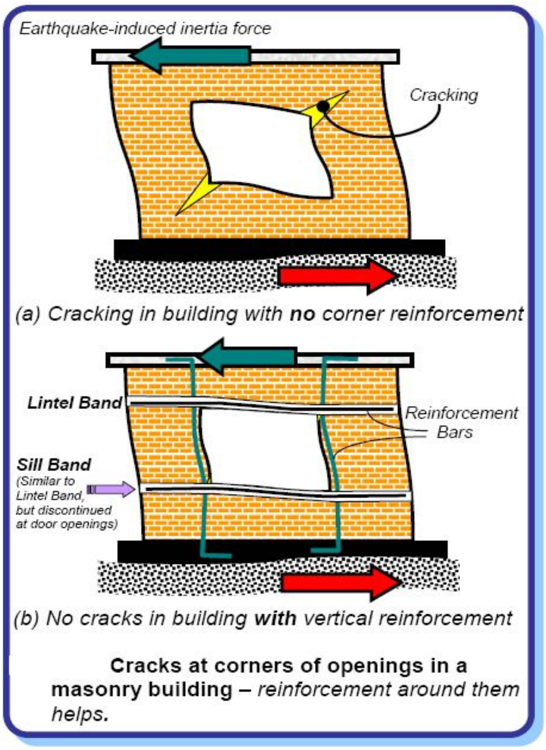

Fig 3.1 IIT Roorkee provide some tips to prevent the building from Earth quake

III. MATERIAL PROPERTIES

This chapter demonstrates the detailed experimental programme of this investigation. It includes materials and fibres used, detailed methodology of experimental programme, mix proportions, specimen details and test set up
For preparing test specimens, 43 Grade Ordinary Portland Cement and natural river sand were used. A sieve analysis conforming to IS 383-1970 was carried out for both fine aggregates. The water cement ratio is 0.5.

3.1.1 Brick

Brick of 190x90x90mm in size, bricks are hand moulded, allowance being made for shrinkage in drying and burning. Bricks of 90mm height shall be moulded with a frog, 10mm deep on one of its flat sides. The physical properties of brick and the results are shown in Table 4.1

3.1.2 Cement

Ordinary Portland cement of 43 grades conforming to IS 8112-1989 was used. Tests were carried out on various physical properties of cement and the results are shown in Table 4.2

3.1.3 Fine Aggregate

Natural river sand was used as fine aggregate. The properties of sand were determined by conducing tests as per IS: 2386 (Part- I). The results are shown in Table 4.3. The results obtained from sieve analysis are furnished. The results indicate that the sand conforms to Zone II of IS: 383 – 1970

3.1.4 Water

Portable water free from salts was used for casting and curing of concrete as per IS: 456 – 2000 recommendations.

3.1.5 Fibres

Locally available Nylon material was collected and properly shaped in the form of fibres. The re0sults are shown in Table 4.4.

Table.3.1 Physical Properties of 43 Grade Ordinary Portland Cement

Physical Properties	Values of OPC used
Standard Consistency	29.2%
Initial Setting Time	45 Minutes
Final Setting Time	265 Minutes
Specific gravity	3.15
Compressive strength in N/mm^2 at 3 days	29
Compressive strength in N/mm^2 at 7 days	38.5
Compressive strength in N/mm^2 at 28 days	48

Table.3.2 Physical Properties of Fine Aggregate

Physical properties	Values
Specific gravity	2.6
Fineness Modulus	2.83
Water Absorption	0.75%
Bulk density (kg/m^3)	1654
Free moisture content	0.1%

Table 3.3 Typical Properties of Fibres

Properties of Fibres	Type of Fibre
	Nylon
Diameter (mm)	0.44
Specific gravity	0.7
Water Absorption (%)	66.66
Density in kg/m³	657

IV. EXPERIMENTAL SET UP

4.1.1 BRICK PILLARS UNDER COMPRESSION:

The masonry pillar of height 800mm and width and breath are 190mm in size. Thickness of mortar is 10mm. Masonry pillar is placed on the Universal Testing Machine capacity of 100 tonnes. The upper and lower mortar joints are directly contact with the steel plates of UTM. The relative displacements are measured by means of mechanical strain gauge with a 0.001mm precision. Mechanical strain gauge is parted at all four sides of the masonry pillar. Mechanical gauges are located at the centre of pillar with intial gauge length of 200mm. Using Displacement from the Mechanical strain gauge Young's modulus is calculated for Brick and Hollow block masonry with and with out Nylon fibre

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4.1.2 BRICK WALLS UNDER LATERAL LOADING:

The quasi-static testing consists in applying cyclic load or displacement to the structure at a low frequency so as to represent full range of deformation of the structure under earthquake loading. The slow application of load allows close observation of the structure even when it is cracked as the test progresses. It is the must economical and common method for obtaining information on the inelastic behavior of structure in which prescribed histories of load or displacement are imposed on the structural system. This type of test provides the reversing character of the loading that distinguishes dynamic response from response to uni-directional static loading.Seismic behavior of brick masonry model has been evaluated by cyclic loading in quasi-static test facility. The model has been constructed and fixed on the strong floor. The lateral load has been applied by one hydraulic jack of 100kN capacity. The LVDTs are fixed at the top and middle of the wall to measure displacement. The walls have been visually inspected and the cracks patterns are identified. The set up have been shown in the Figure.

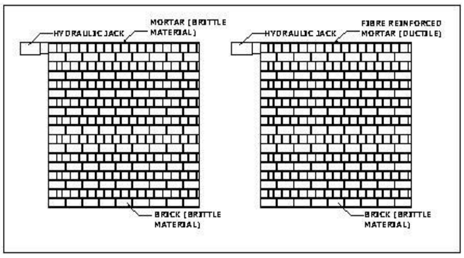


Figure 4.1 Lateral Loading Set up on Masonry Wall

V. ANALYTICAL INVESTIGATION

5.1 Introduction:

Suitable Finite Element models are required for masonry structures. Here in an overview of typical approaches, their motivations and range of applicability is given to provide background for the adopted models. The finite element method is well suited for superimposition of the material models for the constituent parts of a composite material. Material models of this type can be employed for virtually all kinds of Masonry walls. Brick masonry can be represented by solid elements. The mesh size chosen was 60x60mm. PLANE 42 has been chosen for Brick masonry.

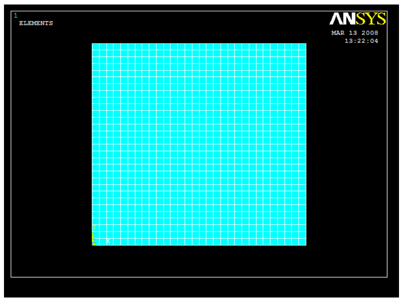


Fig 5.1 Brick Masonry Modeled Using Plane 42 Element

5.2 PLANE 42 ELEMENT:

PLANE42 is used for 2-D modeling of solid structures. The element can be used either as a plane element (plane stress or plane strain) or as an ax symmetric element. The element is defined by four nodes having two degrees of freedom at each node: translations in the nodal x and y directions. The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities.

5.2.1 PLANE42 INPUT DATA

The geometry, node locations, and the coordinate system for the element are "PLANE42 Geometry". The element input data includes four nodes, a thickness (for the plane stress option only) and the orthotropic material properties. Orthotropic material directions correspond to the element coordinate directions. The element coordinate system orientation is as described in Coordinate Systems.Element loads are described in Node and Element Loads. Pressures may be input as surface loads on the element faces as "PLANE42 Geometry". Positive pressures act into the element. Temperatures and fluences may be input as element body loads at the nodes. The node I temperature T(I) defaults to TUNIF. If all other temperatures are unspecified, they default to T(I). For any other input pattern, unspecified temperatures default to TUNIF. Similar defaults occurs for fluence except that zero is used instead of TUNIF.

5.2.2 PLANE42 OUTPUT DATA

The solution output associated with the element is in two forms: Nodal displacements included in the overall nodal solution

Additional element output as shown in "PLANE42 Element Output Definitions"Several items are illustrated in "PLANE42 Stress Output".The element stress directions are parallel to the element coordinate system. Surface stresses are available on any face. Surface stresses on face IJ, for example, are defined parallel and perpendicular to the IJ line and along the Z axis for a plane analysis or in the hoop direction for an axisymmetric analysis.

VI. RESULTS AND DISCUSSION

6.1 Compressive Strength of Masonry Pillars

The results obtained from the compression test of masonry pillars of 800 mm high are listed in table 6.1 Table

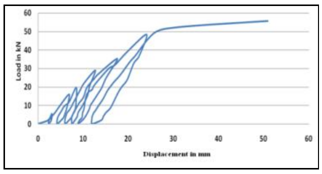
6.1 Compressive Strength of Pillars

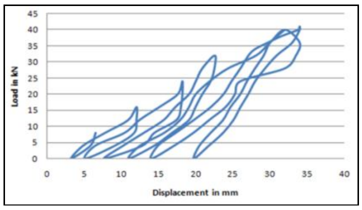
Type of Wall	Type of Mortar	Compressive Strength in N/mm^2
Brick Masonry	Conventional	2.385
	Fibre Reinforced	2.968
Hollow Block Masonry	Conventional	2.108
	Fibre reinforced	2.674

From the above table, it is observed that the Compressive strength of the fiber Reinforced Brick Masonry pillar is greater than 19.64% the Conventional Brick Masonry pillar and also fiber Reinforced Hollow Block Masonry pillar is greater than 20.79% the Conventional Hollow Block Masonry pillar.

6.2 MODULUS OF ELASTICITY OF MASONRY WALLS

The results obtained from the compression test of masonry pillars of 800 mm high are listed in table 6.2





From the above table, it is observed that the Modulus of elasticity of Conventional Brick Masonry pillar is less than(48500 N/mm^2) the value of Fiber Reinforced Brick Masonry pillar (52150 N/mm^2) and also Conventional Hollow Block Masonry pillar is less than (40000N/mm^2) Fiber Reinforced Hollow Block Masonry pillar (43200 N/mm^2).

6.3 LATERAL LOAD RESULTS OF MASONRY WALLS

From the Figure 6.1, it is observed that the cyclic curve of conventional Brick Masonry wall, the wall takes the maximum ultimate load of 44.2kN. Wall was failed in Ninth cycle of cyclic load test

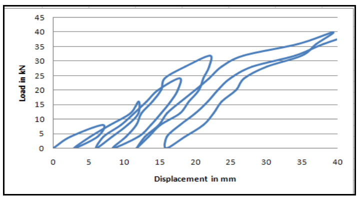


Fig 6.3 Cyclic Curve of Hollow Block Masonry Wall

From the figure 6.3, it is observed that the cyclic curve of conventional Hollow Block masonry wall, the wall takes the maximum ultimate load of 40kN. Wall was failed in eight cycle of cyclic load test.

From the figure 6.4, it is observed that the cyclic curve of Hollow block masonry wall with fibre, the wall takes the maximum ultimate load of 48.5kN. Wall was failed in Tenth cycle of cyclic load test.

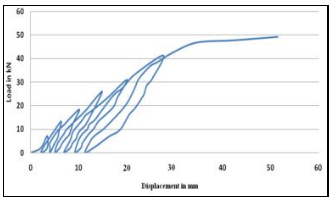


Fig 6.4 Cyclic Curve of Hollow Block Masonry Wall with fibre reinforcement

6.3.2 Load carrying capacity

Specimen	Load Carrying Capacity (kN)	Increase In %
Brick masonry wall	41.2	0
Brick masonry wall with fiber	55.0	19.92
Hollow block masonry wall	40	0
Hollow block masonry wall with fibre	48.5	17.52

From the load carrying capacity table, it is observed that Brick masonry wall with fibre take 19.92% of load than conventional Brick masonry wall and also Hollow block masonry wall with fibre take 17.52% of load than conventional hollow block masonry.

6.3.4 FAILURE PATTERN

Time taken for failure of fibre reinforced masonry walls are more when compared with conventional masonry, so that the fiber reinforced masonry wall increases the warning period of collapse during earthquake.Crack width is closer in fibre reinforced masonry walls when compared with conventional masonry wall; hence it would help the structure to stable for long time during the severe loads. Also the reduction in crack width will be helpful in increasing ductility and energy absorption capacity.

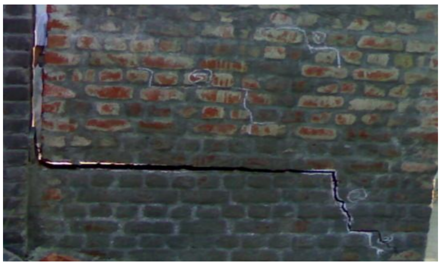


Fig 6.5 Crack occurred in brick conventional masonry


Fig 6.6 Crack occurred in hollow block masonry with fibre reinforcement

6.4 FEA Results of Masonry Walls

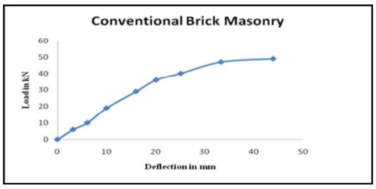


Fig 6.7 Conventional brick masonry wall

The Figure 6.7 shows the static curve of conventional Brick masonry Wall, the wall takes the maximum ultimate load of 42 kN from FEA. The Figure 6.8 shows the static curve Brick masonry wall with fibre mortar, the wall takes the maximum ultimate load of 53 kN from FEA

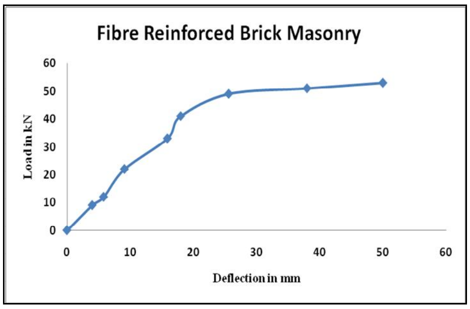


Fig 6.8 Fiber Reinforced brick masonry wall.

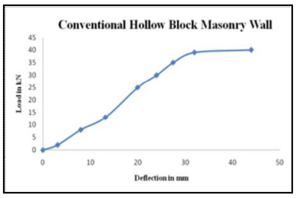


Fig 6.9 Conventional Hollow block masonry

The Figure 6.9 shows the static curve of conventional Hollow block masonry wall, the wall takes the maximum ultimate load of 40 kN from FEA.

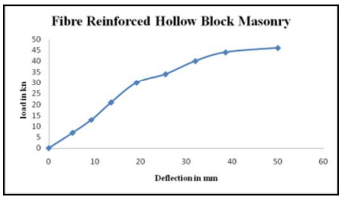


Fig 6.10 Fiber Reinforced Hollow block masonry

The Figure6.10 shows the cyclic curve of Hollow block masonry wall with fibre mortar, the wall takes the maximum ultimate load of 46 kN from FEA. Figure 6.11 and 6.12 shows Deflected Shape and Displacement Contour of Conventional Hollow block masonry.

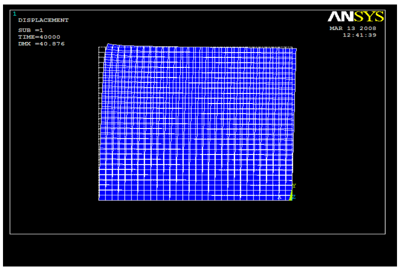


Fig 6.11 Deflected Shape of Conventional Hollow block masonry.

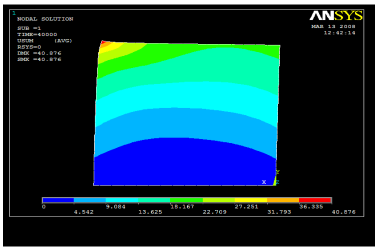


Fig 6.12 Displacement Contour of Conventional Hollow block masonry.

6.5 Comparision of results

6.5.1 Conventional Brick Wall

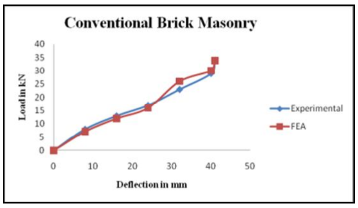


Fig 6.13 Comparision of Experimental curve and FEA – Conventional Wall

From the figure 6.1, it is observed that the energy absorption capacity between Finite Element Analysis curve and Experimental curve of ordinary conventional Brick masonry wall is 4.10%. The variation is small, so it is acceptable one.

6.5.2 Fibre Reinforced Cement Mortar Brick Masonry Wall

From the figure 6.14, it is observed that the energy absorption capacity between Finite Element Analysis curve and Experimental curve of Brick masonry wall with fibre cement mortar is 7.30%. The variation is small, so it is acceptable one.

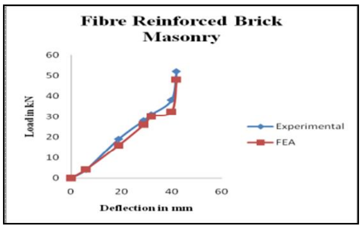


Fig 6.14Comparision of Experimental curve and FEA – Fibre Reinforced Wall

6.5.3 Conventional Hollow Block Masonry Wall

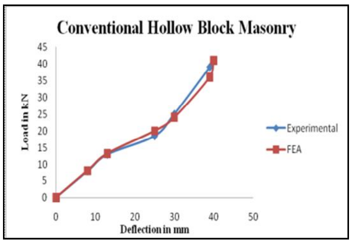


Fig 6.15 Comparision of Experimental curve and FEA - Conventional Hollow Block Wall

From the figure 6.15, it is observed that the energy absorption capacity between Finite Element Analysis curve and Experimental curve of ordinary conventional Hollow block masonry wall is 4.60%. The variation is small, so it is acceptable one.

6.5.4 Fibre Cement Mortar Hollow Block Masonry Wall

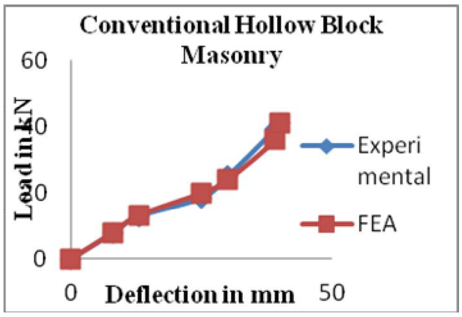


Fig 6.16 Comparision of Experimental curve and FEA – Fibre Reinforced Hollow Block Wall

From the figure 6.16, it is observed that the energy absorption capacity between Finite Element Analysis curve and Experimental curve of Hollow block masonry wall with fibre cement mortar is 4.55%. The variation is small, so it is acceptable one.

VII. CONCLUSIONS

1. The compressive strength of Brick as well as Hollow block masonry walls has been improved by adding the fibre composites with cement mortar. Fibre composites improved the strength by 19.60% for brick and 20.80% for Hollow block masonry pillars.
2. The lateral load (Base shear) carrying capacity of Masonry walls with fibre reinforced mortar is 1.2 times higher than the conventional masonry walls.
3. The crack width developed in the masonry walls with fibre composites is much closer than the crack width in the ordinary walls.
4. During cyclic loading, the failure was happened in the later cycles for composite masonry walls.
5. The energy absorption capacity of fibre reinforced Brick masonry wall is 26.74% higher than the conventional wall.
6. The energy absorption capacity of fibre reinforced Hollow block wall masonry wall is 32.94% higher than the conventional wall.
7. The results of Finite Element Analysis using ANSYS 10 of both conventional and composite masonry walls are well closer to the experimental results.
8. Based upon the detailed experimental and analytical investigations, the fibre reinforced composite masonry walls will perform better than the conventional masonry walls under seismic loading.

REFERENCES

[1] Agarwal,P. and Thakkar, S.K.(1999). "Quasi-static Testing of Seismically Strengthened Brick Masonry Models",International Symposium on Theory and Application of Structural Engineering Test Method,Dept.of Civil Engineering, Tsinghua University, China.
[2] Arya, A.S. and Kumar A. (1982). "An Earthquake Resistant as Well as Economical Brick Building System", 7th Symposium on Earthquake Engineering, Roorkee.
[3] Gong Shaoxi,Li Xiang (1998), "Experimental Research, Finit Eliment Analysis and Calaulation of Bearins Capacity for Wall-beams Supported on RC Frame." Journals of Building Structure (in Chinese).
[4] IS 2250-1993, "Code of Practice for Preparation and Use of Masonry Mortar", Bureau of Indian Standards, New Delhi, 1993.
[5] IS 4326-1993, "Ind. Standard Code of Practice for Earthquake Resistant Des.and Construction of Bldg."Bureau of India Standards,New Delhi,1993.
[6] Jagadish, K.S.Raghunath,S.and Nanjunda Rao,K.S.(2002), "Shock Table Studies on Masonry Building Model with Containment Reinforcement", Journal of Structuraln Engineering.
[7] Krishna Jai,and Chandra B (1965), "Strengthening of Brick buildings aganist earthquake forces" 3rd world Conference on Earth quake Engineering.
[8] Pankaj Agarwal and S.K.Thakkar (2001), "A Comparative Stuy of Brick Masonry House Model under Quasi –Static and Dynamic Loading".ISET Journal of Earthquake Technology.
[9] Sarangapani,G.,Venkatarama Reddy ,B.V.,and Jagadish, K.S.(2002), "Structural Characteristics of Brick, Morttars and Masonry", Journal of Structuraln Engineering.