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Investigation on Collapse Time of Retrofitted Brick Masonry Panel

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ABSTRACT: *In this paper investigation on collapse time of retrofitted brick masonry panel is aimed and an economical and easy technique of retrofitting for the unreinforced brick masonry structures is proposed. To accomplish this, an experimental investigation of un-retrofitted brick panels and retrofitted brick panels with different materials under in-plane diagonal loading is carried out. It was found by after the experimental studies, the collapse time of the retrofitted brick masonry panel was increased as compared to non-retrofitted panels. The behavior of failure of all non-retrofitted panels were brittle with no further load being maintained whereas retrofitted panels continued to carry the load after initial failure.*

Keywords: *Collapse time, Load- Deflection curve, Retrofitted brick masonry panels.*

I. INTRODUCTION

According to Karnataka State Natural Disaster Monitoring Centre (KSNDMC) in India, there were total of 25 micro tremors recorded in the taluk of Basavana Bagewadi, Bijapur district in the year 2010-2012, all these tremors are recorded with magnitudes in the range of 1.2 to 3.1 on the Richter scale with focal depths of 20-23 kms as per the analysis made and are termed as crustal earthquakes (shallow focus earthquake).

Masonry structures are combined materials of brick units and mortar joints and interface connecting the mortar and the unit. Masonry structures are in use extensively all over the world and also being brittle in nature, they are more susceptible to earthquakes. It will be not easy to replace them with new structures and even costly too which most of the people cannot pay for hence there is a need for an cost-effective and easy method of retrofitting. No research has been carried out in the Northern Karnataka in the present topic and this paper focuses on retrofitting of existing brick masonry structures using locally available materials.

In this research, different type of materials are used such as Polypropylene packaging strips, Metallic (Iron) packaging strips, Nylon wire, G I wire for retrofitting of the brick panels which forms a mesh which in turn prevents brittle masonry collapse.

Previous research shows that Polypropylene packaging strips improves the specimen's seismic performance significantly, displaying increased load resistance and ductility before failure [1]. Retrofitting can also be done by introducing steel reinforcing bars, a steel mesh cage around the wall and a similar mesh formed from plastic carrier-bags which increase ductility and the tensile strength of the wall [2]. The ductility of the masonry walls can also be improved by using bamboo as retrofitting material [3].

II. OBJECTIVES AND METHODOLOGY

Following are the objectives of the present research work-

Investigation at Collapse Time of retrofitted brick masonry panel

To investigate the behavior of retrofitted brick panels under in-plane diagonal loading.

Comparing the behavior of non-retrofitted and retrofitted brick panels.

For proposing a low cost and easy method of retrofitting of the brick masonry building, experimental work is carried out by constructing brick panels of size 0.6mx0. 6m and curing for 28 days. The panels are tested placing diagonally in loading frame with some attachments at the top and bottom. The shear behavior of masonry panels is observed while testing. The constructed panels retrofitted with different material such as Polypropylene packaging strips, Metallic packaging strips, Nylon wire, G I wire is tested. The behavior of panels with these materials is observed. The load is applied with the help of hydraulic jack which was placed below the loading cell. The loading cell and LVDT were connected to the computer to measure the horizontal extension and vertical shortening. Spacing of all the retrofitting materials to the masonry is kept same (80mm). Table 1 shows the **s**ize of materials and Figure 1 shows the retrofitting of specimens and the test setup and Figure 2 shows the construction of panels.

Table 1- Tests on Retrofitting Materials

SI No	Materials	Size of materials
1	Polypropylene packaging strips	12.7mm (wide) 0.6mm (thick)
2	Metallic packaging strips	12.7mm (wide) 0.5mm (thick)
3	Nylon wire	5.7mm (dia)
4	G I wire	1.6mm (dia)

Figure 1- Retrofitting of Specimens and Test Setup

III. RESULT AND DISCUSSION

In this section, the results obtained after the experimental investigations are discussed in detail. The results obtained were significant. Metallic strips took higher loads as compared to other materials followed by Nylon wire.

Results showed the behavior of retrofitted panels is far better than non-retrofitted panels. It was found by studying the behavior of each brick panel that all failures of non-retrofitted panels were brittle with no further load being maintained whereas retrofitted panels continued to carry the load after initial failure and vertical deformation is much more than non-retrofitted panels.

Parameters for the Study

Following parameters are taken for the study, the details of which are discussed in the subsequent sections.

a. First Crack Load

b. Load Vs vertical Deflection Curve

Testing of Brick Panels

Brick panels were made of size 0.6mx06mx0. 1m as a square brick panel, as suggested by ASTM E519-02-2002 (American Society for Testing and Materials) [4], E72-1995 (Euro Code), Standard Test Methods of Conducting Strength Tests of Panels for Building Construction [5]. Different panels of non-retrofitted and with materials such as Polypropylene packaging strips, Metallic (Iron) packaging strips, Nylon wire, and G I wire were tested for diagonal tension (Shear).

Non-retrofitted Brick Panels

Figure 2 shows the relation between compressive load applied as diagonal and the vertical deformation. The average value of three non-retrofitted panels was taken for the study. After the experiment, it was observed that, non-retrofitted brick panels were not able to carry load after 10.00 kN, as the brick masonry is brittle, it does not carry load after the failure and it suddenly collapsed while not giving any intimation. Figure 4 shows the relation of Load Vs Deflection curve of non-retrofitted brick panels

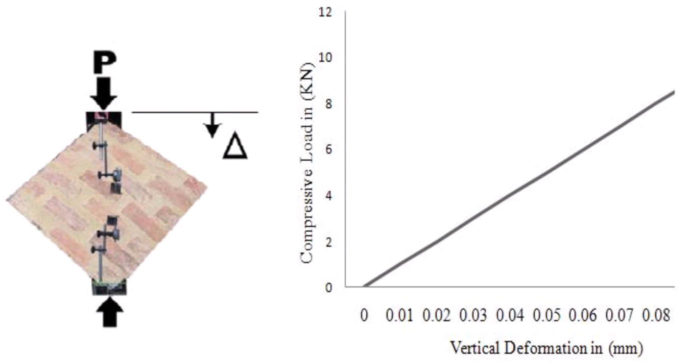

Figure 2- Load Vs Deflection curve of non-retrofitted brick panels

Retrofitted Brick Panels With G I Wire

Figure 3 shows the relation between compressive load applied as diagonal and the vertical deformation. The average value of three GI wire retrofitted panels was taken for the study. As it can be seen from the Figure 5, when the load is applied to the panels, the masonry first takes the load till it fails and then the retrofitting materials takes the load. For brick panels retrofitted with GI wires, it was observed that it carried loads up to 17.60 kN and failed but even after the failure, further it carried the load up to 23.00 kN because of mesh provided by the GI wires.

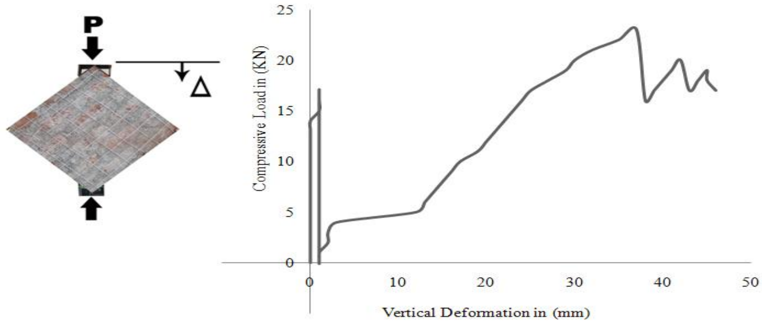

Figure 3- Load Vs Deflection curve of retrofitted panel with GI wire

Retrofitted Brick Panels with Polypropylene Packaging Strips

Figure 4 shows the relation between compressive load applied as diagonal and the vertical deformation. The average value of three Polypropylene packaging strips retrofitted panels was taken for the study. For brick panels retrofitted with Polypropylene packaging strips, it was observed that it carried loads up to 21.36 kN and failed but even after the failure, further it carried the load up to 29.00 KN.

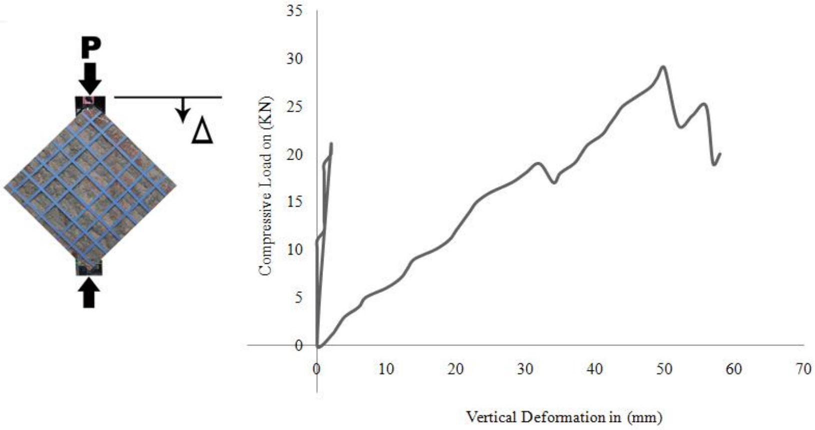

Figure 4- Load Vs Deflection curve of retrofitted panel with Polypropylene

Retrofitted Brick Panels with Nylon Wire

Figure 5 shows the relation between compressive load applied as diagonal and the vertical deformation. The average value of three retrofitted panels with Nylon wire was taken for the study. For brick panels retrofitted with Nylon Wire, it was observed that it carried loads up to 24.63 kN and failed but even after the failure, further it carried the load up to 32.00 kN. Retrofitted brick panels with Nylon wire carried more load as compared to brick panels retrofitted with Polypropylene packaging strips.

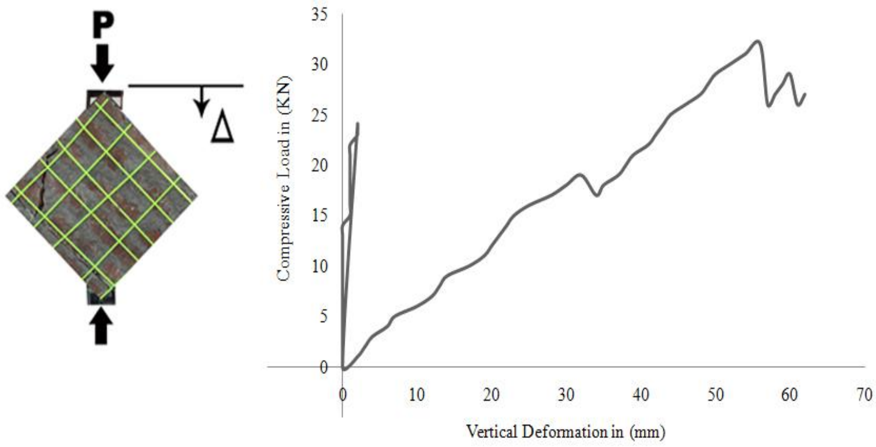

Figure5- Load Vs Deflection curve of retrofitted panel with Nylon wire

Retrofitted Brick Panels with Metallic Packaging Strips

Figure 6 shows the relation between compressive load applied as diagonal and the vertical deformation. The average value of three Metallic packaging strips retrofitted panels was taken for the study. For brick panels retrofitted with Metallic packaging strips, it was observed that it carried loads up to 31.76kN and failed but even after the failure, further it carried the load up to 41.00 kN.

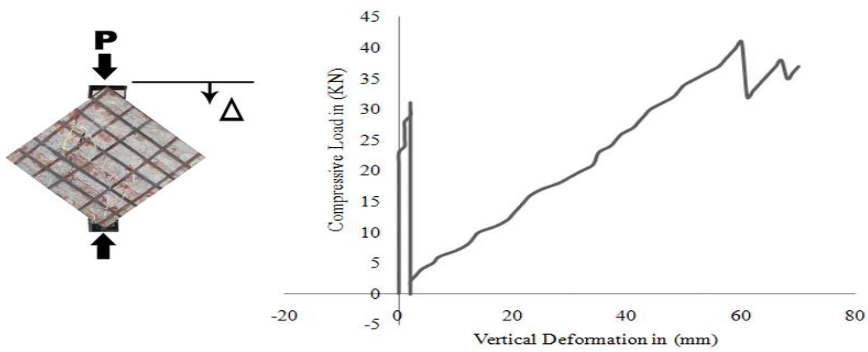

Figure 6- Load Vs Deflection curve of retrofitted panel with Metallic strips

Table 2 summarizes the failure load and ultimate load of materials used for retrofitting the panels. It can be seen that Metallic packaging strips carried the ultimate load as compared to any other type of retrofitted panels.

A comparison has been made between different materials in terms of shear strength and cost considering a room of size 3mx3m as shown in Table-3.

Table 2- Comparison of Failure Load and Ultimate Load of Materials

SI No	Material	Failure Load (kN)	Ultimate load (kN)
1	Non- Retrofitted	10	10
2	Polypropylene strips	21	29
3	G I wire	19	23
4	Nylon wire	24	32
5	Metallic strips	33.60	41

Table 3- Comparison in terms of Cost

Materials	Ultimate load (kN)	Cost per 9m² in INR
Polypropylene strips	29	300
G I wire	23	500
Nylon wire	32	400
Metallic strips	41	600

IV. CONCLUSION AND SUMMARY

Following conclusions can be drawn from this investigation-

This study deals with the development of a new strengthening alternative, which will be an economic and easily applicable method, for seismically vulnerable unreinforced brick masonry structures.

The stiffness of the masonry is far greater than that of the mesh and initial failure stress is unaffected by the presence of the mesh, and so the mesh is not engaged until the masonry deforms.

Retrofitted brick panels with Metallic packaging strips carried the ultimate load up to 41 kN which was maximum compared to other retrofitted brick panels and first crack appeared on the brick and then it continued to fail in mortar. It shows that resistance of the mortar because of Metallic strip. Metallic packaging strips have been proven remarkably increased shear capacities of URM elements.

Retrofitted brick panels with Nylon wire carried more load as compared to brick panels retrofitted with Polypropylene packaging strips. It was observed that cracks appeared first on mortar then on brick.

Metallic (Iron) packaging strips gives higher strength i.e. 75% more than non retrofitted brick panels but it costs twice the Nylon wire which gives 68% of strength. Nylon wire can be economical for retrofitting which ensures strength as well as low cost.

Reinforcement can be provided in brick masonry buildings to improve the structural performance and to increase the collapse time during earthquakes.

V. RECOMMENDED FUTURE WORK

Future work is required for the refinement of the proposed methodology for seismic retrofitting of Un-Reinforced Masonry Buildings. The following work is, therefore, recommended to be carried out in the future-

The proposed work does not include the effects of torsion on the lateral strength assessment of URM buildings. Thus, the torsion effect on the lateral strength of masonry buildings can be studied.

The sizes of the panels were relatively small due to the limited equipments, of the experimental work. Testing of large panels, will help in studying the size effect on the result of panels.

More locally available different materials can be studied to know the behavior of brick panels.

This work can be carried out for out-of-plane loading and by using a prototype model, tests can be conducted on Shake tables.

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