Optimisation of Seismic Damages of Buildings by Providing Mechanized Bricks

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Abstract— In the last few decades, a dramatic increase in the losses caused by natural catastrophes has been observed worldwide. Seismic activity is one of the main aspects of these natural catastrophes; this is influenced by the materials used for the building construction. From literature perspective, various studies have been done to improve the quality of construction materials by utilizing or adding different kinds of materials. This paper provides review of research conducted on seismic performance of buildings with bands in different location; these buildings are made by mechanized bricks. The outcome of this paper can serve as a common reference for practitioners and researchers attempting to seek out solutions for further improving overall quality of bricks.

Key words: Seismic Response, Masonry Structure, Band

I. Introduction

An experimental study is undertaken to carry out shock table testing of full- scaled models of one storied stone masonry houses employing different earthquake resistant provisions under progressively increasing intensity of shock. Six models are tested on shock table; one of them is built in a traditional way without any earthquake resistant measures while the other models with gradually increasing strengthening arrangements like roof, lintel and sill bands along with corner reinforcements. From the test it is seen that the provision of seismic band at lintel level is the minimum requirement to prevent collapse of house made in mud or cement sand mortar. The more use of rich mortar without any other earthquake resistance measure is not adequate to prevent collapse of structures Agarwal. P. et al.(2011).

The experimental observations of two symmetrical models with scale 1:2 were done by constructing one model by following European codes, building was designed and built with horizontal and vertical reinforcement and another as a simple and traditional construction.

Its indicates that in spite of the same seismic inputs were applied to both models the final state of masonry building and its nonlinear behaviour led to a considerable amplification of the deformations and damages Avila L. et al. (2012).

The earthquake and harmonic base motion energies were dissipated through inter-brick friction and in some cases by bricks cracking and crushing. The fact that the bricks were dry-stacked allowed them to move and hence dissipate energy Elvin.A et al (2011).

II. Theoretical Background & Materials Properties

The rapid growth of Indian cities in the recent past, have accelerated pressure on housing industry, especially in high seismic zone i.e. Zone-IV & V. The built environment in these zones has been seismically found vulnerable as most of these constructions are without earthquake resistant measures. The Indian cities are dotted with all kinds of buildings and infrastructural facilities comprising of very good construction to poorly design & constructed ones. Seismic vulnerability depends upon:

1) The material of which the structure is made.
2) The mechanical properties of construction materials.
3) The geometry and layout of a building and its structural components.
4) The detailing of structural components as well as floor-wall connection details.

In IS: 2117-1991, the guidelines are provided to select the actual proportion of clay, silt and sand for manufacturing of bricks. It was found that the soil sample collected from the Industry was very effective for manufacturing of bricks.

The ultimate aim of this work was to perform the dynamic test of masonry buildings on Shake table, but the capacity of Shake table is maximum 100 Kg, therefore, it was decided to reduce the scale. The scale was reduced to 1:5 and have an average size of 65mm x 35mm x 30mm. Bricks used in this experimental study had an average compressive strength of 19.67 N/mm^2.

Mortar is mixture of materials used to bind masonry unit into a structural mass. IS 4326:1993 has recommended mortar mixture used in masonry construction in seismic areas for various categories of building. Recommended mortar mixture for A categories of construction type building are M_2 (cement: sand) 1:6. It was, therefore, decided to use the same mortar in this experimental works plastic.

III. Experimental Modeling

Small scale masonry model testing has now been carried out for many decades. The model unit is constructed adopting a scale 1:5, depending on the capacity and load bearing of the shaking table. Plane dimensions were 3m x 2m at ground level and building height 3 m. The materials used for the models are mechanized bricks.

The size of the bricks used for that models are also reduced to a scale 1:5. But actually it is difficult to build such small size bricks in mechanized way, so the sizes of bricks were 60mm x 35mm x 30mm. The models were constructed on a 150 mm thick PCC bed, constructed to allow be transporting and coupling to the shaking table by means of steel anchor. The 2mm diameter of the rods was used for bands. The thickness of the bands is 100 mm. The proportion of the mortar used is 1:6.

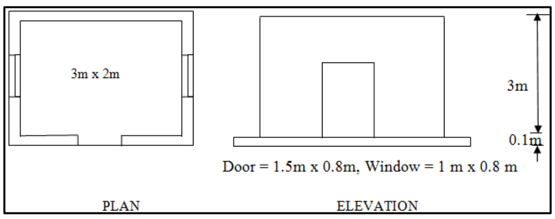

Fig. 1: Plan & Elevation of Model

A. Types of Buildings

- Building A: Without any band (Mortar 1:6).
- Building B: With one band at sill level. (Mortar 1:6).

The measured response parameters are displacement and acceleration of the structure along the direction of force. The displacement response is measured by attaching Brüel & Kjær Deltatron 4507–001 accelerometers (Brüel & Kjær Sound & Vibration Measurement A/S, Nærum, Denmark) at the base and top of the structure. PULSE 3560B computerized data acquisition and multi-analyzer system is used to acquire and analyses the experimental data. The displacement response of the building and shake table is also determined by 16- channel Module of Dynamic LVDT signal conditioner Data Acquisition card. In each set of experiments, the structure is subjected to harmonic sinusoidal base motions with different excitation frequencies.

1) Two accelerometers, at top, bottom of building is fixed to determine the performance of the structure under various frequencies. The positions of the LVDT are shown in figures. Total 7 to 14 numbers of readings were taken.
2) Tachometer is used to measure the revolution per minutes of the Motor.
3) Every physical model is subjected to various frequencies and each frequency for 5 seconds.

Fig. 2: Building A set up on Shake Table before Test

Fig. 3: Building B set up on Shake Table before Test

Fig. 4: Building C Set Up on Shake Table before Test

IV. EXPERIMENTAL RESULTS & DISCUSSION

	Acceleration in (m /sec^2)		Amplitude in (mm)		Inertia Force in (Newton)	
	At bottom of building	At top of building	At bottom of building	At top of building	At bottom of building	At top of building
2.0	2.13	2.24	8.95	9.98	59.36	66.19
2.5	3.75	4.02	11.20	12.47	116.07	129.23
3.0	4.63	5.96	13.43	16.88	200.42	251.59
3.5	5.02	6.87	16.00	20.93	324.99	425.13
4.0	7.25	7.57	17.89	24.03	474.61	637.50
4.5	10.37	10.58	23.15	25.56	777.29	858.21
5.0	14.32	15.20	24.90	26.40	1032.16	1094

Table 1: Seismic Response of Building A

Mass of building = 42 Kg

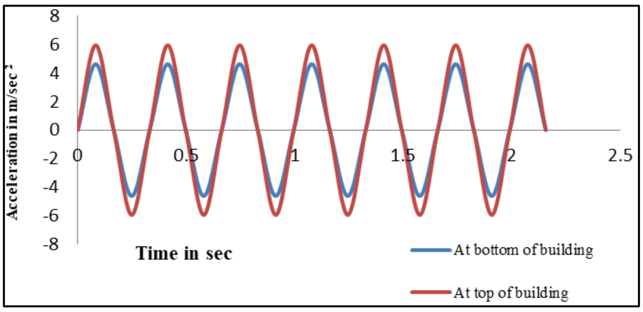

Fig. 5: Acceleration of Building A at different points at 3.0 Hz Frequency

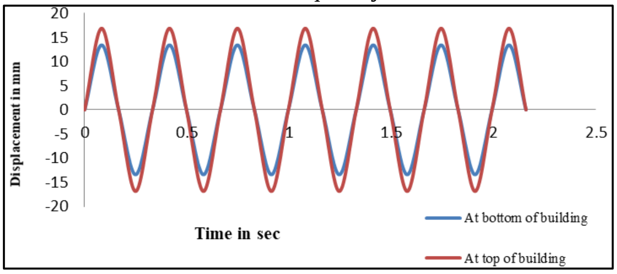

Fig. 6: Amplitude of Building A at different points at 3.0 Hz Frequency

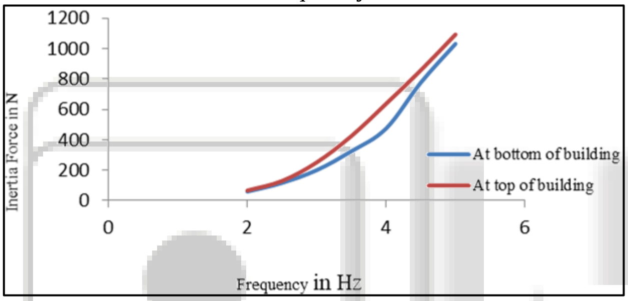

Fig. 7: Inertia Force of Building A at different Frequencies

In several frequencies the experimental work is carried out. The frequencies are ranging from 2 Hz to 5 Hz. The frequencies are controlled by a Tachometer (rpm measuring device). Every model subjected to each shock for 5 minutes. There are no cracks or any deformation in the first model up to 3 Hz. After 3 Hz, when 3.5 Hz is applied small cracks are started to develops on the top of three openings, one is in the wall in the direction of the motion and another two is in the out of plane walls. In 4 Hz the cracks are increase in thickness, cracks are develops diagonally in the wall through the window. In 4.5 Hz the total building is collapse, the walls containing the openings are totally collapse, but in the back wall no cracks are founds because there is no any opening. The failure of the Building A is total collapse

Fig. 8: Building A After Experiments

Frequency in (Hz)	Acceleration in (m /sec²)		Amplitude in (mm)		Inertia Force in (Newton)	
	At bottom of building	At top of building	At bottom of building	At top of building	At bottom of building	At top of building
2.0	1.95	2.05	8.06	8.56	58.55	62.18
2.5	3.50	3.67	9.60	10.38	108.96	117.81
3.0	4.44	4.71	10.74	12.03	175.54	196.62
3.5	4.86	5.81	11.21	12.54	249.16	278.97
4.0	7.00	7.17	12.85	14.23	373.37	413.47
4.5	9.23	9.46	12.91	15.89	474.39	584.34
5.0	13.02	14.11	14.55	16.37	660.57	743.20
5.5	12.78	12.87	15.04	18.20	826.21	999.80
6.0	12.05	13.24	18.20	18.69	1189.85	1221.88
6.5	13.89	15.12	19.07	21.12	1463.17	1620.46
7.0	15.28	15.50	19.49	21.96	1734.31	1954.09
7.5	17.77	19.42	20.11	22.05	2054.24	2252.42
8.0	21.35	25.00	22.14	23.84	2573.21	2770.79

Table 2: Seismic Response of the Building-B

Mass of building = 46 Kg

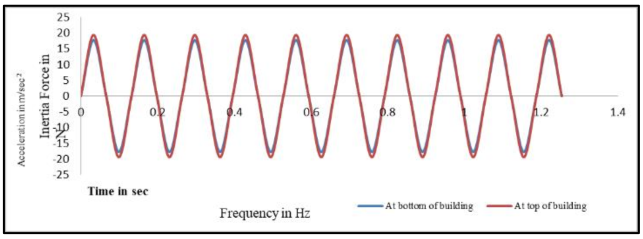

Fig. 9: Acceleration of Building B at different points at 7.5 Hz Frequency

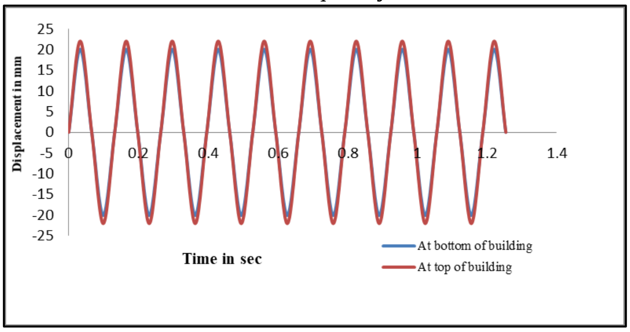

Fig. 10: Amplitude of Building B at different points at 7.5 Hz Frequency

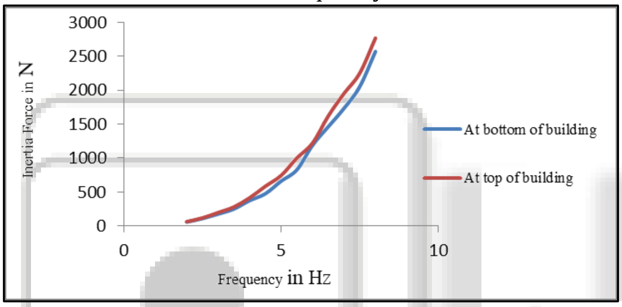

Fig. 11: Inertia Force of Building B at different Frequencies

In the same way in several frequencies the readings for this model are also taken. The response of the Building B for individual frequency is reduced from the response of the Building A. There are no any cracks or structural deformation in this model upto frequency 6 Hz. In 6.5 Hz light cracks are develops in the walls in the sill level, after that in 7 Hz and 7.5 Hz this crack is develops along the transverse direction in the adjacent in plane wall upto the signifies, openings causes vital role for the damages of earthquake.

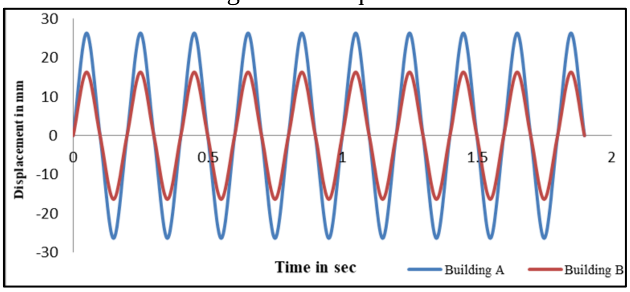

Fig. 13: Acceleration of Buildings A and B at 5.0 Hz Frequency

V. Conclusion

The present study focused on the implementation of mechanized bricks for improving the strength of masonry structures and to mitigate the structural failures and to assess the response of the buildings made by mechanized bricks. A set of experiments were carried out for studying the properties of masonry assemblage and dynamic response of masonry buildings by providing bands in different positions.

In the model made with mechanized bricks and without any band response increases with the increase of external frequency. The Inertia Force at top of building is more than bottom of building. At 5 Hz frequency the building is totally collapsed. The cracks are developed along the openings of the building. But in the back wall which is without any opening, no cracks have developed which opening. In the 8 Hz the cracks are only increase in thickness. No other cracks are found in the other walls .The nature of the cracks is not diagonally, horizontal cracks are formed.

Fig. 12: Building B after Experiments

In the model made with mechanized bricks with one band at sill level cracks have developed at 6.5 Hz frequency along the sill level. The thickness of cracks is very thin. Here the response of the building is reduced to 18.75% over the model made without any band.

From the observation it can be concluded that the building with multiple band which increases rigidity of the structure is more effective during earthquake than single band or without band. During earthquake it is possible to control the responses or damages of the building.

Acknowledgment

The success and final outcome of this project required a lot of guidance and assistance from college and its our privileged to have got this all along the completion of our project.

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