

Seismic analysis of plain masonry structure made of 1:2 reduced scale clay burnt bricks excited by shake table

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ABSTRACT

Masonry building worldwide exhibits severe damage and collapse in strong earthquake events, which is mainly due to the combination of low tensile strength, large mass and insufficient connection between structural elements, is the main limitation for their structural implementation in residential building. The study of structural dynamics is commonly perceived to be a difficult exercise. This paper includes experimental testing of plain masonry structure. To study the basic issues related to vibration behavior, cracking pattern, failure mechanism and In-plane; out-plane behaviour in terms of displacement & lateral drift, an experimental testing of plain masonry structure without reinforcement is carried. The model is plain structure made of clay burnt bricks (1:2 reduced scales). The test is conducted on uniaxial shake table. The frequency of the motion of shake table is varied by changing the RPM of the electric motor.

1. Introduction

Masonry is one of the oldest forms of construction known to humans. The term masonry refers generally to brick, tile, stone, concrete block or combination of thereof, bounded with mortar. From a structural engineering perspective, masonry is classified as plain or unreinforced masonry and reinforced masonry. Plain masonry refers to construction from natural or manufactured building units of burned clay or similar material. Clay bricks are very strong with compression strength. These bricks when used with even the lowest grade mortar; result in a fairly strong masonry assemblage. So effort is made to study the behavior of masonry structure without reinforcement made of 1:2 reduce scale clay burnt bricks. The experimental analysis consists of global parameters such as cracking pattern, failure mechanism and In-plane; out-plane behaviour in terms of displacement and lateral drift. The model is constructed on shake table itself of dimension 1.5 m x 1.5 m. To avoid base failure, foundation of doubly reinforced beam is constructed.

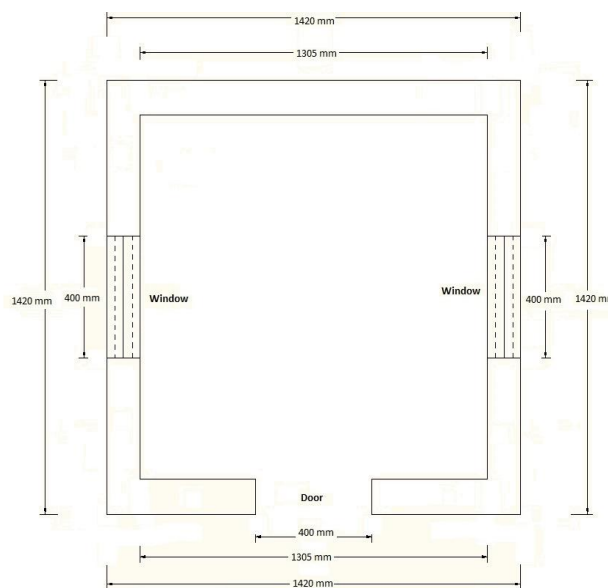
2. Objective of Study

- To find out stiffness of building model experimentally.
- To find out dynamic properties of model like acceleration, natural frequency, time period, with shake table testing.
- To find the cracking pattern, failure mechanism and In-plane; out-plane behavior

3. Geometric Design

A model of 1420mm of length, 1250 mm of height and 120 mm width is constructed. This model is a plain structure without any reinforcement. There is an opening in the three walls. In the east wall, there is a door of length 400 mm and height of 900 mm. In the north wall and the south wall, there is window of size 400 mm x 400 mm. The distance of the opening for both door and window is 510 mm from the corner. Lintel beam of size 800 mm x 120 mm x 37.5 mm has provided at lintel level above the each door and window. Tukri of stone has used as

dead load or roof load with the support of angle provided at the top.



Plan View of Model

Figure 1 Plan of Model

Weight of the superstructure is calculated below:

Weight of west wall = $1.42 \times 1.250 \times 0.120 \times 1900 = 404.7$ kg

Weight of east wall = $(1.42 \times 1.250 \times 0.120 \times 1900) - (0.400 \times 0.900 \times 0.120 \times 1900) = 322.62$ kg

Weight of north wall + weight of south wall = $2 \times [(1.18 \times 1.250 \times 0.120 \times 1900) - (0.400 \times 0.400 \times 0.120 \times 1900)] = 599.64$ kg

Weight of tukrey = $1.300 \times 1.300 \times 0.050 \times 2500 = 211.25$ kg
 Total weight of superstructure = 1538.21 kg



Figure 2 Uniaxial Shake Table



Figure 3 Foundation on Shake Table

Specification of Shake Table:

Motion: Simple Harmonic Motion
Number of Axis: Single Axis
Maximum Pay Load: 2000 kg's
Top Table Size: 1500 mm x 1500 mm
Base Motion Displacement: 50 mm - 100 mm
Operating Frequency: 1-6 Hertz
Frequency Control: 5 %
Drive: A C Motor drive
Motor Rating: 15 HP, 3 Phases
Control panel input voltage: 5 Wire, 3 Phase, 440 Volts
Maximum Height of the model: 1500 mm

4. Experimental Setup

Having constructed the foundation, 10 mm mortar mix of 1:3 is laid on the top surface of foundation. Lintel beam are provided above every opening of concrete mix with reinforcement bar of 6 mm diameter. Having constructed the structure, there is curing for seven days with wet clothes. After 28 days, the structure is tested by means of shake table.

The motion of shake table is simple harmonic. The shake table is adjusted at 40 mm base displacement. Dewesoft software has used for calculating the various results e.g. displacement, velocity and acceleration at particular frequency. Four accelerogram are pasted on the wall. One is at base level, second is at plinth level, third is at lintel and fourth is at roof level. These all accelerogram are connected to data logger

device and this device is connected to the monitor e.g. laptop. Initially a frequency of 0.67 Hz is applied and then increases up to 1.62 HZ. The excitation given to the model is only in one direction.



Figure 5 Model of Shake Table Before Test



Figure 6 Model of Shake Table After Test

5. Result of Experiment

Initially, frequency of 0.6 Hz is applied and increases up to 1.62 Hz. The first crack is initiated at 1.35 Hz. Flexural crack is observed at plinth level and lintel level at north wall. The size of crack is 2 mm thick and 500 mm long. Finally the structure is collapsed at frequency 1.62 Hz.

Under Out-of-Plane Loading:

- (a) **East Wall:** Flexural crack is developed at lintel level of length 500 mm and 3 mm width. Disintegration of mortar joint is occurred at plinth level. A piece of brick has displaced from its original position.
 (b) **West wall:** Flexural crack is developed at plinth level at frequency of 1.62 Hz. The size of the crack is 800 mm long and 2 mm width.

Under In-Plane Loading:

- (c) **North Wall:** Shear crack is developed below the window opening up to base level. The size of the crack is 300 mm in length and 2 mm in width. Horizontal crack is developed at lintel level and plinth level of length 400 mm.
 (d) **South Wall:** Diagonal cracks are observed below the opening of window till up to the base level. Disintegration of mortar joint is occurred at plinth level. A vertical crack of length 300 mm and width 4 mm at roof level is observed.



Figure 7 @ Frequency = 0.67 Hz



Figure 8 @ Frequency = 1.36 Hz

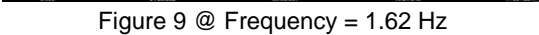


Figure 9 @ Frequency = 1.62 Hz

Various data of this structure (Frequency, Acceleration, Velocity and Displacement) at different level (Base, Sill, Lintel & Roof) for the frequencies of 0.67 Hz, 0.73 Hz, 0.86 Hz, 0.92 Hz, 0.92 Hz, 1.00 Hz, 1.14 Hz, 1.23 Hz, 1.35 Hz and 1.62 Hz are listed in table. All these data are calculated by using Dewesoft software with the help of accelerogram pasted on all the four walls.

Table 1 Result at Base Level

S. No	Frequency (Hz)	Acceleration (g)	Velocity (mm/s)	Displacement (mm)
1	0.67	0.0697	0.2.34	0.3043
2	0.73	0.0609	0.2231	0.4276
3	0.86	0.0728	40.5900	1.5956
4	0.92	0.0563	12.9771	0.6234
5	1.00	0.1689	10.0944	1.5934
6	1.14	0.1002	31.4469	8.6780
7	1.23	0.0595	68.6185	2.1122
8	1.35	0.3838	40.4064	2.8450
9	1.62	0.0049	6.0644	11.5844

Table 2 Result at Sill Level

S. No	Frequency (Hz)	Acceleration (g)	Velocity (mm/s)	Displacement (mm)
1	0.67	0.0419	0.3295	0.3100
2	0.73	0.0380	0.4433	0.4384
3	0.86	0.0558	1.7755	1.6598
4	0.92	0.0950	0.6464	0.6234

5	1.00	0.1854	1.7255	1.6416
6	1.14	0.1502	9.0466	8.8546
7	1.23	0.0605	68.6185	2.1122
8	1.350	0.3599	3.4628	3.0410
9	1.62	0.0740	13.2053	11.8668

Table 3 Result at Lintel Level

S. No	Frequency (Hz)	Acceleration (g)	Velocity (mm/s)	Displacement (mm)
1	0.67	0.0570	1.2795	0.3288
2	0.73	0.0478	0.9367	0.4396
3	0.86	0.0122	44.4146	1.7713
4	0.92	0.0938	9.8299	0.6265
5	1.00	0.1941	11.8634	1.6870
6	1.14	0.2142	1.1124	8.9263
7	1.23	0.0570	70.3568	2.3672
8	1.35	0.1551	2.9771	3.5000
9	1.62	0.5496	31.9104	13.3122

Table 4 Result at Roof Level

S. No	Frequency (Hz)	Acceleration (g)	Velocity (mm/s)	Displacement (mm)
1	0.67	0.0273	1.0244	0.3295
2	0.73	0.0397	0.3359	0.4433
3	0.86	0.0310	44.4255	1.7755
4	0.92	0.0930	11.0861	0.6464
5	1.00	0.1699	11.4880	1.7255
6	1.14	0.1631	6.7780	9.0466
7	1.23	0.0711	70.7307	2.4034
8	1.35	0.2681	5.9345	3.4628
9	1.62	0.4623	21.0508	13.2053

6. Conclusion

Flexural crack is developed at lintel level in the east wall and at plinth level in the west wall. Shear crack is developed below the window opening up to base level in the north wall while Diagonal cracks are observed below the opening of window till up to the base level in the south wall.

- The modal is collapsed at the frequency of 1.62 Hz.
- Acceleration, Velocity & Displacement is calculated experimentally.
- The maximum displacement was at roof level of 13.31 mm @ 1.62 Hz.
- Under-out-of plane loading, flexure cracks are observed.
- Under In-plane loading, shear cracks are observed.

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