

Comparative Study of Effect of Aspect ratio (Height to Base Ratio) on Seismic Performance of Brick Masonry Buildings

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Abstract

Masonry buildings are widely used for housing construction not only in India but in many other countries of the world. Most of the casualties are due to collapse of these constructions in earthquakes. Irregularity in plan (C or U shape), mass or stiffness result in generation of torsional forces causing collapse of building due to irregular response and complex dynamics. Building shaped like a box, such as rectangular, both in plan and elevation, is inherently stronger than one that is L-shaped or U-shape building. Aspect Ratio is also an important factor contributing to effective performance of brick masonry building during earthquake. It is a ratio of height of building to base width along the direction of lateral forces induced because of earthquake.

Introduction

An important feature in building configuration is its regularity and symmetry in horizontal and vertical plane. Seismic behavior of irregular shaped plans differs from regular shapes. Irregularity give origin to undesired stress concentrations in some resisting members of the building. On the contrary, the ideal rectangular or square plan, structurally symmetric, with enough in-plane stiffness in its diaphragm, presents an ideal behavior, because it has the same displacement at every point in the slab. Therefore, building shaped like a box, such as rectangular, both in plan and elevation, is inherently stronger than one that is L-shaped or U-shaped, that is a building with wings.

Various factors related with dimensions of building, affecting performance of unreinforced masonry are as per following

1. Configuration of Building
2. Aspect Ratio

Aspect Ratio is an important factor contributing to effective performance of brick masonry building during earthquake. It is a ratio of height of building to base width along the direction of lateral forces induced because of earthquake. Our thesis work is focused on the effect of Aspect ratio on seismic performance of masonry buildings. Aspect Ratio affects the Natural Period of Oscillation of building during earthquake induced motion. The elastic properties and mass of building cause to develop a vibratory motion when they are subjected to dynamic action. In low-rise building (say less than five-storey high) the seismic response depends primarily on the fundamental mode of vibration; accordingly, the period of vibration of this mode, expressed in seconds, is one of the most representative characteristics of the dynamic response of a

building. On the basis of time period, building may be classified as rigid ($T < 0.3$ sec), semi-rigid ($0.3 \text{ sec} < T < 1.0 \text{ sec}$) and flexible structure ($T > 1.0 \text{ sec}$). Past studies show that the predominant period at firm ground site is typically in the range 0.2-0.4sec, while the period can reach 2 sec or more on soft ground. Since building structures have fundamental periods of approximately $0.1 N$ (where N is the number of storeys), it can be concluded that if the foundation soil is firm, rigid structure will have more unfavourable seismic response than flexible structures, whereas the seismic response of flexible structures on soft foundation sites will be less favourable than that of rigid structure.

EXPERIMENTAL PROGRAMME

For collection of data and to analyze the effect of Aspect Ratio on Seismic performance of Masonry structures, we studied various houses in a colony situated at Shahpura locality in Bhopal. These houses had been constructed in 1985. All houses are built with load bearing masonry walls with spread footing foundation. Initially these houses were built as EWS houses with box type configuration having one room of $3.00 \times 4.50\text{m}$ and one of $3.00 \times 2.50\text{m}$ space containing kitchen and toilet. The houses were made in groups of blocks, as one block of two houses and one block of three houses with base width of 3.00m , 6.00m and 9.00m . After some years with additional construction of upper stories, some houses got converted in to two and three storey houses.

These buildings are with box type configuration with no balcony or projections, hence ideal to be analyzed for their vulnerability to seismic forces on aspect ratio basis.

Aspect Ratio was determined for various blocks under following categories.

Single storey houses with base width 3.00m

Single storey houses with base width 6.00m

Single storey houses with base width 9.00m

Double storey houses with base width 3.00m

Double storey houses with base width 6.00m

Double storey houses with base width 9.00m

Three storey houses with base width 3.00m

Three storey houses with base width 6.00m

Three storey houses with base width 9.00m .

Natural Period of Oscillation for above buildings were determined by using the formulae stated in IS:1893. The change in natural time period was compared to analyse the performance of these building blocks for seismic forces.

The value of time period of the building may be determined as follows:

$$T_a = \frac{0.09h}{\sqrt{d}} \quad \text{Where ,}$$

h = height of building in m,

d = base dimension of the building at plinth level,

in m, along considered direction of the lateral force.

Observation and Calculations

Table :Time Period of Buildings with various Base Width for different Heights

Aspect Ratio= h/d	$h/d^{1/2}$	Time Period $0.09 \times h/d^{1/2}$
3/3=1.00	1.732	0.155
6/3=2.00	3.464	0.311
9/3=3.00	5.196	0.467
3/6=0.5	1.224	0.110
6/6=1.00	2.449	0.220
9/6=1.50	3.67	0.33
3/9=0.33	0.99	0.089
6/9=0.67	2.01	0.18
9/9=1.00	3.00	0.27

CONCLUSION:

With the increase in Aspect Ratio, Natural Period of Oscillation of building increases. This results in to dominating flexural stresses inducing out of plane failure of masonry walls. This study can further be used to optimize the height of building and size of walls to achieve efficient design of rooms /space for better seismic performance of building during earthquake.

References:

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