International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 07 | July 2019 www.irjet.net p-ISSN: 2395-0072

Evaluation of Ductility Demand in a Multi Storey Building having Symmetrical Plan in High Seismic Zone

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Abstract - In every structural design, ductility is given importance, as it has the ability to absorb energy without undergoing critical failure. If a structure is formed using ductile members it can undergo huge deformations before attaining failure state. This is an advantage for structures subjected to overloading, it undergoes large deformations before it attains failure state, which gives sufficient amount of time to take preventive measures. Thereby reduces significant loss of life. In an earthquake resistant design the building proportions play a vital role. For a tall structure as there is an increase in height the level of response to earthquake forces change, therefore the building proportions in both length and height needs to be carefully studied with its Aspect ratio.

1. INTRODUCTION

Earthquake is shaking of surface of the earth and one of the unsafe natural calamities. It can be extremely violent and are caused by abnormal movements of earth's tectonic plates. Studying of earthquake is termed as seismology. Magnitude of earthquake is measured by the instrument named Ritcher Scale. The point at which the earth quake initiates is called as Focus and waves radiated from this are seismic waves.

Earthquake which takes place at shallow depth cause immense destruction and damage for both living and non-living things such as human beings, animals, buildings, vehicles etc.

There are various measures to reduce stress in building's that is by introducing flexible columns inside the hollow columns or by using rubber pads to separate the base column from the ground. In the context of the design process defined in the IS Code, a civil engineer faces the challenge of reducing the damage caused by earthquakes in designing buildings.

1.1 Ductility

Ductility is a measure of the ability of a material to undergo significant plastic deformation prior to rupture. This can be expressed as percent elongation or area reduction from a tensile test. Ductility is used in earthquake engineering to denote how well a building endures large lateral shifts caused by ground shaking.

1.2 Aspect Ratio

The aspect ratio or slenderness ratio can significantly influence the behaviour of skyscrapers under wind. As the building grows larger, the reaction level changes to the dynamic load. Therefore, the proportions of height and length must be carefully weighed. The wind analysis needs to be even more accurate when the tall building is characterized by an unusual shape or a large geometric slenderness, which is defined by the aspect ratio (building height /shortest side of its plan). Usually up to $\lambda \geq 8–11$ some comfort problems could exist, if the structure does not have enough stiffness or it is not equipped with damping devices.

The maximum plan aspect ratio of the overall building shall not exceed 5.0 as per IS codes.

2. Pushover Analysis

As the name states "Push - over", push the building until you reach its maximum capacity to deform. It helps in understanding the deformation and cracking of a structure in case of earthquake and gives you a kind of fair understanding of the deformation of building and formation of plastic hinges in the structure. It is a sort of approximate tool to understand your building performance.

Seismic analysis is generally a dynamic analysis that can be linear or nonlinear while pushover analysis is a nonlinear static analysis. The difference is that when you try to pushover, you try to determine the building's capacity for maximum displacement, and seismic analysis tries to keep your shifts under control according to the codes.

3. AIM

To determine the ductility of 10, 20 and 30 stories building in high seismic zone with plan aspect ratio of 1, 2.5 and 3.

4. Objectives

To study the literature review on ductility for high rise structures

To analyse the ductility of high rise building with different plan aspect ratio.

To compare the ductility of high rise buildings of height 10, 20 and 30 storeys.

To study the effect of ductility in terms of displacement and base shear

5. Methodology

1 Introduction
The project is carried out to study the ductility of a high rise building in high seismic zone with different plan aspect ratio.

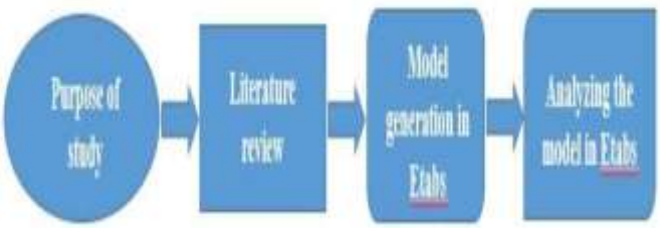
• The high rise reinforced concrete structure is modelled by setting the plan dimensions, storey number and height accordingly.
• Etabs software is used for the modelling and analysis of the structure.
• Material properties are defined as per:-

IS 456: 2000 – Plain and reinforced concrete.
IS 800: 2007 – General construction steel.

• Loads and load combinations are defined based on IS codes.
• Dynamic analysis is done with and static analysis is carried out with pushover analysis.
• Results are obtained in terms of parameters like yield displacement, ultimate displacement and ductility.
• Conclusions are made to understand the behaviour of ductility in high rise building the with different aspect ratio.

5.1 Sequence of flow

The work carried out is represented in a sequence of flow chart as which is as follows:-



5.2 Loadings

The types of loads and load combinations are defined based on IS codes:-

Types of loads

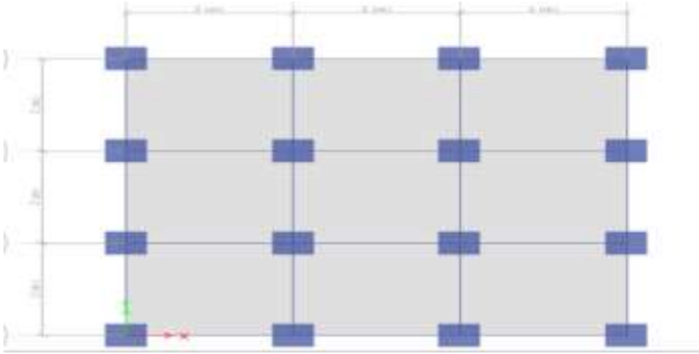
Dead loads – IS 875: 1987(Part 1)

Live load – IS 875: 1987(Part 2)

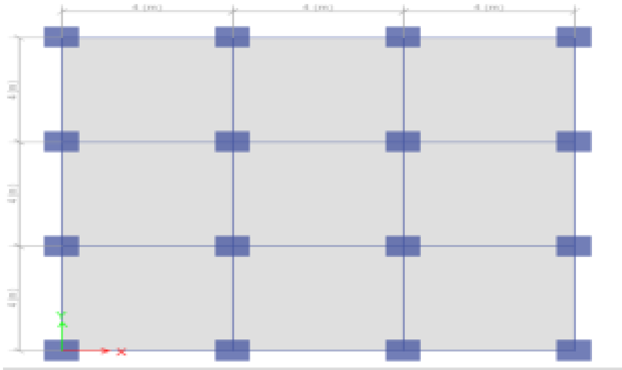
Earthquake loads – IS 1893: 2016(Part 1)

Pushover

6. Etabs Models



10 Storey Plan, aspect ratio 1:1



20 Storey Plan, aspect ratio 1:1

Model Details:-

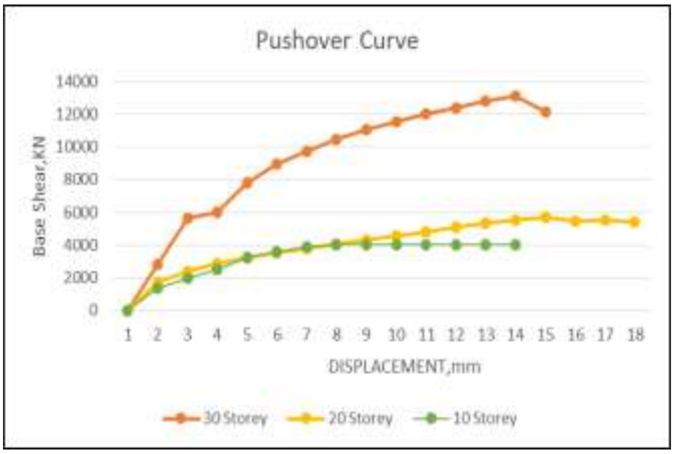
	10 Story	20 Story	30 Story
Column size(mm)	500*500	800*800	1000*1000
Beam size(mm)	300*450	300*500	300*600
Concrete grade	M30	M30	M30
Steel grade	HYSD500	HYSD500	HYSD500
Bay size(m)	6*6	12*12	18*18
Height of Story	30	60	90
h/B ratio	5	5	5
Aspect ratio	1:1	1:1	1:1

7. CONCLUSIONS

a) For 10 story structure , Ductility ratio as for aspect ratio 1:1 abatements by 41.5% to 1:2 aspect ratio and descreases by 24.9% to 1:3 aspect ratio.

b) For 20 story structure , Ductiliy ratio concerning aspect ratio 1:1 reductions by 35.8% to 1:2 aspect ratio and furthermore descreases by 13.9% to 1:3 aspect ratio.

c) For 30 story structure , Ductility ratio as for aspect ratio 1:1 reductions by 31% to 1:2 aspect ratio and furthermore descreases by 13% to 1:3 aspect ratio.



Pushover curve of 10, 20 and 30 story

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