

Estimation of Ductility for High Rise Buildings for a Different Plan Aspect Ratio

Veena R¹, Sushma C K², Vijayalakshmi Akella³

¹Assistant Professor, Dept of Civil Engineering, JIT, Bengaluru, India

²Asst Professor, Dept. of Civil Engineering, Dayananda sagar College of Engineering, Bengaluru, India

³Professor, Dept of Civil Engineering, KSSEM, Bengaluru, India

Abstract - Ductility is 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 repeated loading; 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 breadth needs to be carefully studied with its Aspect ratio.

When there is a severe earthquake and the structure has to be behaving elastically. Then the energy in structural performance is improved by the amount of plastic energy that is dissipated by the structure during the design ground motion.

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 $\lambda \geq 8-11$ if the structure does not have enough stiffness.

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

1.3 Pushover Analysis

Pushover is a static-nonlinear analysis method where a structure is subjected to gravity loading and a monotonic displacement-controlled lateral load pattern in which until an ultimate condition is reached.

2. Methodology

The project has been carried out for mid raise building to study ductility in seismic zone 4 with different aspect ratio.

A 10 storey reinforced concrete building has been modeled according to the plan dimension, storey number and desired storey height using ETABS 2017 software.

Material properties are defined as per:-

IS 456: 2000 – Plain and reinforced concrete.

IS 800: 2007 – General construction steel.

Earthquake loads – IS 1893: 2016(Part 1)

1. INTRODUCTION

An earthquake is a sudden tremor or movement of the earth's crust, which originates naturally at or below the surface. About 90% of all earthquake result from tectonic events, primarily movements on the faults. The remaining is related to volcanism, collapse of subterranean cavities or manmade effect.

The effect of ground shaking is mostly dependent on the duration of strong motion part .the area under the acceleration pulse is a measure of vibrations transmitted to the structure. The ground acceleration is the most significant parameter of strong motion being directly proportional to the inertia force imposed on the structure. The ground velocity is better correlated with the intensity of damage and it is also directly related with the energy transmitted to the structures.

Seismic zoning map of a country segregates country in various areas of similar probable maximum intensity of ground motion. The maximum intensity is fixed in such a way that the lifeline/critical structures will remain functional and there is low possibility of collapse for structure designed with the provision provided in the code even for the occurrence of the earthquake with higher intensity. Thus a structure designed with the provision of code can suffer damage both structural and non structural.

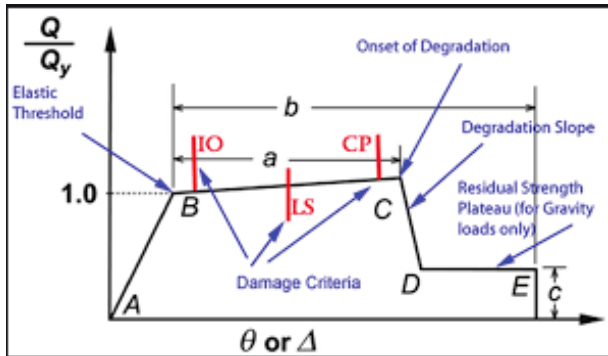
1.1 Ductility

Ductility is defined as the extent to which the material or structure can go large deformation without failing.

Static analysis is done first and dynamic analysis and is carried out with pushover analysis.

Auto hinges are applied at beam and column junction and analyzed.

Hinge states are categorized as per ATC 40.



The above figure shows the hinge states.

3. Model description

A reinforced concrete building has been modeled with (G+9) stories with different plan aspect ratio of 1,2,3,4 and 5, with different grid spacing in both direction and analyzed. Table 1 Table 2 show the loads assumed on the structure.

Table 1

Sl no	Types of load	Details
1	Sidl	1kN/m ²
2	Live	1kN/m ²
3	Load combinations	As per IS1893:2016

Table 2

Zone factor	Zone 4
Importance factor	1
Response reduction	5
Soil type	2

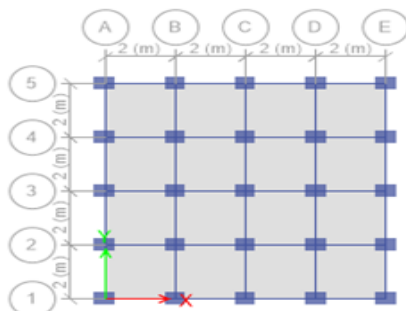


Fig.1

Fig 1 Plan of Etabs model of a 10 storey building with aspect ratio 1

4. Result and Discussions

For each model with varying aspect ratio, base shear v/s monitored displacement curve value is Obtained.

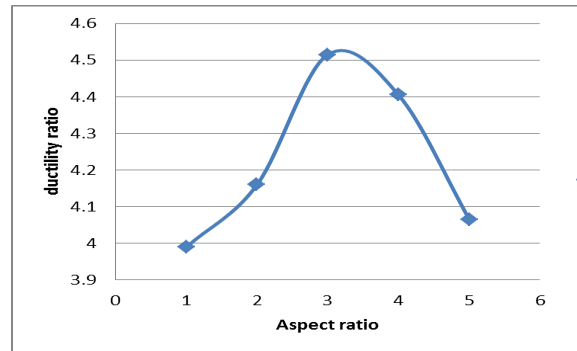


Fig 2

Fig 2 shows varying ductility ratio for different aspect ratio of 10 storey building.

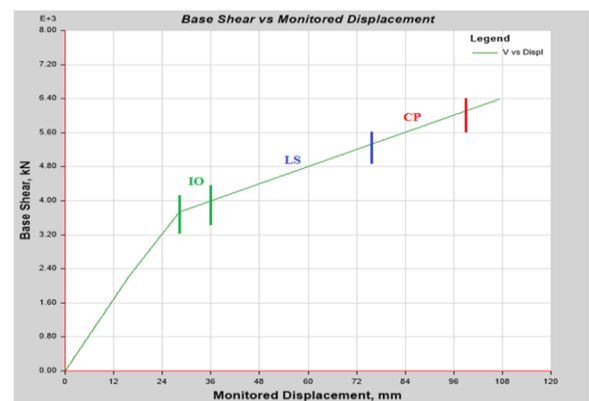


Fig 3

Fig 3 Static pushover curve for Aspect ratio 1.

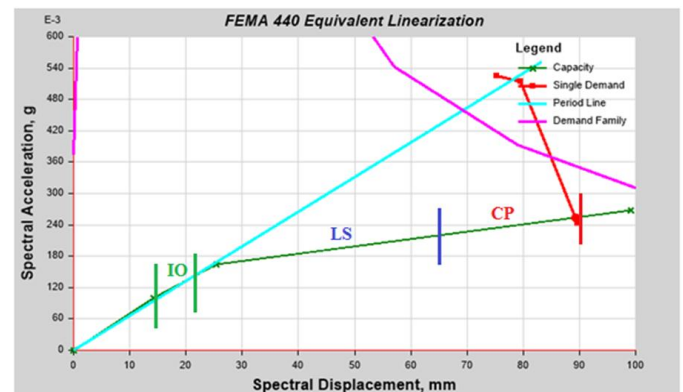


Fig 4

Fig 4 shows performance point of aspect ratio 1

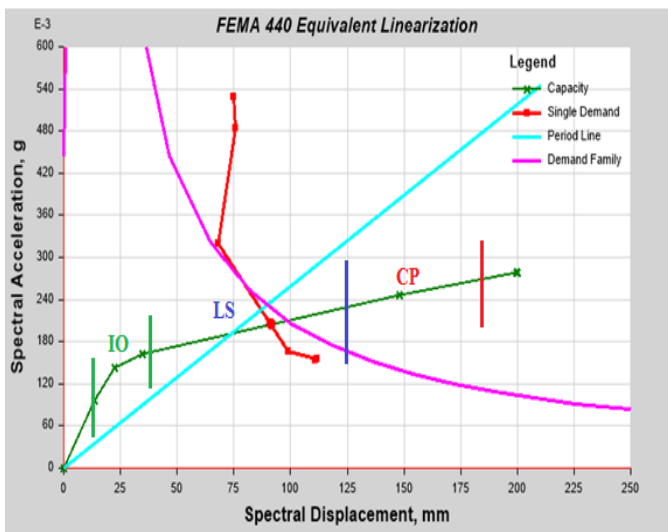


Fig 5

Fig 5 shows performance point of aspect ratio 4.

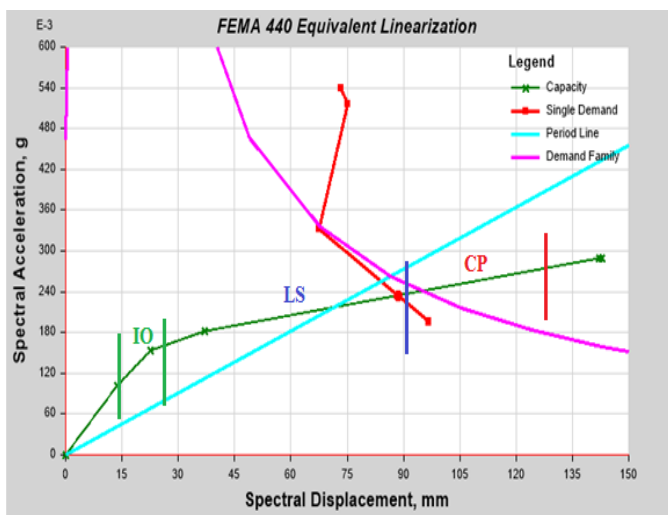


Fig 6

Fig 5 shows performance point of aspect ratio 5.

Performance point for aspect ratio 1 is found almost close to CP, again for aspect ratio 4 and 5 it linearly increases and moves farther from LS region.

5. Conclusions

Based on the current analysis done the following conclusions are drawn below.

- 1) Ductility for aspect ratio 1 to 3 is found to increasing by 13.15% and Ductility for aspect ratio 4 to 5 is found to be decreasing by 7.69%.

- 2) Base shear for aspect ratio 1 to 3 is found to be increasing by 5.26% and base shear for aspect ratio 4 to 5 is found to be decreasing by 0.9%
- 3) Performance point for aspect ratio 1 is found almost close to CP. And is linearly decreasing for aspect ratio 2 and is nearer to LS region. Further for aspect ratio 3 decreases and lies in LS region.
- 4) Performance point for aspect ratio 4 and 5 it linearly increases and moves farther from LS region.

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