IARJSET
ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified ⁜ Impact Factor 7.105 ⁜ Vol. 9, Issue 7, July 2022
DOI: 10.17148/IARJSET.2022.9745

EVALUATION OF DUCTILITY DEMAND IN A MULTISTORY STEEL BUILDING IN A HIGH SEISMIC ZONE

Anjum Taj[1], Sushma C K[2]

Department of Structural Engineering, Dayananda Sagar College of Engineering, Bengaluru, Karnataka, India[1&2]

Abstract: Tall building developments are rapidly increasing worldwide. In past years, developed countries have emerged as centres for brand spanking new high-rise buildings. The land is scarce and expensive, particularly in big cities like Japan, where tall buildings represent the simplest solution for solving the matter. Steel-frame structures of relatively lightweight, high strength, and high ductility became mainstream for the earthquake-resistant construction of high-rise buildings. Taller buildings also face higher wind loads hence steel is flexible, allowing the building to maneuver and deflect with the wind forces, instead of making it rigid like concrete. High-rise buildings, built completely in steel or primarily with steel are limited in India. In this paper, an attempt has been made to assess global and local ductility of a steel structure.

Keywords: High rise building, steel structure, ductility, analysis, seismic design.

I. INTRODUCTION

The tallest building within the world, as of 2022 is Burj Khalifa. The title of "world's tallest building" has been borne by various buildings, like the 3rd-century Jetavanaramaya stupa, Lincoln Cathedral, the New York Building and therefore the original World Trade Centre.
Before the trendy skyscraper era, between c. 1311 and 1884, the tallest buildings and structures were mostly Christian churches and cathedrals.

(Mir and Kyoung 2011) Tall buildings emerged in the late nineteenth century in the US of America. They constituted a so-called “American Building Type,” meaning that almost all important tall buildings were in-built by the U.S.A. Many tall buildings are built worldwide, especially in Asian countries, such as China, Korea, Japan, and Malaysia.
Traditionally the function of tall buildings has been as commercial office buildings. Other usages like residential, mixed-use, and hotel tower developments have rapidly increased. Tall building development involves various complex factors like economics, aesthetics, technology, municipal regulations, and politics. Among these, economics has been the first governing factor.

In the late nineteenth century, early tall building developments were based on economic equations – increasing rentable area by stacking office spaces vertically and maximizing the rents of these offices by introducing as much natural light as possible. In order to serve this economic driver, new technologies were pursued that improved upon the conventional loadbearing masonry walls that had relatively small punched openings. The result was the iron/steel frame structure which minimized the depth and width of the structural members at building perimeters.

(Nazri and Ken 2014) Most of the construction in Malaysia concentrates only on the use of reinforced concrete as the choice for the structural system. In the past few years the industry has been experiencing shortage of cement for concrete construction. With all these considerations, steel structures may provide a better choice for the construction industry present needs.

(Ibrahim 2007) Steel is highly durable metal. Due to its strength and load bearing capacity to weight ratio, steel is the undisputed material of choice for high-rise building structures. It can withstand a considerable amount of external pressure and hence steel structures are earthquake resistant. Steel structures can have a variety of structural forms like braced frames and moment resistant frames suitable to meet the specific requirements of higher buildings.

II. AIM

To determine the global and local ductility of 10 stories building in high seismic zone with different plan aspect ratio.

International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified ⋇ Impact Factor 7.105 ⋇ Vol. 9, Issue 7, July 2022
DOI: 10.17148/IARJSET.2022.9745

III. OBJECTIVES

- To prepare models for 10 stories using structural steel sections with varying plan aspect ratio of 1:1, 1:2, 1:3, 1:4, 1:5 and 1:6 in high seismic zone.
- To analyse and design the prepared models according to IS 800:2007 and IS 1893:2016.
- To assess the overall ductility of the building.
- To calculate the local ductility in terms of story shear.
- To establish relationship between global ductility and local ductility.

IV. METHODOLOGY

- To prepare the models in ETABS and assign the required parameters and necessary loads.
- To analyze and design the models conforming to IS 800:2007.
- To obtain the results from response spectrum and pushover analysis in the form of ductility ratio, story stiffness, time period and base shear.
- To find the values of global and local ductility.
- To compare the results with different aspect ratio, i.e. 1:1, 1:2, 1:3, 1:4, 1:5 and 1:6.
- To establish relationships between global and local ductility.

V. ETABS MODELS

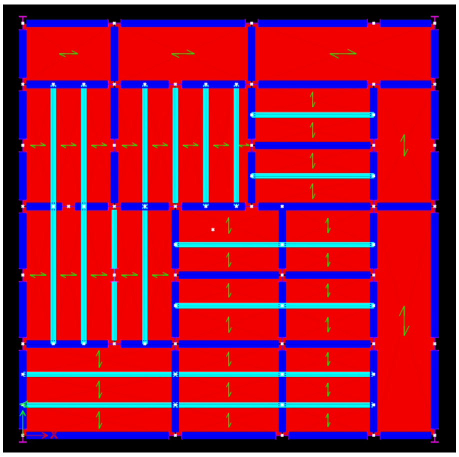

Fig. 1 Plan of ETABS models of aspect ratio 1:1

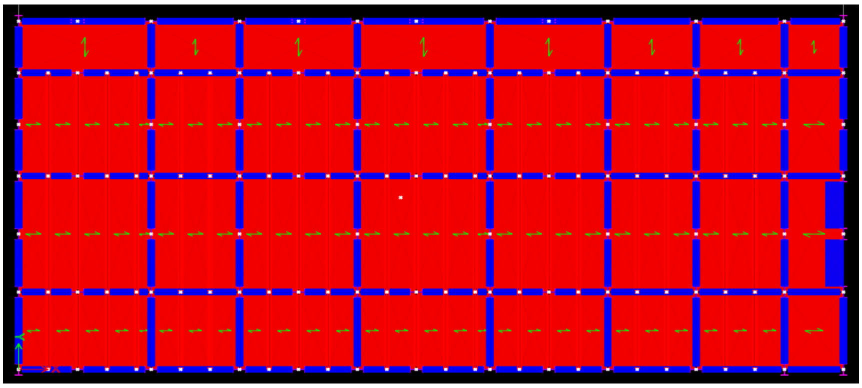

Fig. 2 Plan of ETABS models of aspect ratio 1:2

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 7.105 ⁜ Vol. 9, Issue 7, July 2022

DOI: 10.17148/IARJSET.2022.9745

Table 1 Sections that are used for modelling the structural members

MODEL	MEMBER	GRADE	SECTION
1:1	Column	Fe550	ISHB450
	Primary beam	Fe450	ISMB600
	Secondary beam	Fe450	ISMB400
	Braces	Fe450	ISMB300
1:2	Column	Fe450	ISHB450
	Primary beam	Fe450	ISMB600
	Secondary beam	Fe450	ISMB400
	Braces	Fe450	ISMB350
1:3	Column	Fe450	ISHB450
	Primary beam	Fe450	ISMB600
	Secondary beam	Fe450	ISMB400
	Braces	Fe450	ISMB450
1:4	Column	Fe550	ISWB600
	Primary beam	Fe550	ISMB600
	Secondary beam	Fe550	ISMB400
	Braces	Fe550	ISMB500
1:5	Column	Fe650	ISWB600
	Primary beam	Fe450	ISMB600
	Secondary beam	Fe450	ISMB400
	Braces	Fe450	ISMB500
1:6	Column	Fe650	ISWB600
	Primary beam	Fe650	ISMB600
	Secondary beam	Fe450	ISMB400
	Braces	Fe650	ISMB500

VI. CONCLUSION

1. The ductility demand of the critical story in most cases occurs in the upper stories of the structure and the amount is significantly high in tall structures especially under severe earthquakes.
2. It is observed that, the story stiffness is gradually increasing with respect to the aspect ratio.
3. The time period of the critical story in most cases occurs in the lower stories of the structure (first story).
4. From the calculations, it is observed that the base shear increases with increase in plan aspect ratio and the values of base shear from ETABS and calculations are nearly same.

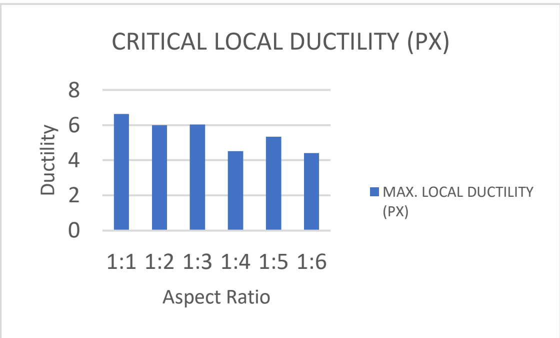

Fig. 3 Graphical representation of local ductility in X-direction

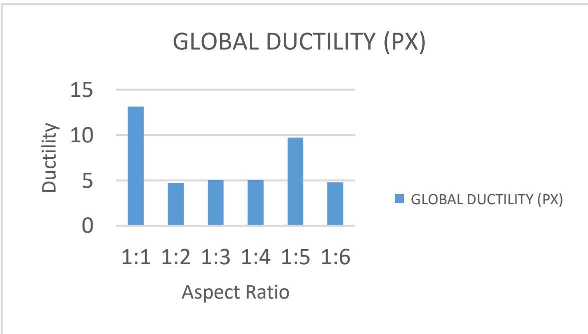

Fig. 4 Graphical representation of global ductility in X-direction

DOI: 10.17148/IARJSET.2022.9745

REFERENCES

[1] Seyed Morteza Kia, and Mahmood Yahyai. 2004. “Relationship between Local and Global Ductility Demand in Steel Moment Resisting Frames.” (3072).
[2] De Stefano, Mario, Edoardo Michele Marino, and Pier Paolo Rossi. 2006. “Effect of Overstrength on the Seismic Behaviour of Multi-Storey Regularly Asymmetric Buildings.” *Bulletin of Earthquake Engineering* 4(1): 23–42.
[3] Tiwari, Arun K., and Vinay K. Gupta. 2000. “Scaling of Ductility and Damage-Based Strength Reduction Factors for Horizontal Motions.” *Earthquake Engineering and Structural Dynamics* 29(7): 969–87.
[4] Zahrai, Seyed Mehdi, and Meysam Jalali. 2014. “Experimental and Analytical Investigations on Seismic Behavior of Ductile Steel Knee Braced Frames.” *Steel and Composite Structures* 16(1): 1–21.
[5] Zhai, Chang Hai, Wei Ping Wen, Shuang Li, and Li Li Xie. 2015. “The Ductility-Based Strength Reduction Factor for the Mainshock–Aftershock Sequence-Type Ground Motions.” *Bulletin of Earthquake Engineering* 13(10): 2893–2914.
[6] Zubritskiy, Maksim, Oleg Ushakov, Linar Sabitov, and Karina Nabiullina. 2021. “Seismic Resistance Estimation of Multi-Story Steel Frames under Ductility Level Earthquake Impact by Nonlinear Static Method.” *E3S Web of Conferences* 263.