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Comparative Analysis of Multistorey Steel Structure with Bracings at Various Location

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Abstract
The study involves an in-depth analysis of the structural elements concerning their behavior and efficiency. By assessing their seismic resistance, lateral load distribution and overall structural integrity, this paper contributes the valuable insights into the analysis of multistorey steel buildings for enhanced safety and sustainability. The seismic behavior of the structure will check with and without the bracings. The structure is analyzed by Response Spectrum Method. Deflection, Fundamental time period and Steel take off are checked for all type of structures. Static load, Lateral load due to earthquake and wind forces are considered for the analysis.

Keywords: Bracings, Multistorey, Steel Structure.

INTRODUCTION

India, being a developing country massive residential building construction is taking place in various parts of the country. Since 30% of the Indian population lives in towns and cities hence construction is more in urban places. The requirement for housing is tremendous but there will always be a shortage of house availability as the present masonry construction technology cannot meet the rising demand every year. Hence alternative construction systems like construction using steel sections can be possible. India has an installed steel capacity of 35 to 40 million tones & apparent steel consumption is around 27 to 30 million tons. Steel Buildings use a combination of built-up sections, hot-rolled sections and cold-formed elements which provide the basic steel framework with an RCC slab for roofing and brick masonry walls. The concept is designed to provide a complete building envelope system that is energy-efficient, optimum in weight and above all, designed to fit user requirements. Steel structures are very common structures required in all kinds of plants, industries and commercial sectors but they can also be used as residential and institutional buildings. As steel is an inherently ductile and flexible material, it is the material of choice for design.

The bracing element in the structural system plays a vital role in structural behaviour during an earthquake. The pattern of the bracing can extensively modify the global seismic behaviour of the framed steel building.

Maximum Value from Steel Construction

- Speed of Construction
- Flexibility and adaptability

- Reduced disruption to the locality
- Quality Service Integration
- Safer Construction
- Environmental Benefits

Literature Review

The study of literature given below is carried out to focus on the type of work done up till now, the methods and methodologies used to carry out the work and the material used in the studies. It is attempted to make the literature review on the analysis and design of steel structures, particularly in the following category.

Mr Shantanu P. Daterao, Prof. Mayur A. Banarase, "Seismic Analysis and Design of Multistoried Steel Structure Using IS 1893:2016"

In the work of this paper, the performance of steel multi-storeyed buildings has been evaluated by using both codes IS-1893:2002 and IS-1893:2016. The comparison, G+11 and G+6 buildings are considered. The models with a bracing system are studied and compared for deflection by using an equivalent static method. This study concluded that the response of a structure analyzed according to IS-1893:2016 is approximately 20% higher than a structure analyzed according to IS-1893:2002. The study observed that there is a significant increase in the lateral drift and displacement demand which ultimately increases the member forces. When IS 1893:2016 is compared with IS 1893:2002, it is found that there is an increment in lateral displacement by nearly 20%, an increment in storey drift by nearly 20%, increment in base shear by nearly 20%. It can be concluded that the Seismic response of building will increase by 20%. For multistorey up to G+11, increment in seismic forces is about 20%, increment in column moments is about 20% for biaxial moment column and 20% for axial and uniaxial moment column, increment in column axial forces are mostly similar and varying only by 4 to 7%. For multistorey building G+6, the increment in column moments is about 128% for the biaxial moment column and 20% for the axial and uniaxial moment column.

Gayatri Thakre, A.R. Kambekar, "Effect of Steel bracings in Steel Structure"

The study is focused on the behaviour of structure to resist lateral load for different types of bracings. The four types of bracings that are Diagonal bracing, Inverted bracing, V-type bracing and X-type bracing are compared. Parameters compared are Base reactions, Maximum displacement of the member, Nodal displacements and Nodal rotation for a fixed base steel structure. G+7 storey building model has been analysed under wind loading using STAAD Pro V8i SS6. It is observed that the displacement in a braced frame is reduced by 87% after providing diagonal bracing and 96% after providing X, V and inverted V bracing. The vertical reaction in the case of all bracings is reduced by 10%.

K. K. Sangle, K. M. Bajoria, V. Mhalungkar, "Seismic Analysis of High-Rise Steel Frame Building with and without Bracings"

In this paper, the linear time history analysis is carried out on high-rise steel buildings with a different pattern of a bracing system for the Northridge earthquake. Natural frequencies, fundamental time period, mode shapes, inter-story drift and base shear are calculated with a different pattern of bracing system. Further optimization study was carried out to decide the suitable type of the bracing pattern by keeping the inter-story drift, total lateral displacement and stress level within the permissible limit. The study aimed to compare the results of seismic analysis of high-rise steel buildings with a different pattern of the bracing system and without a bracing system.

Mahmood Hosseini, Peyman Shadman Heidari and Mojtaba Heravi, "Analytical and experimental study of the effect of bracing pattern in the lateral load bearing Capacity of Concentrically Braced Steel Frames" This paper presents the results of an analytical and experimental investigation performed on a series of 5-story Concentrically Braced Frames with three bays of which one or two bays have been braced with different patterns. At first, Push Over Analyses (POA) have been performed to find out the ultimate capacity of Concentrically Braced Frames. Then, some 1/3 scale samples of frames have been built and tested subjected to lateral loads to verify the numerical calculations. Results show that the ultimate capacity of Concentrically Braced Frames and their ductility factor strongly depends on the number and location of braced bays and the bracing pattern. The capacity can vary up to 100% from case to case, and the displacement ductility factor can be as low as 3.5 in some cases, which is much lower than the code suggested value. On this basis, it can be said that the code suggested values of 'response modification factors' need essential modifications.

Research Method

This research inculcates the analysis and design of steel structure for residential buildings. There is a combination of bracings and steel shear walls as a lift duct walls with moment resisting frame. This structure is analyzed for static loads, seismic loads and for wind forces. The Response Spectrum Method is used for analyzing the structure. The specifications are used as per the standard code IS:800-2007, IS:875 (Part1, 2, 3, 5), IS:1893-2016 and IS:456-2000. The effect of various position of bracings in the moment resisting frame and the frame without bracings are checked for effective result. The details of building are given below

- Number of floors: G+10
- Total Height of Building: 37m
- Each Floor Height: 3m
- Height of Headroom of Staircase and Machine Room above top floor: 2.5m
- Location of Building: Pune
- Seismic Zone: III Parameters

1. Zone Factor Z = 0.16 Table 3 (Cl. 6.4.2), IS:1893-2016
2. Response Reduction Factor R = 4 Table 9, IS:1893-2016
3. Importance Factor I = 1.2 Table 8, IS:1893-2016
4. Damping dm = 0.05 (Cl. 7.2.4), IS:1893-2016
5. Soil Type Factor (Medium Soil) SS = 2 Table 4 (Cl. 6.4.2.1), IS:1893-2016
6. Depth of Foundation below Ground Level DT = 1.5 m

Basic Wind Speed: 39m/s

1. Risk Coefficient K1 = 1 Table 1, IS:875 (Part-3) – 2015
2. Terrain Roughness & Height Factor K2 = 1.016, Terrain Category 4 from Table 2, IS:875 (Part-3) - 2015
3. Topography Factor K3 = 1 (Cl. 6.3.3.1), IS:875 (Part-3) – 2015
4. Importance Factor for Cyclonic region K4 = 1 (Cl. 6.3.4), IS:875 (Part-3) – 2015
5. Wind Directionality Factor Kd = 0.9 (Cl. 6.2.1), IS:875 (Part-3) – 2015
6. Area Averaging Factor Ka = 1 Table 4, IS:875 (Part-3) – 2015
7. Combination Factor Kc = 0.9 (Cl. 7.3.3.13), IS:875 (Part-3) – 2015

8. Internal Pressure Coefficient Cpi = ±0.5 (Cl. 7.3.2), IS:875 (Part-3) – 2015
9. External Pressure Coefficient Cpe is as per (Cl. 7.3.3), IS:875 (Part-3) – 2015

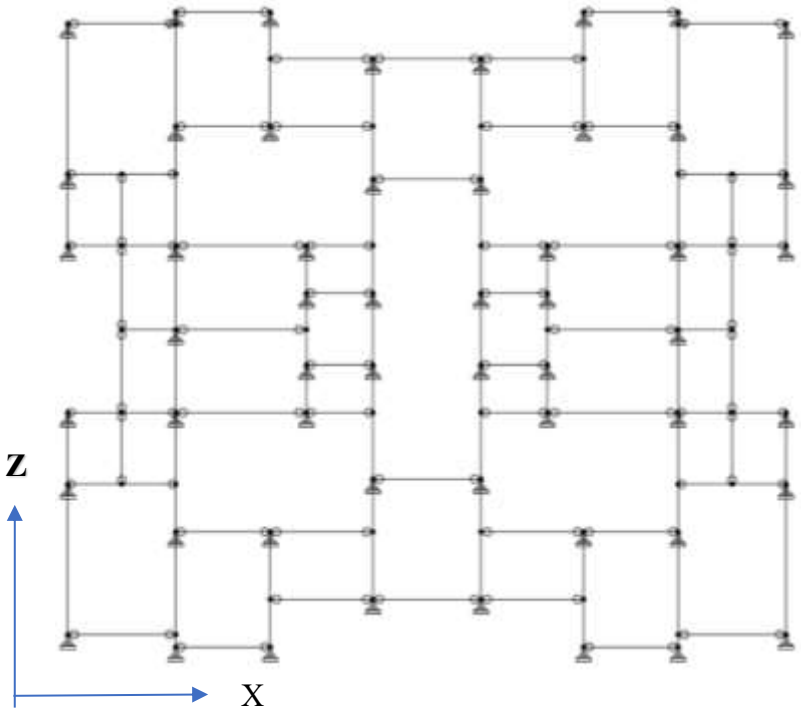


Fig.1 Typical Floor Plan

Results and Discussion

There are three models of residential building with same architectural plan are taken in to consideration for the analysis. The differences are

1. A residential Steel building without bracings in staircase.
2. A residential Steel building with bracings at landing to landing in staircase.
3. A residential Steel building with bracings at floor to floor in staircase.

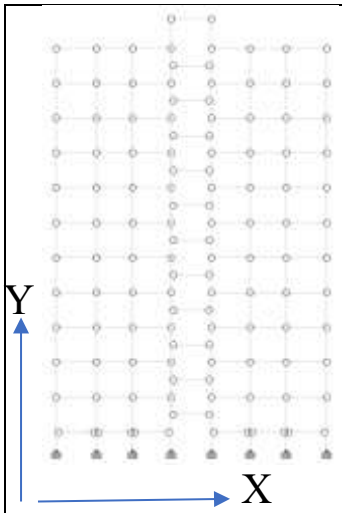


Fig. 2a. Building without bracings.

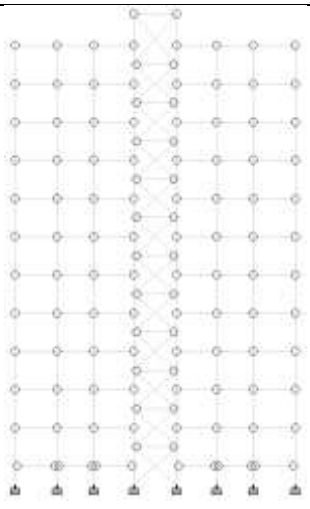


Fig. 2b. Building with bracings at landing to landing in staircase.

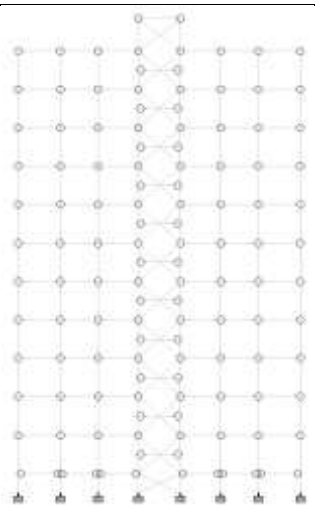


Fig. 2c. Building with bracings at floor to floor in staircase.

Following tables and graphs are showing the comparison of results with respect to displacements, fundamental time period and steel take off.

Table 1 Node Displacement Table

Directions	Displacement in mm		
	W/O Bracings	Bracings L-L	Bracings F-F
X	100.711	74.565	68.217
Y	13.360	11.657	11.900
Z	18.210	20.778	20.056

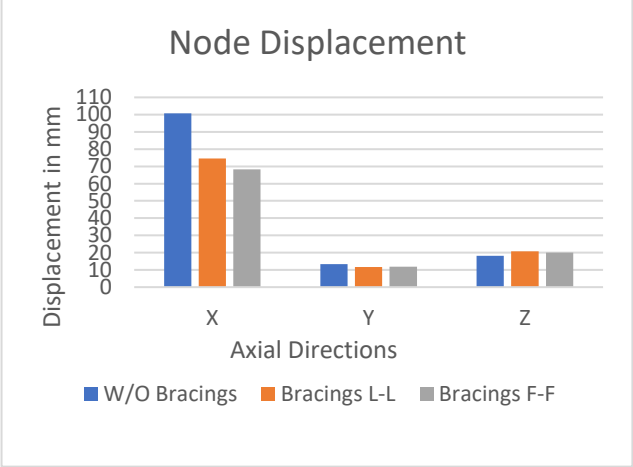


Table 2 Fundamental Time Period in Sec

W/O Bracings	Bracings L-L	Bracings F-F
2.34	1.848	1.785

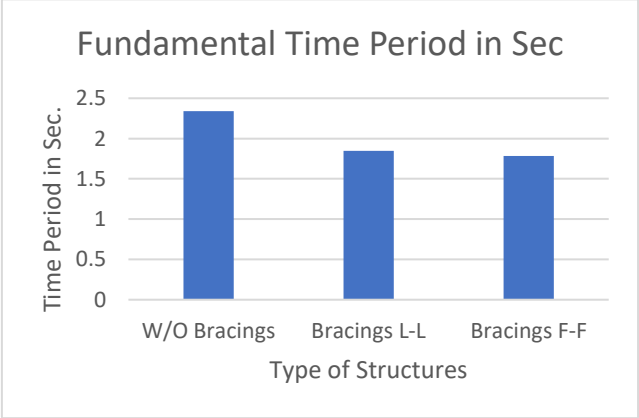
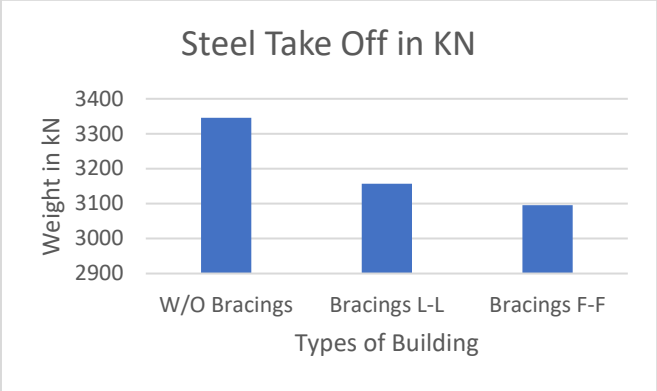


Table 3 Steel Take Off in KN

W/O Bracings	Bracings L-L	Bracings F-F
3345.213	3157.121	3095.736



Conclusion

The study concludes that the incorporation of bracing systems significantly enhances the lateral stability of buildings. Among the configurations considered, Floor - Floor bracing provides the best performance by minimizing displacement, reducing the fundamental time period, and optimizing steel usage. These findings support the implementation of bracing systems in seismic and wind-prone regions to ensure structural safety and material efficiency.

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