Effect of Braced Core Location on the behaviour of High Rise Steel Structure with Outrigger Subjected to Dynamic Loads by using ETABS

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Abstract— A Steel Structure is generally a combination of different Steel Structural, which are designed to resist Gravity and Lateral loads, and also provide adequate Stability. Application of Steel Structures is found in almost all the construction sectors, which includes long span Structure like airport terminals, stadiums, exhibition centres, high rises buildings, manufacturing plants, tower and masts structures, portal frames, Bridges and Steel Structural members are used in Infrastructures and Agricultural Buildings and Building cranes. The different types of Bracing systems are provide at each Floor level which provides load paths to transfer horizontal forces to vertical frames, particularly to Columns where ultimately the forces will transfer to Ground level. High rise Steel moment resisting frame is considered for the Static and Dynamic analysis. Steel moment resisting frame are studied by incorporating outriggers and Steel braced Core. Braced core location is varied with respect to Centre of the building. Maximum lateral load resistance from braced core for particular location away from the Centre is found out. Equivalent Static and Dynamic Time history Analysis is carried out. From the analytical results and discussions it is concluded that Steel moment resisting frame with outrigger and braced core 10 m offset along negative Y direction can be recommended for the structure where shear core or braced core and outrigger systems cannot be provided at the centre of the structure. Also offset braced core steel structural systems are better in resisting the lateral force than that of conventional braced Core and outrigger system.

Key words: ETABS, Outriggers, Steel, Structure

I. Introduction

Application of Steel Structures is found in almost all the construction sectors, which includes long span structure like airport terminals, stadiums, exhibition centres, high rises buildings, manufacturing plants, tower and masts structures, portal frames, bridges and steel structural members are used in infrastructures and agricultural buildings and building cranes. The main structural types involved in the above applications includes truss structures, frame structures, grid structures, arches and prestressed structures, beam girders in bridges, truss members in truss bridges, arch bridges, cable stayed brides and suspension Bridges. In most of the Steel Structural systems, provision of bracing systems plays an important role in resisting the lateral loads by giving more Stiffness to the Structure hence increases the Structural Stability against wind and seismic loads. Bracing members will work effectively as compression and tension member. In Steel Structural system, beams and columns the vertical frame which transfer the gravity loads to foundation, where the bracings systems are carries the lateral loads, which helps in minimizing the lateral displacements. The different types of bracing systems are provide at each floor level which provides load paths to transfer horizontal forces to vertical frames, particularly to columns where ultimately the forces will transfer to ground level. Commonly used bracings are diagonal bracings, X – bracings, V – bracings, knee bracings, eccentric bracings as show in below in Fig. 1.

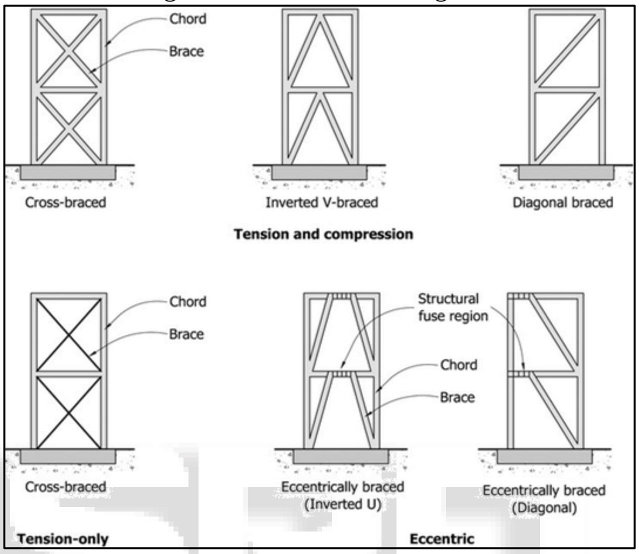

Fig. 1: Different Types of Bracing Systems

II. Objectives

The following objectives are considered in this work.

1) High Rise Steel moment resisting frame is considered for the Static and Dynamic analysis.
2) Steel moment resisting frame are studied by incorporating outriggers and Steel braced core.
3) Braced Core location is varied with respect to Centre of the building.
4) Maximum lateral load resistance from braced core for particular location away from the Centre is found out.
5) Equivalent Static and Dynamic Time history analysis is carried out.

III. Types of Models

Following types of models are considered for the present study.

1) Type – 1:2. (Fig2)
2) Type – 2: SRF with outrigger and braced core at the centre of the structure. (Fig. 3)
3) Type – 3: SRF with outrigger and braced core 10 m offset along the negative X direction. (Fig.4)
4) Type – 4: SRF with outrigger and braced core 10 m offset along the negative Y direction. (Fig.5)
5) Type – 5: SRF with outrigger and braced core 20 m offset along the negative X direction and 10 m along negative Y direction. (Fig. 6)

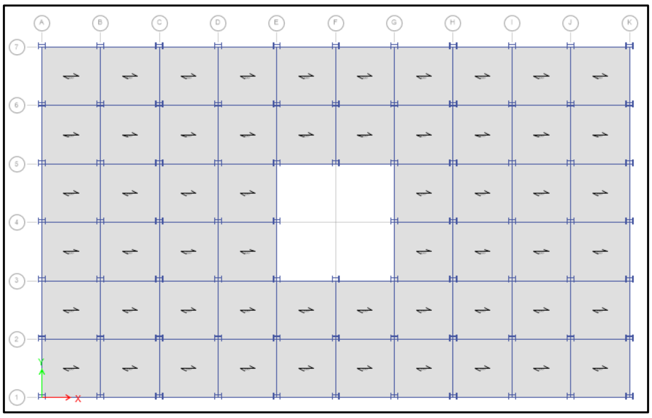

Fig. 2: Steel moment resisting frame (SRF) with centre opening of 10 x 10 m

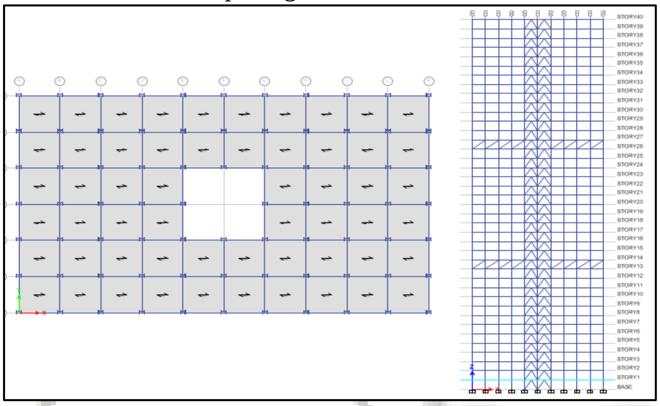

Fig. 3: SRF with outrigger and braced core at the centre of the Structure

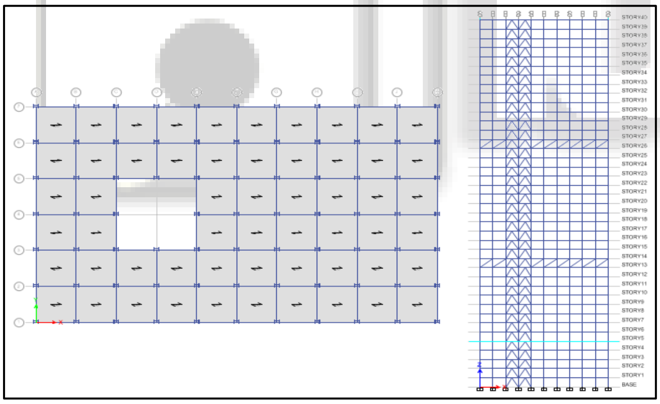

Fig. 4: SRF with outrigger and braced core 10 m offset along the −X direction

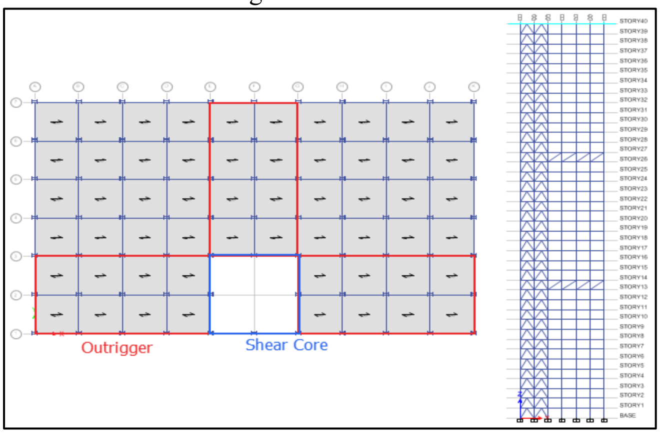

Fig. 5: SRF with outrigger and braced core 10 m offset along the − Y direction.

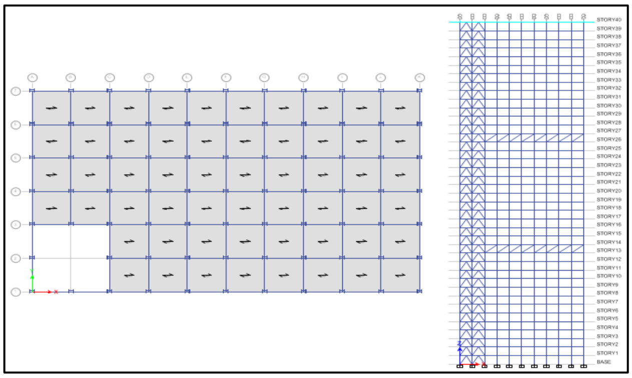

Fig. 6: SRF with outrigger and braced core 20 m offset along the −X direction and 10 m along −Y direction

IV. MATERIAL PROPERTIES

- Grade of Structural Steel is taken as FE 360, having yield Stress of 360 N/mm^2.
- Grade of concrete for deck M30

A. *Frame Section Properties*

- Column : Built-up section made of ISWB – 600 (Fig. 7)
- Structural Beam : ISMB 600 (Fig. 8)
- Deck : 200 thick
- Shear core truss and Outrigger element ISMB 600

V. MODAL ANALYSIS

In order to understand the dynamic behaviour of the steel structures, modal analysis is carried out where, time period and frequency of the structures under different modes are observed. Here twelve modes are taken for the study.

	Time Period (Seconds)				
Mode No.	Steel MRF	Shear Core & Outrigger	Shear Core & Outrigger offset 1	Shear Core & Outrigger offset 2	Shear Core & Outrigger offset 3
1	7.13	5.79	6.09	6.09	6.56
2	5.56	4.98	4.67	5.22	5.03
3	5.54	4.62	4.56	4.23	3.91
4	2.29	1.77	1.92	1.85	2.06
5	1.84	1.65	1.48	1.71	1.59
6	1.81	1.47	1.47	1.37	1.25
7	1.27	0.98	1.07	0.99	1.14
8	1.08	0.94	0.82	0.98	0.87
9	1.02	0.81	0.82	0.77	0.81
10	0.89	0.69	0.75	0.70	0.68
11	0.77	0.62	0.58	0.64	0.62
12	0.72	0.54	0.54	0.54	0.58

Table 1: Mode vs. Time Period

	Frequency (Cycles/sec)				
Mode No.	Steel MRF	Shear Core & Outrigger	Shear Core & Outrigger offset 1	Shear Core & Outrigger offset 2	Shear Core & Outrigger offset 3
1	0.14	0.173	0.164	0.164	0.153
2	0.18	0.201	0.214	0.192	0.199
3	0.18	0.217	0.219	0.236	0.256
4	0.44	0.564	0.522	0.541	0.486

5	0.54	0.605	0.674	0.586	0.631
6	0.55	0.679	0.681	0.732	0.802
7	0.79	1.021	0.930	1.005	0.878
8	0.92	1.063	1.218	1.024	1.152
9	0.98	1.230	1.225	1.302	1.240
10	1.12	1.442	1.335	1.424	1.473
11	1.30	1.608	1.720	1.564	1.611
12	1.40	1.847	1.842	1.840	1.739

Table 2: Mode vs. Frequency

VI. TIME HISTORY ANALYSIS

Models	Base Force (kN)		Peak Displacement (mm)		Peak Acceleration (m/s^2)	
	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.
Type – 1	7730	5716	172.57	210.65	2.69	2.65
Type –2	10802	6871	136.08	185.42	2.71	2.89
Type –3	10540	5715	137.75	153.65	2.81	3.33
Type –4	9468	6193	133.76	195.13	3.39	2.85
Type –5	9680	5663	148.12	165.66	2.77	3.37

Table 3: Time History Response Summary Chart

Fig presents time history plots of base force, peak displacement and peak acceleration along X and Y direction. And in Table 3 summary of dynamic time history analysis is presented.

VII. CONCLUSIONS

1) Frequency of the structure will increase (1.847Cycles/sec) due to the incorporation of the outrigger and shear core due to decrease in time period. Provision of offset shear core and outrigger will have less effect towards time period and frequency change.
2) Base shear remains constant for all types of structures with and without outrigger and shear core (5967kN), with and without off set since, it is function of seismic weight.
3) Type – 4 structure i.e., SRF with outrigger and braced core 10 m offset along negative Y direction provides greater resistance against lateral deformation.
4) Type – 2 and Type – 3 SRF structure has minimum drifts and is found to be 49.23% compared to other types.
5) From dynamic time history analysis the structure of type – 4 give best resistance (10802kN) for dynamic loads.

From the above conclusions Type – 4 i.e., SRF with outrigger and braced core 10 m offset along negative Y direction can be recommended for the structure where shear core or braced core and outrigger systems cannot be provided at the centre of the structure. Also offset braced core steel structural systems are better in resisting the lateral force than that of conventional braced core and outrigger system.

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