Seismic Behaviour of Multistorey Steel Structure With Different Type of Bracing System

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Abstract- *Structures in high seismic risk areas may be susceptible to severe damage in a major earthquake. For the variety of structures and possible deficiencies that arise, several retrofitting techniques can be considered. Bracing system is one of the retrofitting techniques and it provides an excellent approach for strengthening and stiffening existing building for lateral forces. Also, another potential advantage of this system is the comparatively small increase in mass associated with the retrofitting scheme since this is a great problem for several retrofitting techniques.*

The study of braced steel frame response is widely studied in many branches of Structural engineering. Many researchers have been deeply studying these structures, over the years, mainly for their greater capacity of carrying external loads. Every Special moment resisting frames undergo lateral displacement because they are susceptible to large lateral loading. The problems associated with this are the P-Δ effect and the ductile and brittle failure at beams and columns connections. As a consequence, engineers have increasingly turned to braced steel frames as an economical means for earthquake resistant loads.

I. INTRODUCTION

In the present time, Steel structure plays an important role in the construction industry. Previous earthquakes in India show that not only non-engineered structures but engineered structures need to be designed in such a way that they perform well under seismic loading. Structural response can be increased in Steel moment resisting frames by introducing steel bracings in the structural system. Bracing can be applied as concentric bracing or ecentric bracing. There are 'n' number of possibilities to arrange steel bracings, such as cross bracing 'X', diagonal bracing 'D', and 'V' type bracing.

Steel moment resisting frames without bracing, inelastic response failure generally occurs at beam and column connections. They resist lateral forces by flexure and shear in beams and columns i.e. by frame action. Under severe earthquake loading ductile fracture at beams and columns connections are common. Moment resisting frames have low elastic stiffness. P-Δ effect is an another problem associated with such structures in high rise buildings.

So, to increase the structure response to lateral loading and good ductility properties to perform well under seismic loading concentric bracings can be provided. Beams, columns and bracings are arranged to form a vertical truss and then lateral loading is resisted by truss action. Bracings allow the system to obtain a great increase in lateral stiffness with minimal added weight. Thus, they increase the natural frequency and usually decrease the lateral drift. They develop ductility through inelastic action in braces. Failure occurs because of yielding of truss under tension or buckling of truss under compression. These failures can be compensated by use of Buckling Reinforced Braced frame (BRBs) or Self Centering Energy Dissipating frames (SCEDs). The present study will clearly estimate the advantage of concentrically braced steel frames over Steel moment resisting frames. A simple computer based modeling in StaadPro. Software is performed for Equivalent static analysis and Response spectrum analysis subjected to earthquake loading.

II. OBJECTIVES

Following are the main objective of the present study:

a) To investigate the seismic performance of a multi-storey steel frame building

- When unbraced and then with different bracing arrangement such as cross bracing 'X' and diagonal bracing using Equivalent Static analysis, Response Spectrum analysis .
- Under different earthquake loading and loading combinations.

b) To investigate the seismic response of a multi storey steel frame building

- Under same bracing configuration but with varying number of storey i.e. with varying height of the building.

III. METHODOLOGY

a) A thorough literature review to understand the seismic evaluation of building structures and application of Equivalent Static analysis, Response Spectrum analysis.
b) Seismic behaviour of steel frames with various concentric bracings and ecentric bracing geometrical and structural details.
c) Modeling the steel frame with various concentric bracing by computer software Staad pro.
d) Carry out Equivalent Static analysis and Response Spectrum analysis on the models and arrive at conclusion.

IV. SCOPE OF THE PRESENT STUDY

In the present study, modeling of the steel frame under the two analysis mentioned above using Staad Pro software is done and the results so obtained are compared. Conclusions are drawn based on the tables and graphs obtained .

V. FRAME DESIGN

- The building frame used in this study is assumed to be located in Indian seismic zone IV with medium soil conditions. Seismic loads are estimated as per IS 1893:2002 and design of steel elements are carried as per IS 800 (2007) standards. The characterstic strength of steel is considered 415 Mpa. The gravity loading consists of the self weight of the structure, a floor load of 3kN/m2 on every floor except the roof , the roof floor load is taken 2kN/m2.
- The design horizontal seismic coefficient (Ah) is calculated as per IS 1893:2002

$$Ah = ZI/2R,$$

Where, seismic zone factor, Z = 0.24, Importance factor I = 1.0, Response reduction factor, R = 3.0.

- The design base shear (VB) is calculated as per IS 1893:2002

$$VB = Ah.Sa/g.W$$

- Period for analysis = 0.085H0.75 , which is found to be 0.647 sec.
- Every beam used in the both the models is ISMC 200. Every column used in the model is ISMC 300 and for bracings angle section are used. Every bracing is an angle section IS 75x75x5.

VI. MODELLING & ANALYSIS OF BUILDING

The present study consist of two models. Model 1 is a Steel Moment Resisting Frame (SMRFs) with concentric bracing as per IS 800-2007. Cross bracing, diagonal bracing and an unbraced frame is considered for study. Model 2 consist of two Steel Moment Resisting Frame with similar V type bracing and Inverted V (Chevron bracing) configuration, but with varying height. Performance of each frame is studied through Equivalent static analysis and Response Spectrum analysis

MODEL 1
PLAN

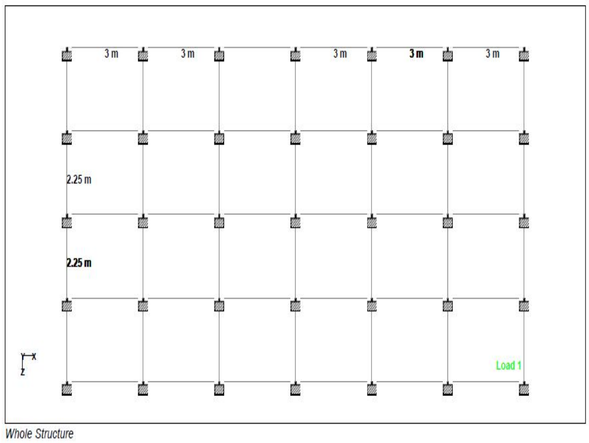

Figure 1. PLAN OF STRUCTURE

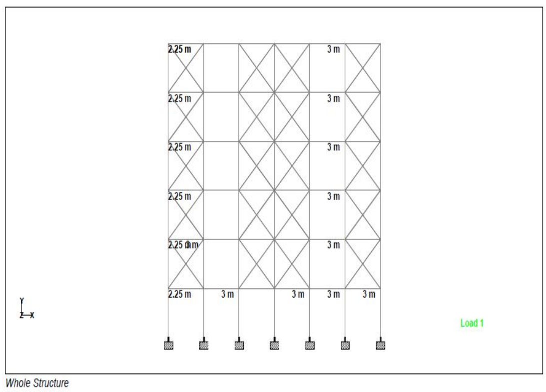

Figure 2. FRONT ELEVATION OF X CROSS BRACING STRUCTURE

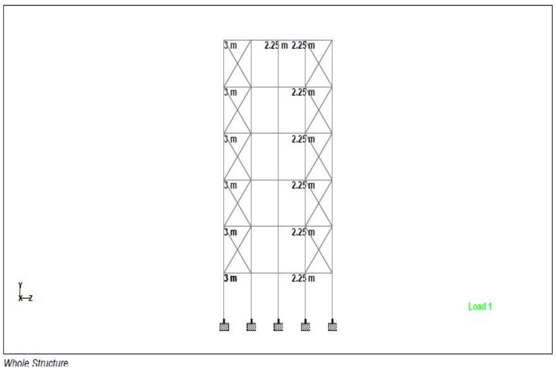

Figure 3. SIDE ELEVATION OF X CROSS BRACING STRUCTURE

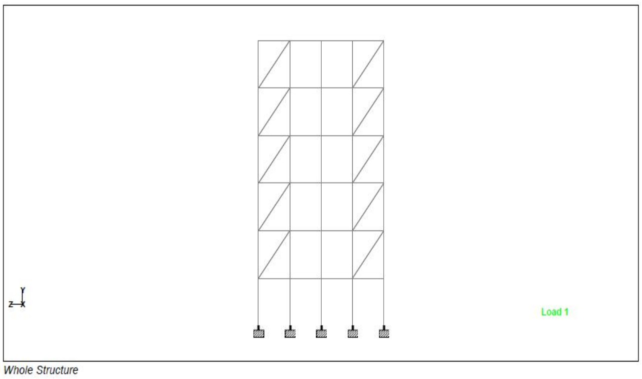

Figure 4. SIDE ELEVATION OF DIGONAL BRACING STRUCTURE

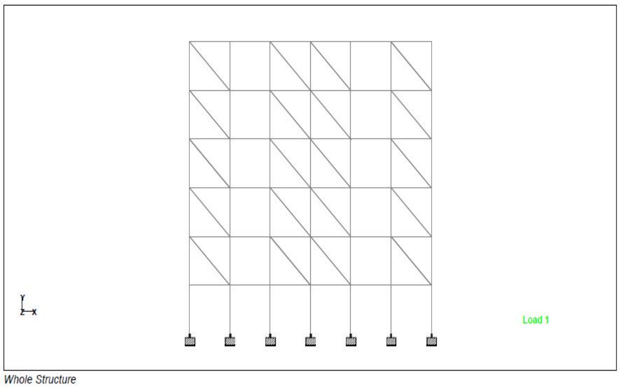

Figure 5. FRONT ELEVATION OF DIGONAL BRACING STRUCTURE

MODEL 2

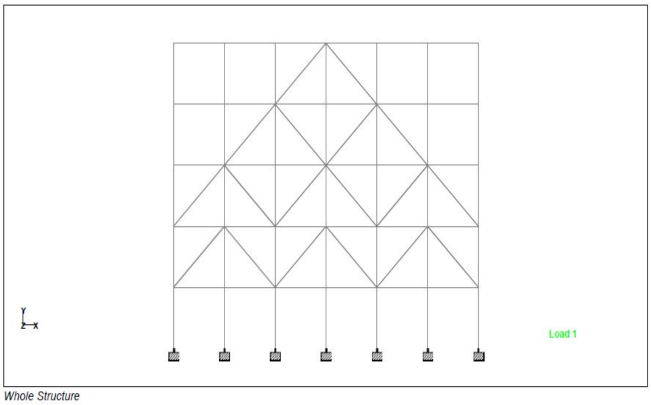

Figure 6. FRONT ELEVATION OF 5-STOREY STRUCTURE

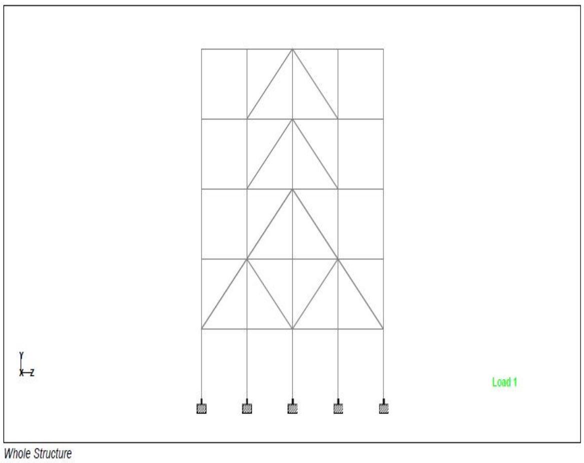

Figure 7. SIDE ELEVATION OF 5-STOREY STRUCTURE

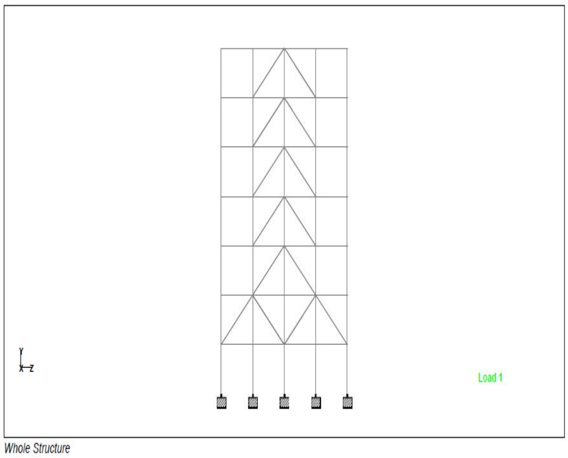

Figure 8. SIDE ELEVATION OF 7-STOREY STRUCTURE

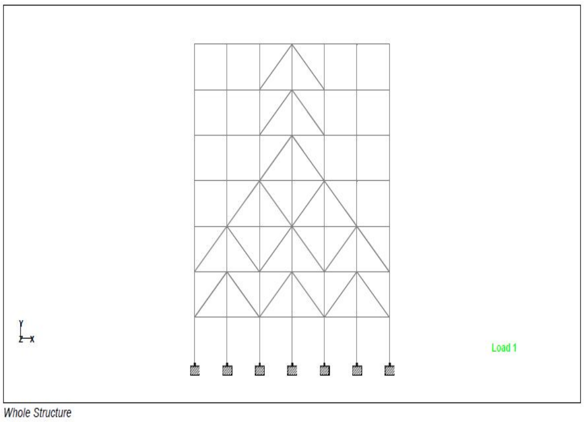

Figure 9. FRONT ELEVATION OF 7-STOREY STRUCTUR

SEISMIC RESPONSE OF STEEL FRAME UNDER DIFFERENT BRACING CONFIGURATION AND LOADING

MODEL 1

LATERAL LOAD PROFILE

LATERAL LOAD PROFILE IN EQUIVALENT LOAD CASES

Table 1.

FLOORS	WITHOUT BRACING (IN KN)	WITH X CROSS BRACING (IN KN)	DIGONAL BRACING (IN KN)
1	1.71	1.765	1.769
2	7.045	7.078	7.111
3	15.850	15.925	16.00
4	28.178	28.311	28.444
5	44.029	44.236	44.444
6	42.830	42.978	43.125

BASE SHEAR COMPARISION

Table 2.

	EQUIVALENT STATIC ANALYSIS (kN)	RESPONSE SPECTRUM ANALYSIS (kN)
WITHOUT BRACING	13.969	13.956
X CROSS BRACING	14.089	14.076
D BRACING	14.089	14.016

PEAK STOREY SHEAR FOR RESPONSE SPECTRUM ANALYSIS

Table 3.

FLOORS	WITHOUT BRACING (IN KN)	WITH X CROSS BRACING (IN KN)	DIGONAL BRACING (IN KN)
6	4.11	4.12	4.21
5	9.49	9.53	9.28
4	13.67	13.79	12.53
3	17.03	17.23	14.85
2	19.88	20.15	17.16
1	21.81	22.12	18.81
BASE	21.81	22.12	18.81

STORY DRIFT OF THE MODEL

Table 4.

FLOORS	WITHOUT BRACING (in mm)	DIGONAL BRACING (in mm)	WITH X CROSS BRACING (in mm)
6	0.13	0.079	0.074
5	0.22	0.12	0.11
4	0.29	0.16	0.14
3	0.33	0.176	0.15
2	0.32	0.175	0.15
1	0.18	0.15	0.14
BASE	0	0	0

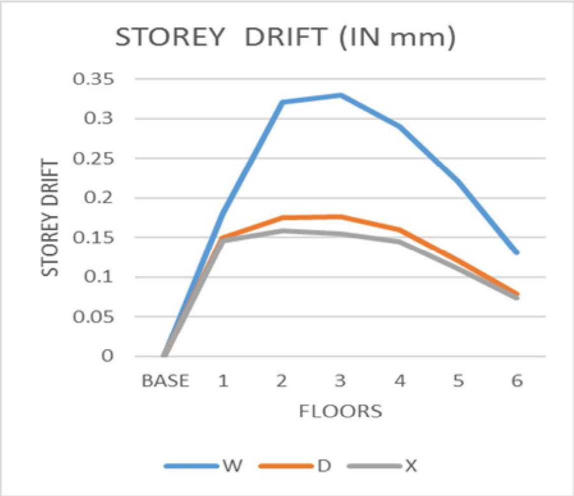

Figure 10.

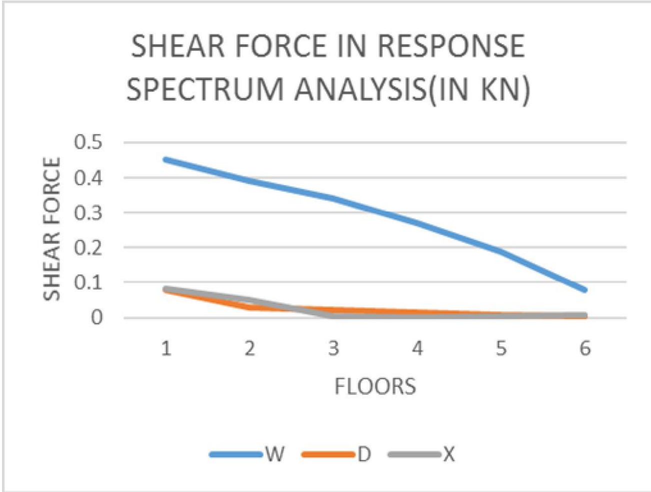

Figure 11.

A COMPARISION OF SHEAR FORCE, BENDING MOMENT AND AXIAL FORCE AT THE CORNER COLUMNS

Shear force comparision

Table 5.

FLOORS	WITHOUT BRACING (IN KN)	DIGONAL BRACING (IN KN)	WITH X CROSS BRACING (IN KN)
1	0.45	0.079	0.082
2	0.39	0.028	0.05
3	0.34	0.022	0.005
4	0.27	0.014	0.002
5	0.19	0.007	0.004
6	0.08	0.003	0.007

Bending moment comparision

Table 6.

FLOORS	WITHOUT BRACING (IN KNM)	DIGONAL BRACING (IN KNM)	WITH X CROSS BRACING (IN KNM)
1	0.217	0.251	0.262
2	0.106	0.072	0.096
3	0.093	0.022	0.021
4	0.084	0.009	0.003
5	0.068	0.009	0.003
6	0.029	0.007	0.003

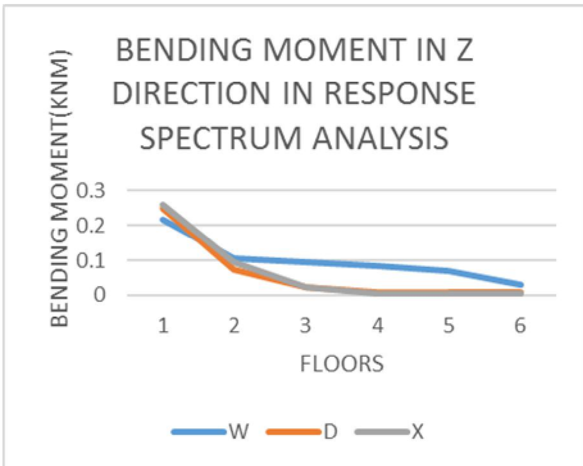

Figure 12

Axial force comparision

Table 7.

FLOORS	WITHOUT BRACING (IN KN)	DIGONAL BRACING (IN KN)	WITH X CROSS BRACING (IN KN)
1	52.3	103.8	105.9
2	39.6	75.8	69.5
3	26.7	43.6	39.7
4	15.5	22.08	18.7
5	7.1	9.1	5.1
6	2.1	4.5	5.005

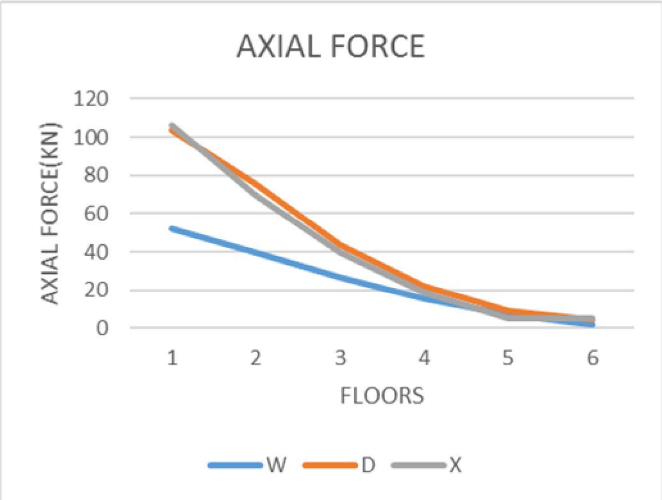

Figure 13

MODEL 2

BASE SHEAR COMPARISION FOR BOTH THE MODELS WITH VARYING HEIGHT

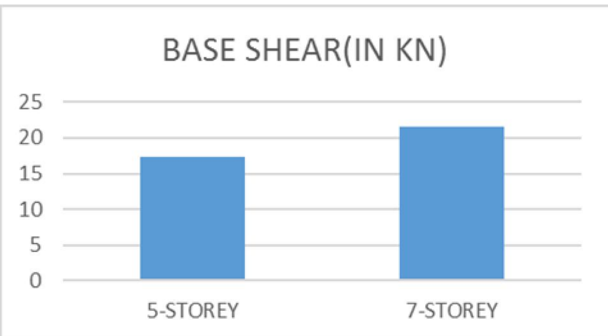

Figure 14.

STORY DRIFT COMPARISION

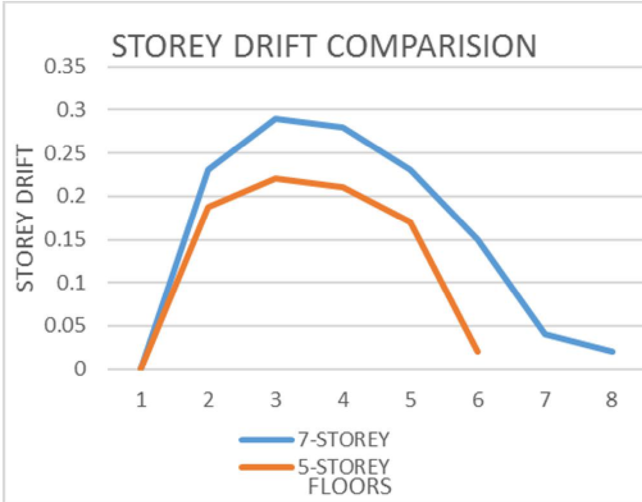

Figure 15.

VII. CONCLUSION

- Braced steel frame have more base shear than unbraced frames.
- Cross bracing undergo more base shear than diagonal bracing.
- Bracings reduce the lateral displacement of floors.
- Cross bracing undergo lesser lateral displacement than diagonal bracing.
- Cross braced stories will have more peak story shear than unbraced and diagonal braced frames.
- Axial forces in columns increases from unbraced to braced system.
- Shear forces in columns decrease from unbraced to braced system. Diagonal braced columns undergo more shear force than cross braced.
- Bending moment in column decreases from unbraced to braced system. Diagonal braced column undergo more bending moment than cross braced frame.
- Under the same bracing system and loading, system with larger height or more number of storeys will have more base shear than the smaller one.
- Under the same bracing system and loading, system with larget height or more number of storys will undergo large lateral displacement on the same storys than the smaller one.

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