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Seismic Analysis of Multi-Storey Steel Structure with Steel Bracing at Different Location

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Abstract - Buildings that are situated seismic zones have higher risk of buildings receiving damage and causes terrible loss of assets along with life. The bracing system is the most effective systems used to control the lateral movement because of earthquake load, so that, during seismic load due to earthquake the danger of structural and non-structural harm can be reduced to a large extent. The study is carried out by arranging bracings at different places in the structure in direction to recommend the appropriate location of bracing by comparing different seismic parameters like displacement, storey drift. X-type bracing system is used and loads are considered as per IS: 1893(Part1)-2016. The modelling and analysis is performed using software ETABS.

Key Words: lateral displacement, storey drift, response spectrum analysis, ETAB.

1. INTRODUCTION

The terrible effects of past seismic activity on life and assets have increased the necessity for a close evaluation of the conventional lateral load resisting systems and to use lateral load resisting systems which are effective in reducing earthquake forces. Buildings are planned as per code standards at the time of their erection to avoid the damage of building even at large scale earthquake. Buildings have inadequate lateral strength as well as ductility even if they are planned as per code standards. Seismic strengthening is mostly dependent upon the economic status and life protection.

In general, ground motion due to earthquake can happen any place in the world and the danger related with the buildings, particularly under severe seismic forces wants to be given special care. While providing bracing in structural system in structure construction the location of bracing should be at effective location to make building stiffer. Mostly steel bracings used are X, V, inverted V etc. This paper deals with the study of X type bracing system on steel building.

1.1 X Bracing

Now a days X bracing is a system used to reinforce structures in which corner of the support in diagonal direction intersect. Bracing is important in quake resistant buildings since it helps keep a building safe. Depending upon force, one brace in tension while the other is in compression. Cross bracing can be connected to any four-sided building.

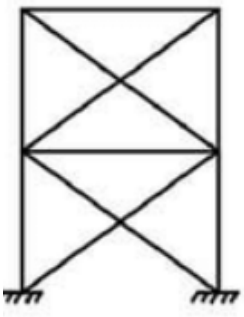

Fig -1: Cross Bracing

2. MODELLING

To study the response spectrum analysis of structure, G+15 multi-storied building is considered. The modelling and analysis of work is done by using ETABS software. Storey shears, story drifts and storey Displacement is compared for Braced and unbraced structural system.

2.1 Material Properties:

The basic material properties used are as follows:

- Modulus of Elasticity of steel, Es = 20,0000 MPa
- Modulus of Elasticity of concrete, Ec = 27386.12 MPa
- Grade of concrete = M30

2.2 Details of models:

The various parameters considered for analysis of building which is modelled in ETABS. Seismic parameters are taken from IS 1893 (Part 1) 2016. Parameters considered are as per tabulation.

Table -1: Parameters considered for modelling

Type of Building	Steel
No. of story	G+ 15
Plan area(m^2)	16*16
Grade of steel	Fe345 and Fe415
Column	ISHB 200-250/16 & ISHB 300-400/16
Beam	ISWB 300 and ISLB 150
Slab thickness	150mm
Steel Bracing	ISA 110*110*10
Bracing type	X type

2.3 Plan View of Building with location of Bracing

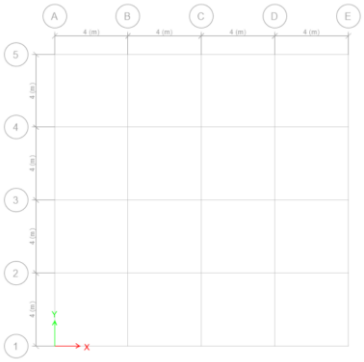

Fig -2: Conventional frame model without bracing (Model 1)

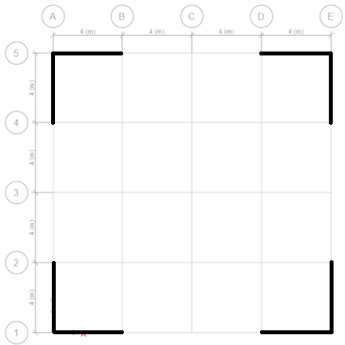

Fig -3: Model with bracing at corner of structure (Model 2)

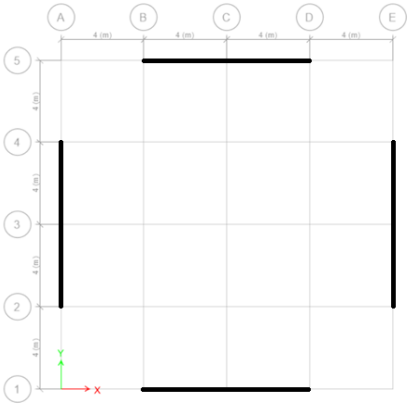

Fig -4: Model with bracing at second and third bay in both direction (Model 3)

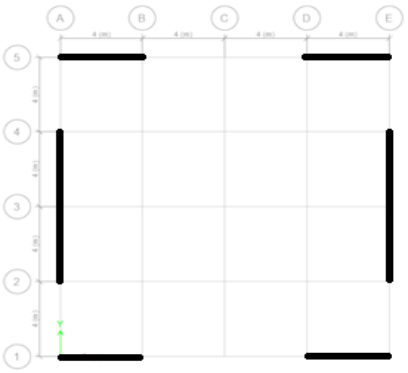

Fig -5: Model with bracing at first and fourth bay in X-direction and second and third bay in Y-direction (Model 4)

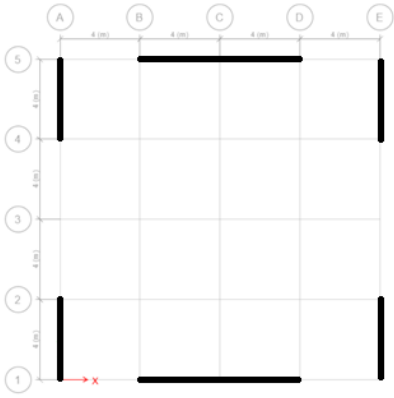

Fig -6: Model with bracing at second and third bay in X-direction and first and fourth bay in Y-direction (Model 5)

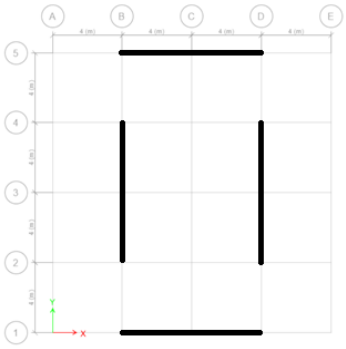

Fig -7: Model with bracing at second and third bay in X-direction and second and third bay in Y-direction at core (Model 6)

3. ANALYSIS:

To make the building structure more ductile and to provide sufficient stiffness X type bracing system is used in this study, the analysis of G+15 storey steel building with X type bracing structural system subjected to seismic forces is proposed to be carried out. The modelling is done by using ETABS software and analysis is carried out by response spectrum method which is also known as linear dynamic method.

3.1 Response Spectrum Method

There are computational benefits in using the response spectrum method of seismic evaluation for prediction of displacements and member forces in structural method. The technique includes the calculation of big values of the displacements and member forces in every mode of vibration.

Response spectra are curves plotted among max response of single degree of freedom (SDOF) system subjected to certain earthquake ground movement and its time period.

3.2 Loads Considered in the Analysis

The following loads were considered for the analysis of various buildings:

a. Gravity loads –

The intensity of dead load and live load at various floor levels considered in the study are listed below.

i. Dead load –

Weight of Slab = 3.75 kN/m^2

Weight of Floor Finish = 1.5 kN/m^2

ii. Live Load –

Live Load at all floor levels has been taken as 3 kN/m^2.

b. Seismic Load –

IS 1893(part I) is used for seismic load calculations. The mass of the building is supposed to be lumped at the floor levels. The weight of columns beams and walls have been equally distributed to the floors above and below. The floor load includes the self-weight of the floor load as per the codal provisions. For the purpose of analysis, the following seismic factors were considered.

Response spectrum factor	5 (SMRF)
Importance factor	1.2
Zone factor	0.24 (Zone IV)
Damping ratio	2%
Soil type	Type II
Imposed load	3 kN/m^2

4. RESULTS AND DISCUSSION

4.1 Lateral displacements:

Maximum displacement of building by response spectrum analysis in X direction:

Table -2: Maximum lateral displacement in X direction and percentage reduction

Model No.	Maximum displacement at top storey (mm)	Percentage reduction in displacement with respect to model 1 (%)
Model 1	66.682	-
Model 2	51.31	23.05
Model 3	43.716	34.44
Model 4	51.862	22.22
Model 5	44.207	33.7
Model 6	43.773	34.45

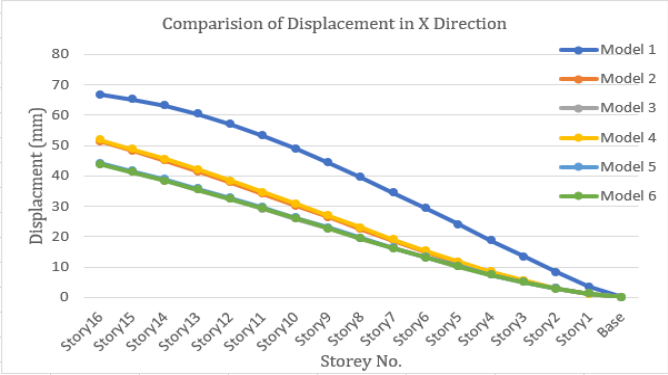

Chart -1: Graphical representation of lateral displacement in X direction

The graphical illustration of storey displacement found for steel structure with & without bracing shown in chart-1 and table 2. The maximum reduction of displacement in model 6 which is 34.45%.

Maximum displacement of building by response spectrum analysis in Y direction:

Table -3: Maximum lateral displacement in Y direction and percentage reduction

Model No.	Maximum displacement at top storey (mm)	Percentage reduction in displacement with respect to model 1 (%)
Model 1	169.249	-
Model 2	60.166	64.45
Model 3	49.165	70.95
Model 4	48.166	71.54
Model 5	66.609	60.64
Model 6	46.355	72.61

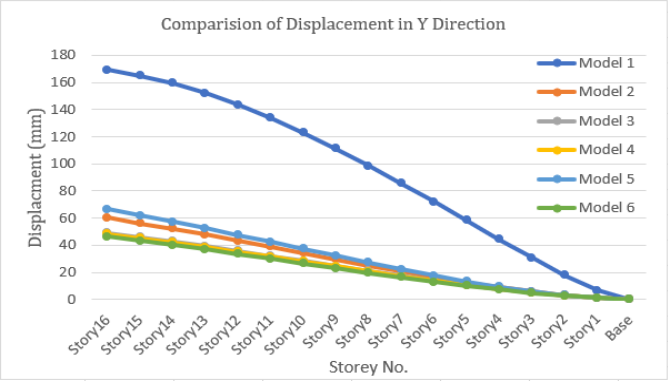

Chart -2: Graphical representation of lateral displacement in Y direction

The graphical illustration of storey displacement found for steel structure with & without bracing shown in chart-2 and table 3. The maximum reduction of displacement in model 6 which is 72.61%.

4.2 Storey Drift

Maximum drift of building by response spectrum analysis in X direction:

Table -4: Maximum drift in X direction and percentage reduction

Model No.	Maximum drift	Percentage reduction in drift with respect to model 1 (%)
Model 1	0.001766	-
Model 2	0.001296	26.61
Model 3	0.001096	37.93
Model 4	0.001314	25.59
Model 5	0.001105	37.42
Model 6	0.001094	38.05

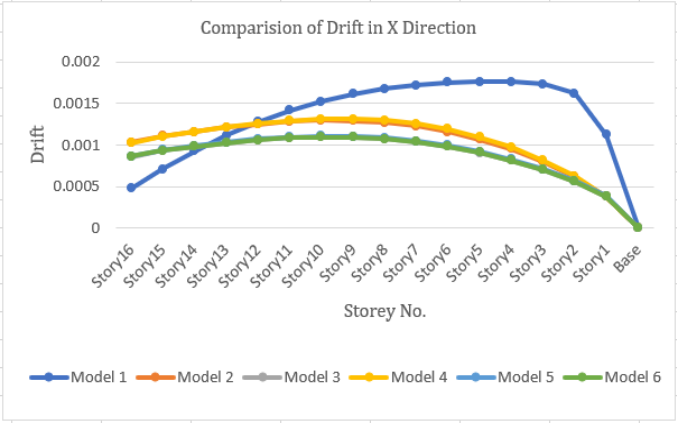

Chart -3: Graphical representation of drift in X direction

From the above chart-3 and table 4, It is found that, with bracing systems structure will have better control over story drifts. The maximum reduction of storey drift in X direction is 38.05%.

Maximum drift of building by response spectrum analysis in Y direction:

Table -5: Maximum drift in Y direction and percentage reduction

Model No.	Maximum drift	Percentage reduction in drift with respect to model 1 (%)
Model 1	0.004587	-
Model 2	0.0012	73.83
Model 3	0.000992	78.37
Model 4	0.000983	78.56
Model 5	0.001307	71.5
Model 6	0.000915	80.05

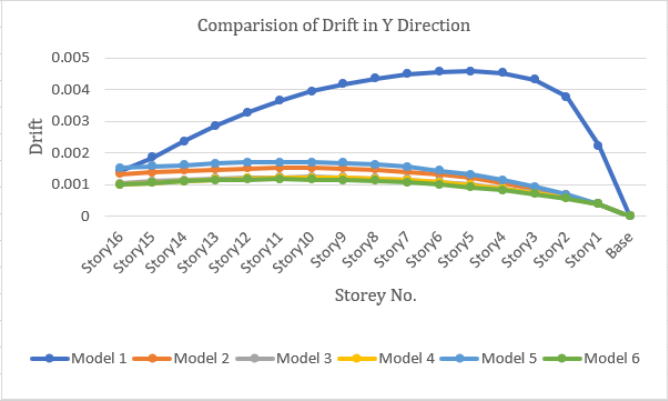

Chart -4: Graphical representation of drift in Y direction

From the above Chart-4 and table 5, It is found that, with bracing systems structure will have better control over story drifts. The maximum reduction of storey drift in Y direction is 80.05%.

5. CONCLUSIONS

From analysis of 16 storied Steel structure with provision of Bracing for different types, following conclusions are drawn.

1. The lateral load resisting capacity of building increases with increase in stiffness with the use of bracing in structural system than conventional structure.

2. Model with bracing at second and third bay in X-direction and second and third bay in Y-direction at core(Model 6) performing well in terms of reduction in displacement and storey drift.

3. The displacement of the structure is reduced by 34.45% in X direction and 72.61% in Y direction with the use of X-bracing.

4. The drift of the structure is reduced by 38.05% in X direction and 80.05% in Y direction with the use of X-bracing. The values of storey drift for all the stories are found to be within the limits i.e. 0.004 times to storey height according to IS 1893:2016 (Part I).

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BIOGRAPHIES

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