Design Optimization of X-Bracing using SAP2000

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***Abstract*—this paper focuses on design optimization by studying the performance vs cost relationship of X-bracings using SAP2000 for an open ground storey structure during seismic loading. Bracings are provided to arrest lateral stress and prevent swaying of the given structure. The open ground storey creates a soft storey condition.**

Keywords—Open ground storey; soft storey; bracing; lateral stress, cost.

I. INTRODUCTION

Steel braced frame is one of the structural systems used to resist earthquake and wind loads in multistoried buildings. Many existing reinforced concrete buildings need retrofit to overcome deficiencies to resist seismic loads. The use of steel bracing systems for strengthening or retrofitting seismically an inadequate reinforced concrete frame is a viable solution for enhancing earthquake resistance. Steel bracing is economical, easy to erect, occupies less space and has the flexibility to design for meeting the required strength and stiffness. Table 2 shows the position of steel bracing.

II. MODELLING

The building used for analysis is a four-storied RC building with a floor height of 3m as shown fig 1. The building is assumed to be located in a seismic zone V and the earthquake zone is plotted using fig 5. The table 1 provides data regarding the G+3 storey building.

Table 1. Design data of G+3 storey building

Sr.No.	Content	Description
1	No. of Storey	G+3
2	Floor Height	3m
3	Material	Concrete(M25) & Reinforcement (Fe415)
4	Size of Column	C1=300mm×300mm All column of G.F & Outer column
		C2=280mm×280mm Interior column for Ist & IInd Floor
		C3=250mm×250mm Interior column for IIIrd floor
5	Size of Beam	230mm×450mm

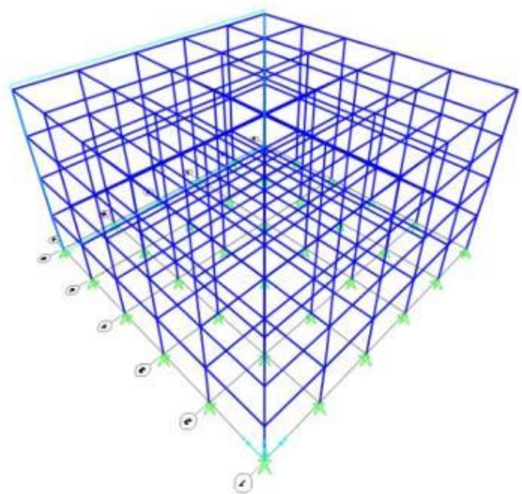

Fig 1: Base model of G+3

Fig 1 shows a G+3 Storey building with 5 bays in X & Y directions. Fixed restrains are provided at the bottom.

Table2. Different cases of providing bracing.

Sr.No.	Designation	Position of bracing
1	Model 01	Without Bracing
2	Model 02	Bracing throughout
3	Model 03	Storey (1+2+3)
4	Model 04	Storey (2+3)
5	Model 05	Storey (3)
6	Model 06	Storey (1+3)
7	Model 07	Storey (G+2)
8	Model 08	Alternative direction

The X-bracings are provided at the exterior parameter of the structure. Soil conditions are considered medium stiff and a damping ratio of 5% and the importance factor taken is 1. The loads are provided as per IS 1893:2002 (Part 1). The structural data is the same for all the structures.

A. Models considered

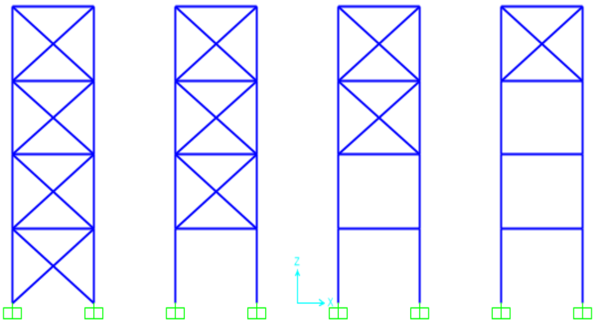

Fig 2: Model 02, 03, 04 & 05

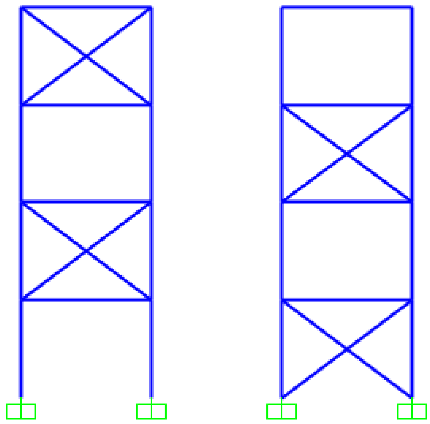

Fig 3: Model 06 & 07

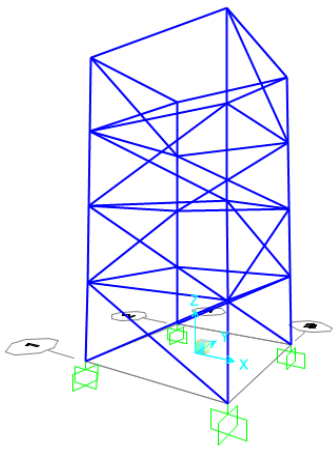

Fig 4: Model 08

- Fig 2, 3 & 4 shows the models of steel bracing provided.
- In model 08, the bracings are provided for G&2 storey in X-Z plane and for 1 & 3 storey in Y-Z plane.
- The bracing used in the model is made of steel.

B. Seismic zone in India

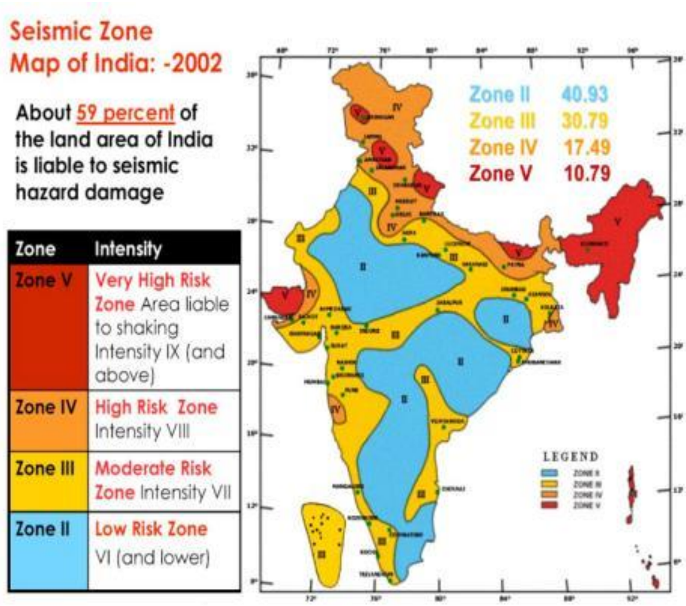

Fig 5: Major Zonation and Intensity map in India

Table 3. Region-wise major Earthquakes in India.

Seismic Region	No. of Earthquakes of Magnitude				Return period
	5.0-5.9	*6.0-6.9*	*7.0-7.9*	*8.0+*	
Kashmir & Western Himalayas	25	7	2	1	2.5-3 yrs.
Central Himalayas	68	28	4	1	1 yrs.
North East India	200	128	15	4	<4 months
Indo-Gangetic Basin and Rajasthan	14	6	-	-	5 yrs.
Cambay and Rann of kutch	4	4	1	1	20 yrs.
Peninsular India	31	10	-	-	2.5-3 yrs.
Andaman & Nicobar	80	68	1	1	<8 months

Table 3 provides information regarding the No. of Earthquakes of Magnitude 5.0- 8.0+ & their return period.

III. METHODOLOGY

In this study 8 models are considered with different bracing combinations as shown in fig 2, 3 & 4. The position combination of X-bracings is entered into the design evaluation of SAP2000. By comparing all the results to the cost parameter the optimal selection of the position of X-bracing is verified. Accodingly, minimum lateral drift is achieved.The procedure is shown in fig 6.

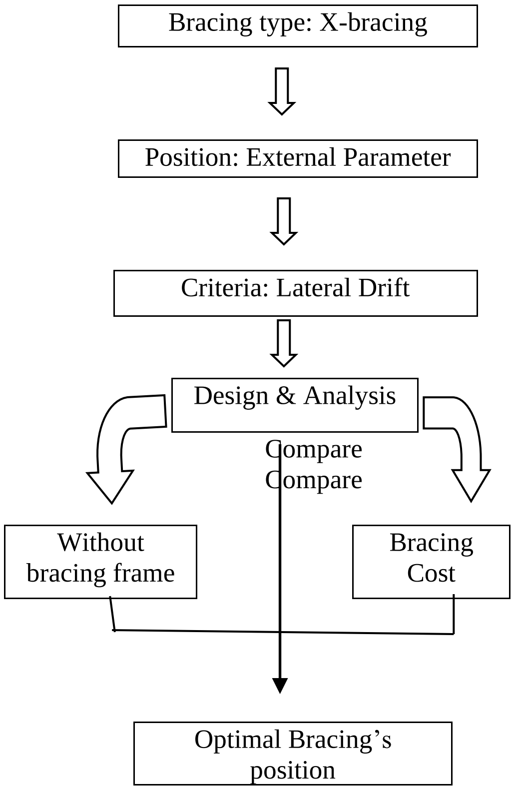

Fig 6: Selection of the optimal bracing's position

Fig 6 show how the optimal bracing position is selected by comparing braced frame with G+3 without bracing frame & Bracing cost.

IV. RESULTS AND DISCUSSIONS

Table 4. Displacement in X-direction (EQ-x)

Model No	Joint No:			
	217	*218*	*219*	*220*
M1	0.0008	0.0014	0.0016	0.0016
M2	8.159E-05	0.0002	0.0003	0.0004
M3	0.0009	0.001	0.0011	0.0011
M4	0.0008	0.0015	0.0015	0.0016
M5	0.0008	0.0014	0.0017	0.0017
M6	0.0009	0.0009	0.0012	0.0012
M7	7.255E-05	0.0007	0.0008	0.0009
M8	7.309E-05	0.0007	0.0008	0.0009

Table 4 Represents the displacement in X-direction. The values are given for EQ-x and they are in meters. The values are plotted as graph in fig 7.

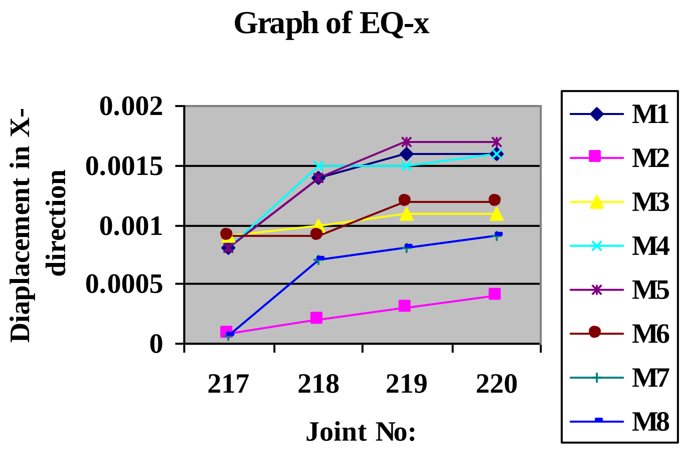

Fig 7: Displacement in X-direction vs Joint No:

Table 5. Displacement in Y-direction (EQ-y)

Model No	Joint No:			
	217	*218*	*219*	*220*
M1	0.0008	0.0015	0.0017	0.0017
M2	0.0006	0.0009	0.001	0.0009
M3	0.0008	0.0013	0.0015	0.0014
M4	0.0009	0.0015	0.0017	0.0017
M5	0.0008	0.0015	0.0018	0.0018
M6	0.00018	0.0013	0.0015	0.0014
M7	0.0006	0.0011	0.0013	0.0012
M8	0.0008	0.0013	0.0015	0.0014

Table 5 Represents the displacement in Y-direction. The values are given for EQ-y and they are in meters. The values are plotted as graph in fig 8.

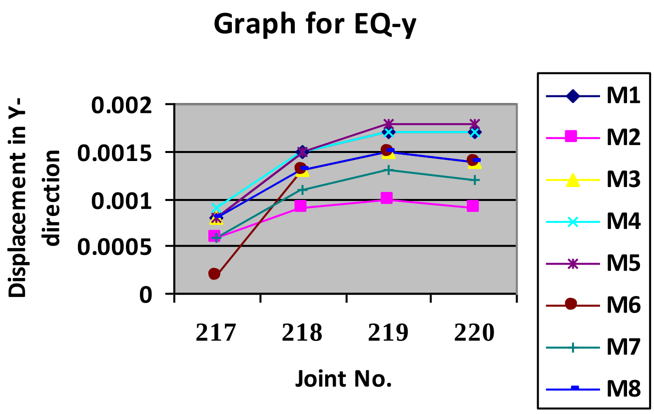

Fig 8: Displacement in Y-direction vs Joint No.

- By comparing the above plots, the addition of X-bracing to open ground storey structure improves the performance of the building to some extent.
- For the nonlinear static analysis, from table 4 it is clear that M2, M7& M8 are producing minimum displacement in X-direction. Fig 7 shows the graphical representation of displacement in X-direction vs joint no. and the models are plotted inside the graph.
- Table 5 shows that M2, M7 & M8 are producing minimum displacement in Y-direction. Fig 8 shows the graphical representation of displacement in Y-

direction vs joint no. and the models are plotted inside the graph.

- By comparing the displacement parameter with cost parameters, we could conclude that M7 and M8 provides better performance than other models. The displacement parameters values are taken from fig 7 & fig 8.

V. CONCLUSIONS

In this study, the analysis and design software, SAP2000 is utilized to develop a numerical model of G+3 storey structures as shown in fig 1. Standard bracings are provided at the external parameter. From the study, we can conclude that in M2, minimum deflection is obtained which results in lower chances of failure of the structure during an earthquake. Providing bracings throughout the section is not feasible, M7 and M8 can be considered economical and still provide less lateral deflection. The model considered here is symmetrical, Further studies can be carried on unsymmetrical models.

VI. REFERENCES

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