Seismic performance of a multi storey building with steel bracings: A comparative study

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Abstract:

Steel bracing is a most efficient and economical method which improves the seismic performance by increasing lateral stiffness and capacity to resist the lateral forces of a multi storey building. According to this investigation the main focus is to study the different types of bracing system such as cross bracing and V bracing at different orientations of a G+5 storied building.The building considered in analysis has a plan dimension of 16m x 20m is subjected to Bhuj earthquake ground motion. Time history method one of the advanced methods of non-linear dynamic analysis is used to study the seismic performance of the structure. Commercial software STAAD Pro. V8i is used for this analysis.The behavior of the structure is evaluated by parameters such as storey drift, storey displacement, base shear, nodal displacement and time-acceleration response etc. The results of the seismic performance of each model are tabulated and represented graphically for comparing the variation in performances of each model (bare frame and braced frame) and determining the effective bracing systems and its location.

Key words: Cross Bracing, V bracing, Time History Analysis, Base shear, Storey drift, Storey displacement, Time-acceleration.

INTRODUCTION

In case of multistoried building Steel bracings can be provided with different orientations of the building and designed properly to increase the building strength and stiffness capacity. For construction steel bracings are more suitable than concrete bracing because steel bracings are more economic and easy to erect from their position. Therefore for the construction it is a vital factor to decide the effective location for providing steel bracings for a lateral load resisting frame. In this study the results are to be compared for different bracing types with different orientations according to bare frame which can be a deciding factor for an economic construction.

RELATED WORKS

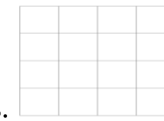
I. Adithya.M., Swathi rani,K.S,Shruthi,H.K, and Ramesh, B.R.(2015) studied the seismic behavior of a Multi storied R.C.C building with steel bracing..This project is studied about the efficiency of using different types of bracings and with different steel profiles for bracing members for multi-storey steel frames.
II. Mehta, V., andRana K. (2017) studied on Multi-storey regular buildings with (G+25) stories have been modelled using software STAAD Pro.for seismic zone V inIndia and by using Time history method for multi-storey building the storey displacement and storey drift calculated.
III. Kulkarni, Y.U.,Chandak,P.G., Devtale,M.K.,Sayyed, S.S. (2016) studied on the behaviour of the bracing system in analysis for parameters like displacement, weight etc by using different types of bracing systems e.g. X bracing, V bracing, Inverted V bracings, Knee bracings.

DESCRIPTION OF MODELS

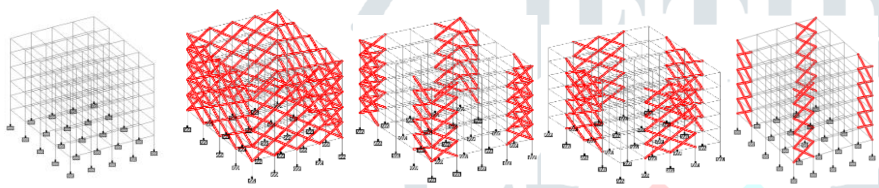
In this study a G+5building with plan dimension 16m x 20m has been considered for seismic analysis. The height of the each storey of this building is 3m. The seismic analysis has been carried out in STAAD pro.V8i software using Time history analysis. For this analysis the collection of Bhuj Earthquake time-acceleration data is taken as the external input which is processed by IIT, Roorkee.

Table-1: Dimensional properties of structure

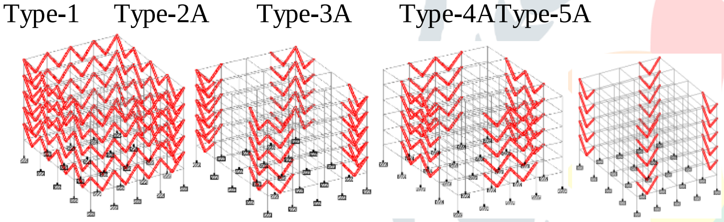
S.no	Properties	Dimensions
1	Columns	0.5 x 0.5 m
2	Beams	0.3 x 0.5 m
3	Member weight on floor beams	12.5 kN/m
4	Member weight on roof beams	4.2 kN/m
5	Slab thickness	0.125 m
6	Bracing	ISA150 x150 x12
7	Imposed load on floors	3.0 kN/m^2
8	Imposed load on roof	1.5 kN/m^2
9	Damping	5%



Bracings are provided at four different locations in the frame and the models are represented as follows.



Type-1 Type-2A Type-3A Type-4AType-5A



Type-2B Type-3B Type-4B Type-5B

Table-2: Representation of Models

TYPE OF MODEL	REPRESENTATION
Bare frame	Type 1
Braced frame of X bracing	Type 2A
Braced frame of V bracing	Type 2B
Bracing applied at corner of X bracing	Type-3A
Bracing applied at corner of V bracing	Type-3B
Bracing applied at middle of X bracing	Type-4A
Bracing applied at middle of V bracing	Type-4B
Bracing applied at periphery diagonally of X bracing	Type-5A
Bracing applied at periphery diagonally of V bracing	Type-5B

RESULTS AND DISCUSSION

The seismic analysis has been done by using STAAD Pro. V8i software and the results are tabulated and then represented graphically. To ascertain the behavior of the structure parameters considered are maximum base shear, inter storey drift, storey displacements and maximum nodal displacements and time-acceleration.

Base Shear:

The base shear isinterpreted as the maximum expected lateral force that will occur due to the seismic ground motion at the base of a structure.

Table-3: Base shear in X direction

Type of Model	Base shear (kN)
Type-1	1323.877
Type-2A	1384.311
Type-2B	1373.557
Type-3A	1309.801
Type-3B	1298.725
Type-4A	1337.495
Type-4B	1310.681
Type-5A	1304.492
Type-5B	1319.469

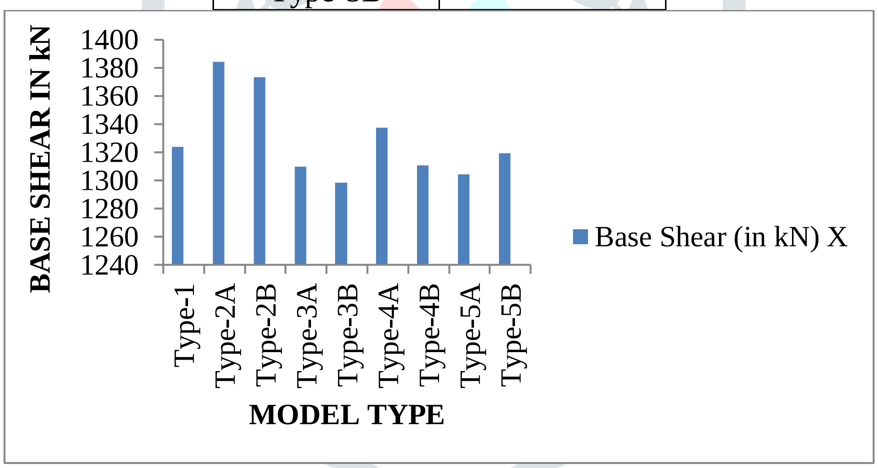


Figure 6: Comparison of base shear

Among the bracing frames maximum base shear in X direction is observed in Type-2A and minimum for Type-3B. When the bracing system is provided at other positions of the building like corner,middle and periphery diagonally and as compared to the bare framemaximum base shear is observed in Type-4Aand minimum base shear is observed in Type-3B.

Inter Storey Drift:

Storey drift should be taken within 0.4% of the storey height as per IS 1893-2002 (Part-1). The building considered in this study, the safe limit for storey drift is 12mm. Inter storey drifts in the bare frame was found to exceed this limit of 12mm.

Table 4: Inter Storey Drift in X direction

Storey	Inter Storey Drift in mm								
	Type 1	Type 2A	Type 2B	Type 3A	Type 3B	Type 4A	Type 4B	Type 5A	Type 5B
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.639	3.716	3.964	3.871	4.179	4.293	4.058	4.293	4.611
3	10.132	3.419	3.552	4.428	4.856	5.800	4.794	5.8	6.468
4	9.909	2.838	2.982	4.131	4.508	5.427	4.350	5.427	6.027
5	7.837	2.079	2.264	3.491	3.852	4.614	3.550	4.614	5.036
6	5.297	1.253	1.472	2.616	2.918	3.517	2.509	3.517	3.785
7	3.037	0.646	1.432	1.722	2.483	2.375	1.559	2.375	2.720

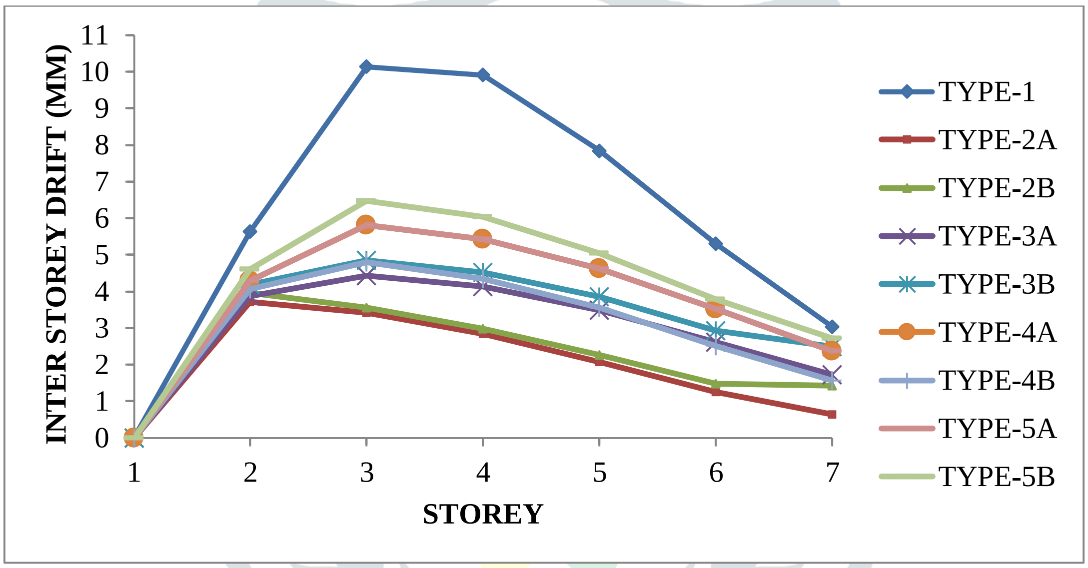


Figure7: Inter storey drift in X direction

Minimum inter storey drift was observed in Type-2A and maximum in Type-1. When the bracing system is provided at other positions of the building like corner, middle and periphery diagonally and as compared to the bare frame maximuminter storey driftis observed in Type-1and minimum inter storey drift is observed in Type-4B.

Storey displacement:

Storey displacement may be interpreted as lateral displacement of a given storey with respect to the basement of the structure. Storey displacements for the models with different steel bracing orientations are tabulated below.

Table 5: StoreyDisplacementin X direction

Storey	Storey Displacement in mm								
	Type 1	Type 2A	Type 2B	Type 3A	Type 3B	Type 4A	Type 4B	Type 5A	Type 5B
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.639	3.716	3.964	3.871	4.179	3.883	4.058	4.293	4.611
3	15.771	7.135	7.516	8.299	9.034	8.159	8.853	10.093	11.079
4	25.680	9.973	10.498	12.430	13.543	11.939	13.203	15.520	17.106

5	33.516	12.052	12.762	15.921	17.395	14.983	16.753	20.133	22.142
6	38.813	13.306	14.234	18.538	20.313	17.119	19.262	23.650	25.927
7	41.850	13.951	15.666	20.260	22.796	18.390	20.821	26.025	28.646

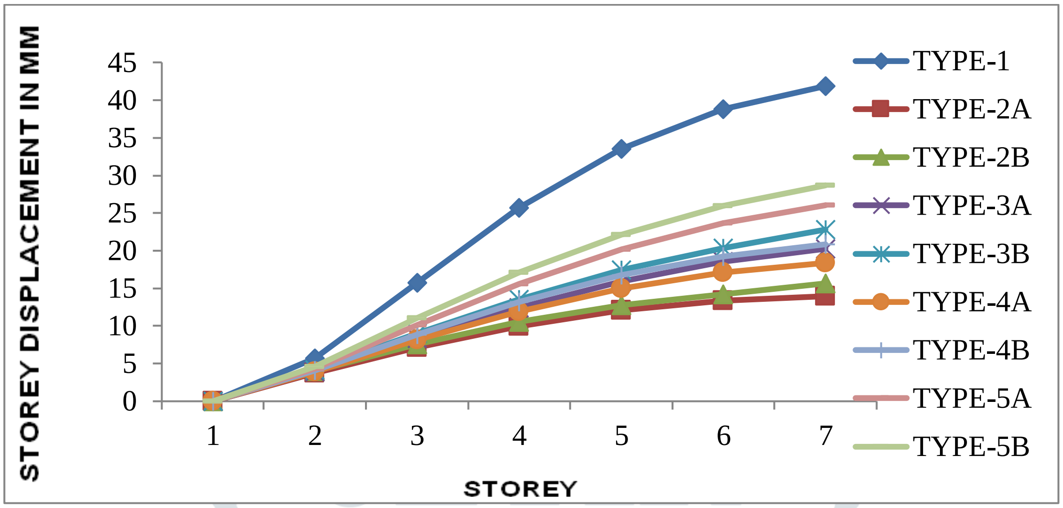


Figure8: Storey displacement in X direction

Minimum storeydisplacement was observed in Type-2A and maximum in Type-1. When the bracings are provided at some positions of the building like corner, middle and periphery diagonally and as copmared to the bare frame maximumstoreydisplacementis observed in Type-1 and minimum storey displacementis observed in Type-4A.

Maximum Nodal Displacement:

The maximum nodal displacement in lateral directions of the bare frame was found to be higher than the braced frames. For the safety purpose nodal displacement should be minimum.

Table 6: Maximum Nodal Displacementin direction

Model Type	Maximum Nodal displacement (mm)
Type-1	42.683
Type-2A	19.474
Type-2B	20.969
Type-3A	24.606
Type-3B	26.717
Type-4A	23.129
Type-4B	25.204
Type-5A	29.252
Type-5B	31.443

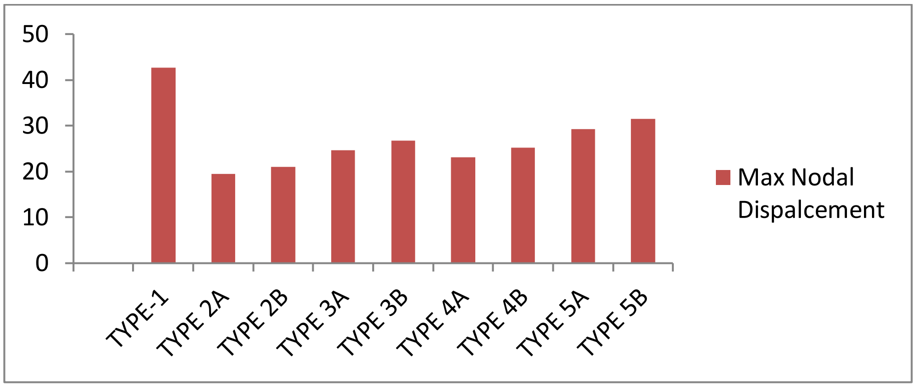
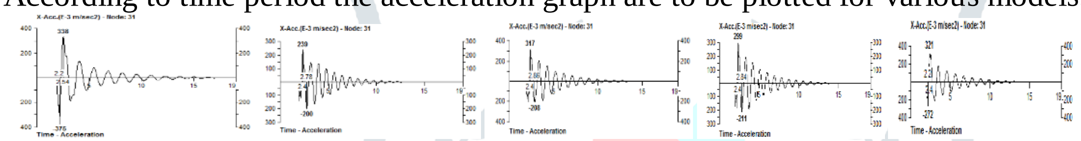


Figure9: Maximum nodal displacement in X direction

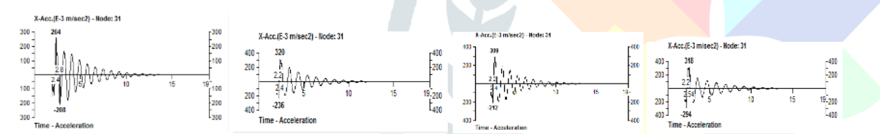
Among the models, with steel bracings, minimum nodal displacement was observed in case of type-2A i.e. in braced frame and maximum nodal displacement was observed in case of type-1 i.e. bare frame.When the bracing provided at some position of the building like corner, middle and periphery diagonally and as compared to the bare frame maximum nodaldisplacementis observed in Type-1 and minimum nodal displacementis observed in Type-4A.

Acceleration according to time period:

According to time period the acceleration graph are to be plotted for various models.



Type-1 Type-2A Type-3A Type-4AType-5A



Type-2B Type-3B Type-4B Type-5B

Among the models, with steel bracing, minimum acceleration was observed in case of type-2A i.e. in braced frame and maximum acceleration was observed in case of type-1 i.e. bare frame.When the bracing provided at some position of the building like corner, middle and periphery diagonally and as compared to the bare frame maximum accelerationis observed in Type-1 and minimum accelerationis observed in Type-4A.

CONCLUSION

Form the results obtained it can be concluded that when the bracings are applied the inter storey drift, storey displacement and nodal displacement, acceleration reduced significantly.Hence Type-2A may be considered as the stiffer orientation in comparison to other type of models

When the bracing provided at some position like corner, middle and periphery diagonally of the building and the bare frame Type-4A may be considered as the stiffer orientation in comparison to other models and cross bracing is more suitable than V bracing.

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