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Analysis of multistoried braced frame subjected to seismic and gravity loading.

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ABSTRACT

The structure in high seismic areas may be susceptible to the severe damage. Along with gravity load structure has to withstand to lateral load which can develop high stresses. Now-a-days, shear wall in R.C. structure and steel bracings in steel structure are most popular system to resist lateral load due to earthquake, wind, blast etc. bracing is a highly efficient and economical method of resisting horizontal forces in a frame structure. Bracing is efficient because the diagonals work in axial stress and therefore call for minimum member sizes in providing stiffness and strength against horizontal shear. Through the addition of the bracing system, load could be transferred out of the frame and into the braces, by passing the weak columns while increasing strength. In this study Steel Frame is modeled and analyzed three Parts viz., (i) Model without Steel bracing (bare frame), (ii) Model completely Steel braced (fully braced frame), (iii) Model with partially Steel bay wise braced frames. The computer aided analysis is done by using STAAD-PRO to find out the effective lateral load system during earthquake in high seismic areas.

***Keywords* –** Axial force, Bare frame, Bracings, Equivalent static analysis, Lateral Displacement

I. Introduction

Over the past three decades, India has experienced number of earthquakes that caused large damage to residential and industrial structure. Today, over 60% of Indian land areas lies in higher three seismic zone III, IV and V as per Indian seismic code [IS 1893 (Part-1):2002]. However, only about 3% of build environment is properly engineered. India has potential for strong seismic shaking with large stock of vulnerable buildings. Thus, there is urgent need to introduce proper earthquake-resistant design and construction features. Use of steel in construction can be of significant help in building safe built-environment in earthquake prone regions of India. Steel as material is ductile. The stress-strain curve of common mild carbon steel has a yield plateau, a strain hardening region followed by a strain softening part. However, this does not guarantee that all the steel structure will be ductile. It is responsibility of designer to advantageously use the ductility of steel to build earthquake-resistant ductile steel structures. Earthquake ground motion may generate very large inertia forces that need to be resisted by structural element in a building. These forces produce large stresses, strains, deformation and displacement particularly in tall structures. It is necessary to keep the displacement within the limit. To keep this displacement within limit generally bracing is provided in steel structure. Bracings increase lateral-stiffness, lateral- strength as well as lateral stability of the frame. Under dynamic loading bracing act as good energy dissipater. In this paper structural behavior of Bare frame, `A` and `V` type of braced frames which are shown in fig.1.1 for simple building frame.

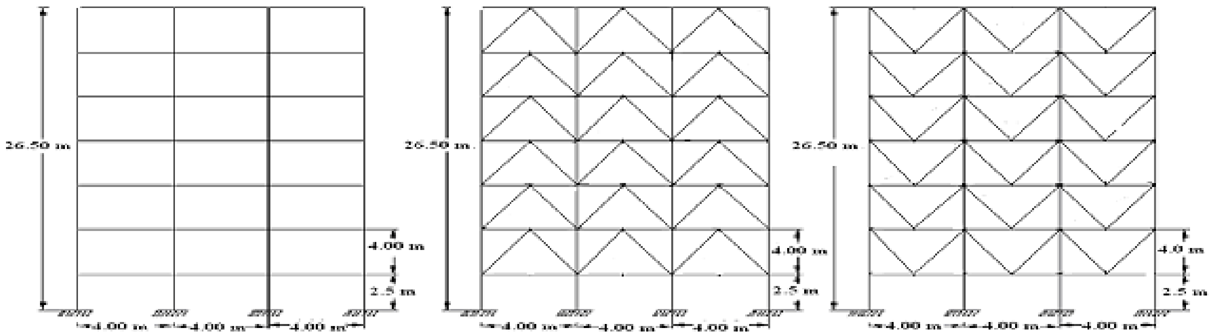
II. Problem Definition

Linear elastic Plane frame analysis is performed for the different models of the building using STAAD analysis package. The frame members are modeled with rigid end zones. Equivalent static analysis is performed on the models of the building considered in this study. Column sizes and bracing sizes are changed according to loading condition and storey height.

2.1 Load Combination

Given load combinations shall be accounted as per I.S. 1893 (Part I) - 2002. Where the terms D.L, L.L, and EQ stand for the response quantities due to dead load, imposed (Live) load, earthquake load respectively.

1)1.7(D.L+L.L)
2)1.7(D.L ± EQX)
3)1.3(D.L+L.L±EQX)



(a) Bare *frame* ***(b) 'A' type frame*** ***(c) 'V' type frame***

Fig 1.1 Models used for analysis

Table 1-Models used for analysis.

Sr. No.	Model	Frame Type	Structure variation	Bay variation	Beam depth variation in (mm)
1	I	Bare Frame	G+5 to G+11	3, 5 and 7	ISMB500-P=24 to ISMB600-P=24
2	II	"A" type Braced Frame	G+5 to G+11	3, 5 and 7	ISMB500-P=24 to ISMB600-P=24
3	III	"V" type Braced Frame	G+5 to G+11	3, 5 and 7	ISMB500-P=24 to ISMB600-P=24

III. RESULT- For 3 Bays Bare Frame

Table 2-Variations observed in axial forces for 3 bays bare frame

H/w Ratios	***Beam Depth*** →	**ISMB500-P=24**	**ISMB550-P=24**	**ISMB600-P=24**
	Levels (i) ↓			
2.208	5	1.000	1.013	1.029
3.208	8	2.491	2.530	2.571
4.208	11	4.055	4.114	4.176

Table 3-Variations observed in shear forces for 3 bays bare frame

H/w Ratios	***Beam Depth*** →	**ISMB500-P=24**	**ISMB550-P=24**	**ISMB600-P=24**
	Levels (i) ↓			
2.208	5	1.000	1.032	1.063
3.208	8	1.131	1.165	1.200
4.208	11	1.166	1.197	1.230

Table 4-Variations observed in bending moment for 3 bays bare frame

H/w Ratios	***Beam Depth*** →	**ISMB500-P=24**	**ISMB550-P=24**	**ISMB600-P=24**
	Levels (i) ↓			
2.208	5	1.000	1.044	1.087
3.208	8	1.202	1.244	1.285
4.208	11	1.277	1.314	1.351

For 3 Bays Fully 'A'-Braced Frame

Table 5-Variations observed in axial forces for 3 bays fully 'A'-braced frame

H/w Ratios	***Beam Depth*** →	**ISMB500-P=24**	**ISMB550-P=24**	**ISMB600-P=24**
	Levels (i) ↓			
2.208	5	1.000	1.000	1.003
3.208	8	2.683	2.677	2.675
4.208	11	4.421	4.409	4.405

Table 6-Variations observed in shear forces for 3 bays fully 'A'-braced frame

H/w Ratios	***Beam Depth*** →	**ISMB500-P=24**	**ISMB550-P=24**	**ISMB600-P=24**
	Levels (i) ↓			
2.208	5	1.000	1.078	1.167
3.208	8	0.325	0.372	0.459
4.208	11	0.290	0.301	0.255

Table7-Variation observed in bending moment for 3 bays fully 'A'-braced frame

H/w Ratios	***Beam Depth*** →	**ISMB500-P=24**	**ISMB550-P=24**	**ISMB600-P=24**
	Levels (i) ↓			
2.208	5	1.000	1.098	1.215
3.208	8	0.405	0.458	0.562
4.208	11	0.174	0.193	0.140

For 3 Bays Fully 'V'-Braced Frame

Table:-8 Variations observed in axial forces for 3 bays fully 'V'-braced frame

H/w Ratios	***Beam Depth*** →	**ISMB500-P=24**	**ISMB550-P=24**	**ISMB600-P=24**
	Levels (i) ↓			
2.208	5	1.000	0.984	0.971
3.208	8	2.223	2.198	2.179
4.208	11	3.472	3.441	3.418

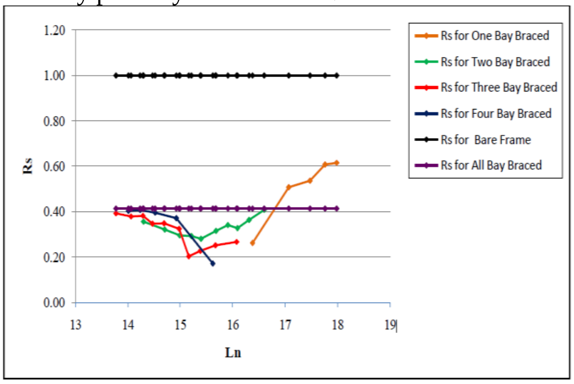
Table 9-Variations observed in shear forces for 3 bays fully 'V'-braced frame

H/w Ratios	***Beam Depth*** →	**ISMB500-P=24**	**ISMB550-P=24**	**ISMB600-P=24**
	Levels (i) ↓			
2.208	5	1.000	1.067	1.119
3.208	8	1.374	1.503	1.614
4.208	11	1.683	1.853	1.999

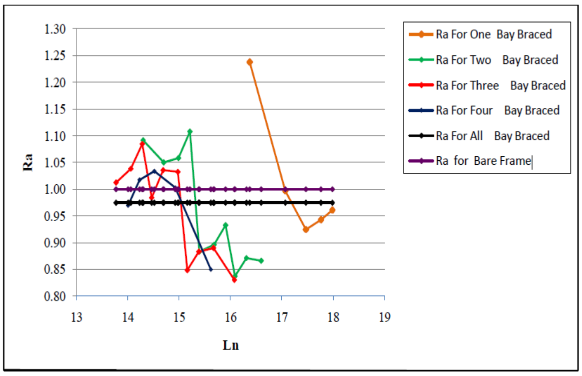
Table 10-Variations observed in bending moment for 3 bays fully 'V'-braced Frame

H/w Ratios	***Beam Depth*** →	**ISMB500-P=24**	**ISMB550-P=24**	**ISMB600-P=24**
	Levels (i) ↓			
2.208	5	1.000	1.080	1.146
3.208	8	1.460	1.601	1.726
4.208	11	1.810	1.991	2.151

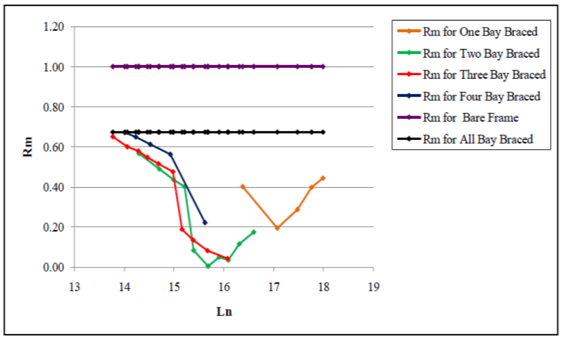
3.1 Graph 1, 2, 3 shows variation of internal forces for 5 bay partially braced frame.



Graph-1 Variation of Axial Force

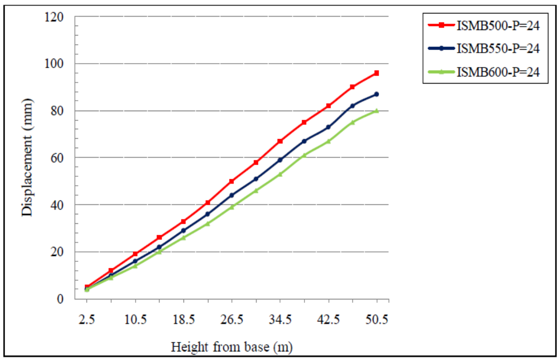


Graph-2 Variation of Shear Force

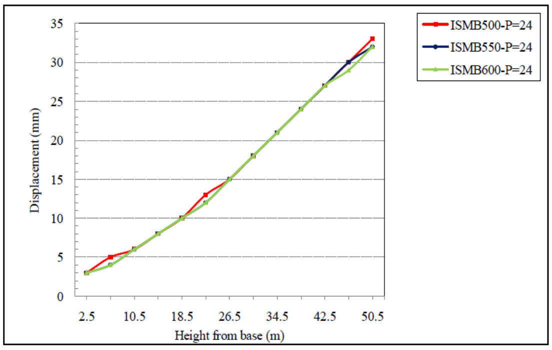


Graph-3 Variation of Bending Moment

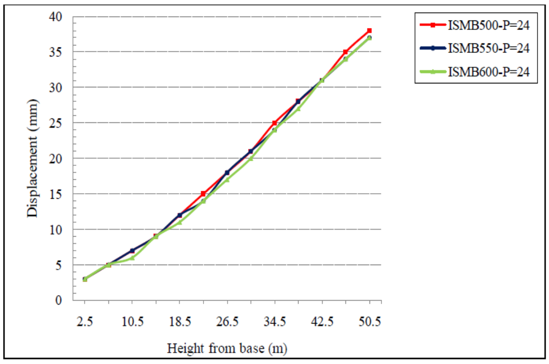
Graph 4, 5, 6 shows variation of displacement in frame.



Graph-4 Variation of Lateral Displacement in Bare Frame



Graph-5 Variation of Lateral Displacement in 'A'-braced frame



Graph-6 Variation of Lateral Displacement in 'V'-braced frame

IV. CONCLUSIONS

Following conclusions are drawn on the basis of the analyses carried out for various types of structures.

4.1About Bare Frame

1. Column segments at higher level attract larger axial forces as the beam depth increases. These segments are found to be more sensitive to the variation in stiffness of beam.
2. Despite allowing a large variation in column so as to minimize the lateral drift tall structures are found to violate the lateral drift criterion specified by IS: 1893 for all beams of same uniform depth, at all levels up to ISMB550- P=24 mm. Heavy beams are necessary to limit maximum lateral drift to 0.004H in twelve storied structure.

4.2About 'A' and 'V' type braced frames

1. Axial force in 'V' Braced frame columns increases as compared with that in bare frames and 'A'Braced frames
2. Braces are found to carry large axial forces compared with shear forces and bending moments, which are insignificantly small,also Maximum lateral displacements are found to reduce drastically as compared with bare frames.
3. End columns in 'A' braced frames are loaded to smaller extent as compared to 'V' braced frames.
4. The comparative saving in material for fully braced frame with 'A' & 'V' type bracing vis-à-vis bare frames is as follows.

Type of braced frame	Material saving in percentage
'A'-Braced frame	28.426%
'V'-Braced frame	19.991%

4.3About partially braced frames

1. For 5 Bay G+11 Structure that are braced centrally with 'V' type bracing are found to be economical due to reduction in the column cross sections. These are more flexible than fully braced frames (but more rigid than bare frames) and yet displacements produced are within permissible limits. But in case of 'A' Braced frame when 2-4 Bays braced it gives more economical than central Braced 'V' frame due to change in structural behavior.

REFERENCES

[1] K.K. Sangle, K.M. Bajoria, V. Mhalunkar, [2012] "*Seismic analysis of high rise steel frame with and without bracing*" 15 WCEE LISBOA.

[2] E.M. Hines and C.C. Jacobs [2009], "*Eccentric braced frame system*

performance," ASCE Structures Congress, Texas April 30-May 2.

[3] S.H. Chao and M.R Bayat [2008], "*Performance based plastic design of steel concentric braced frame for enhanced confidence level*," 14t**h** World conference on Earthquake engineering October 12-17.

[4] D.S.Pawar [2008], Dissertation report on "*Analysis of multistoried* "A" and "V" type braced frames subjected to seismic and gravity loading on R.C.C frame"

[5] R. Leon and R. Desroches [2006], "*Behavior of braced frame with Innovative bracing schemes*," National Science Foundation NSF award CMS-0324277.

[6] P. Uriz and S.A Mahin [2004], "*Seismic performance assessment of concentrically braced steel frame*" 13t**h** World conference on Earthquake engineering, Vancouver, B.C Canada August 1-6, 2004 Paper No.1639.

[7] S. B. Kore, dissertation report on "*singly braced and doubly braced frames and then compared their responses using various parameters*. He compared the response of each of these frames with the frame without bracing.

[8] Diddi,[2002] Dissertation report on "*Computer aided analysis of multistoried building frames subjected to earthquake*"

[9] Lian Duan and Wai-Fuh Chen [1989]," *Derivation of general effective length factor for columns in unbraced frames*" Journal of Structural Engineering, Vol.115, No.1, Paper No.23125.