Pushover Analysis of RC Frame with Different Bracing Section

MUNJUNATH G S , MOHD AJAZ AHMED

Department of Civil engineering , TOCE Bangalore

***Abstract*— Lateral load resistance in seismic prone areas, has leads to damages to the structure, to overcome this under seismic excitation steel bracing has proved most effective systems against earthquake effect. RC frames in seismic areas has to design in such a way that they resist considerable amount of lateral loads. In this paper RC frame is analyzed with different bracing system such as X, K & ZX & various steel section such as ISA, ISMB, ISMC in zone-V area of India, by Non-linear static procedure, through ETABS software. The lateral loads are carried by bracing. In order that strength & stiffness is increased by using steel bracing in RC frame. In this 10(ten) models is analyzed with 3(three) bracing system of different section & without bracing. Thus the main purpose of analyzing is to known the structural behavior of bracing steel section for building, lateral displacement, and performance of bracing section applied on RC frame and to know the pushover process.**

Keywords*— *Pushover Analysis, Performance of Bracing Sections, Lateral Displacement, Base-Shear.

I. INTRODUCTION

Seismic effect or earthquake effects is a natural hazards and takes place in the ground which commonly develop wave like motion. Among the various types of natural calamities, earthquake is one of the most dangerous kind of threats which has a severe effect on the life safety and economy of people. Structures which design & construct to be strong enough found to be sway during strong ground motions. RC type of structures which usually consist common members called skeleton of beam column etc. RC frame in seismic prone areas may be subjected to severe effects of earthquake. When seismic motions occurs, deformations take place across the members of the load-carrying. RC frames preferred because of it is sustain the economy and simple to the construction. Compression and tension are both reaction act as in once in RC frame.

Earthquakes have the power for causing the greatest damages to the structures since earthquake forces are common in nature & unpredictable, the engineering tools needs to be sharpened for analyzing structures under the action of such forces. Performance based design is gaining a new dimension in the seismic design philosophy in the field of ground motion of structure. Seismic loads or lateral loads are to be carefully design so as to assess the behavior of structure under seismic hazards. In this paper non-linear static analysis is done which is an iterative procedure shall be analyzed for newly executing building. Which is commonly called pushover analysis. This study focuses on pushover analysis of RC frame subjecting to monotonically increasing lateral forces, with different section of bracing. The performance of different section of bracing & its effects on structure is analyzed for performance check & different check of bracing system. In this paper three types of bracing system are considered & section based analysis is done for regular frame. demand like displacement, drift imposed by earthquake loads. The research scholar gave an effective idea of using bracing systems like concentric, eccentric and knee bracing systems. The bracing system provides the structure more capacity to gain up energy when it is under seismic excitation. RC frame structures in seismic prone zones are needed to be designed such that they resist considerable horizontal loads & withstand the structure until it reaches to life safety. Different types of bracing system used in this paper are as follows,

- X-bracing— use of cross bracing to the members adjacent to each other. These only need to be resistant to tension, one brace acting to resist sideways forces at a time depending on the direction of loading. This type of bracing provides the least available space within the structure for openings.
- V-bracing—this involves two diagonal members extending from the top two corners of a horizontal member and meeting at a center point at the lower horizontal member, in the shape of a V.This type of bracing mean that the buckling capacity of the compression brace is likely to be significantly less than the tension yield capacity of the tension brace. This can mean that when the braces reach their resistance capacity, the load must instead be resisted in the bending of the horizontal member.
- Inverted V—Inverted V-bracing (also known as chevron bracing) involves the two members meeting at a center point on the upper horizontal member. This type of bracing mean that the buckling capacity of the compression brace is likely to be significantly less than the tension yield capacity of the tension brace. This can mean that when the braces reach their resistance capacity, the load must instead be resisted in the bending of the horizontal member.
- K-bracing—Braces connect to the columns at mid-height. This frame has more flexibility for the provision of openings and results in the least bending in floor beams. K-bracing is generally discouraged in seismic regions because of potential for columns failure if the compression brace buckles.

I. NON-LINEAR STATIC ANALYSIS

Non-linear static analysis of structure in which static loads are applied in order to increase the ultimate state of structure achieved. The Non-linear static analysis of a structure is a is commonly called as Pushover analysis in which under vertical loads applied to structure leads to gradually increasing in lateral loads. A graph of total base shear or base reaction versus roof displacement of a structure is obtained by this analysis that would indicate a premature failure or weakness under seismic forces. The members of structures which reach yield or have experienced cracks or failure of crushing and even fracture are noticed.In addition, it can be understood that this analysis technique will leads to achieve the inelastic forces, displacements, deformations etc., taking into account the non-linear behavior on the structural material during a seismic effect. The philosophy involved in the formulating of the pushover analysis procedure will be embarked upon in the following way of modelling. Different methods have been developed for the performance evaluation using this procedure; the foremost of these are applied.

Different types of technics or procedures are possible in the application of the lateral load patterns and the performance evaluation formats. Nonlinear static analysis, is a method for determining the ultimate load and deflection capability of a structure. Non-linear structure effects, such as flexural hinges at the member joints, are modeled and the structure is deformed or "pushed" until enough hinges form to develop a collapse mechanism or until the plastic deformation limit is reached at the hinges. Through gradual increasing loads many structural elements may yield sequentially. Using a nonlinear static pushover analysis, a representative non-linear force displacement relationship can be obtained. If the structure shows signs of failure then suitable retrofit measures may also be suggested. Pushover analysis may be categorized as displacement controlled pushover analysis when lateral movement is executed on the building and its equilibrium designates the forces. A plot of the total base shear versus top roof displacement in a building is attained by this analysis that would specify any early failure or weakness. The analysis is performed up to failure, thus it permits purpose of collapse load and ductility capacity.

II. DISCRIPTION OF MODELLING

Ten, Ten storey structure with three different types steel bracing & without bracing in RC buildings have been used in this study, figure 1 (without bracing & with bracing). The plans of slabs were represented in the structural model of the building using their mass in the gravity load case at all joint,& same for with & without bracing system the bay lengths are 4 m along x-direction & 5m along y-direction and the height is 3 m except the base of about 2.5m.The buildings were designed without seismic design criteria, and are located in high seismicity region of zone-V. Table.1.shows the description.

In Fig.2.different type of bracing system used for analysis the model with different section.

Table 1.Discribtion of Models

Sl. No	Structural Description	Parameter	
1	Zone	V	
2	Height of floor	3m (each floor)	
		2.5m (base)	
3	Material property	M25 (beams & slab)	
		HSYD415 (beams& slab)	
		M30 (columns)	
		HSYD-500 (columns)	
		Fe250 (bracing)	
4	Beam size	450x350mm	
5	Column size	750X500mm	OUTER
		700X450mm	INNER
6	BRACING—X,K,V,INVERTED V	ISA-130X130X15	
		ISMB-250	
		ISMC-250	

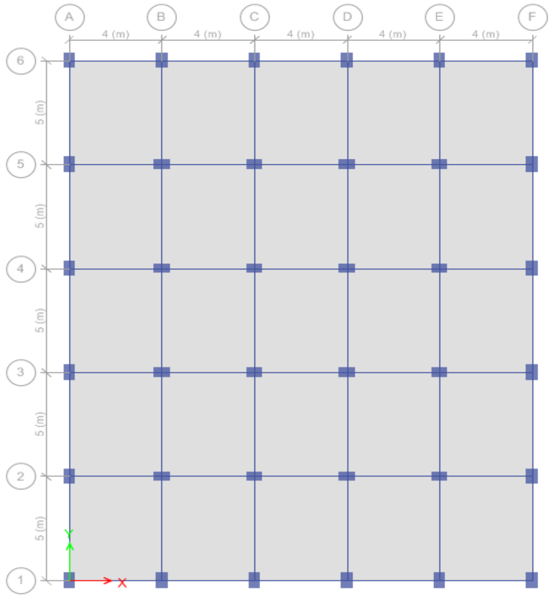

Figure 1. 2D-Plan For All Models

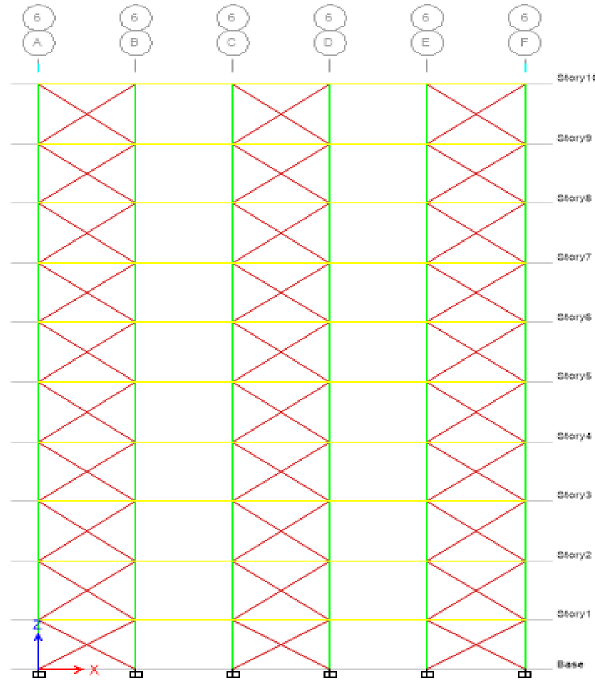

Fig 3. Elevation View of Model with X-Brace

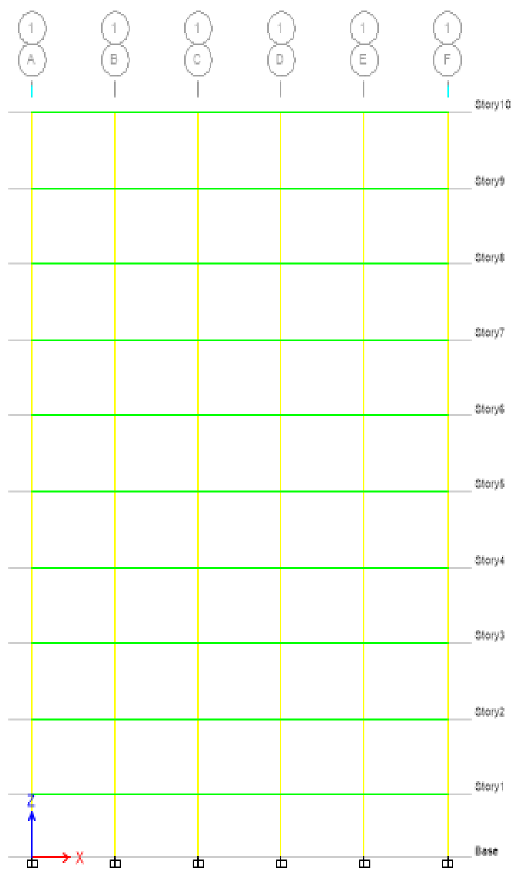

Fig 2. Elevation View of Bare Frame

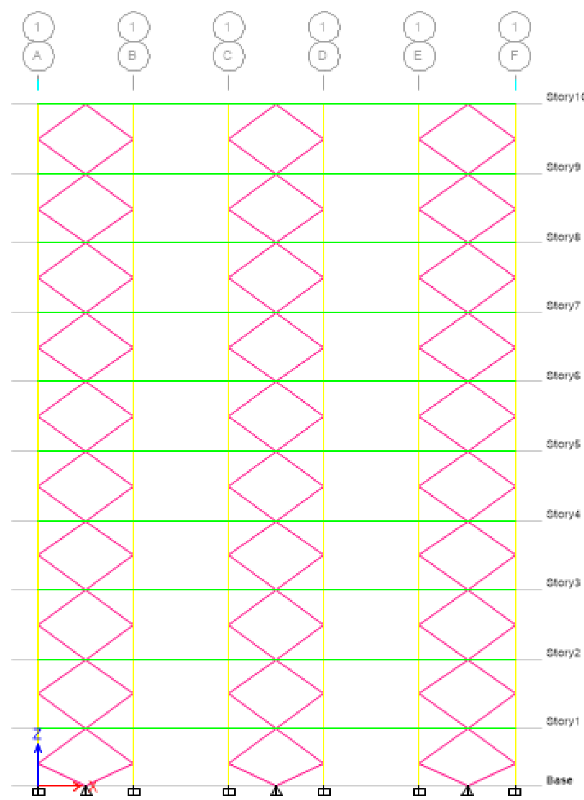

Fig 3. Elevation View of Model with K-Brace

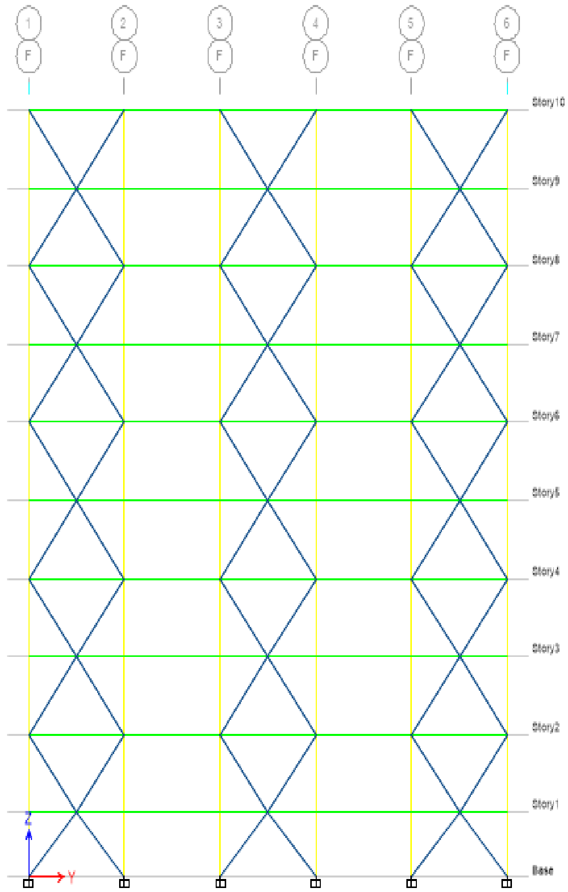

Fig 4. Elevation View of Model with ZX-Brace

All section of steel bracing has same models & same parameters except the section dimensions.

TABLE 2. LOADING DATA

Sl.no	Loading Data	
1)	Live Load	4 kn/m^2
2)	Finishing Load	1 kn/m^2
3)	Seismic Zone	V
4)	Soil Type	Medium soil
5)	Importance Factor	1
6)	Response reduction Factor	5 (SMRF)

III. Analysis Results

1) BASE SHEAR

Base Shear in X-Direction

Types of Bracings	With Bracing	Without Bracing	% DIFFERENCE
ISMB			
X-Brace	4753.168	3474.345	36.808
K-Brace	4226.958	3474.345	21.662
ZX-Brace	5361.185	3474.345	54.308
ISMC			
X-Brace	4687.355	3474.345	34.913
K-Brace	4192.377	3474.345	20.667
ZX-Brace	5237.476	3474.345	50.747
ISA			
X-Brace	4607.78	3474.345	32.623
K-Brace	4218.051	3474.345	21.406
ZX-Brace	4947.9	3474.345	42.412

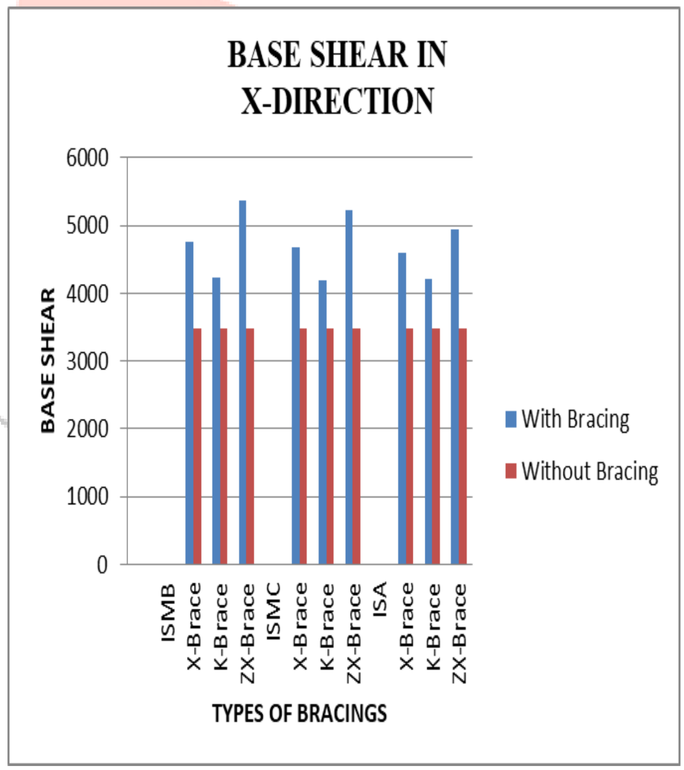

Fig 4. Base Shear of with & without Bracing in X-Direction

Base Shear in Y-Direction

Types of Bracings	With Bracing(kn)	Without Bracing(kn)	% DIFFERENCE
ISMB			

X-Brace	4751.278	3338.33	42.3250
K-Brace	4417.2	3338.33	32.3177
ZX-Brace	5527.95	3338.33	65.5903
ISMC			
X-Brace	4680.98	3338.33	40.2192
K-Brace	4362.14	3338.33	30.6683
ZX-Brace	5056.52	3338.33	51.4685
ISA			
X-Brace	4523.377	3338.33	35.4982
K-Brace	4288.35	3338.33	28.4579
ZX-Brace	4798.9	3338.33	43.7515

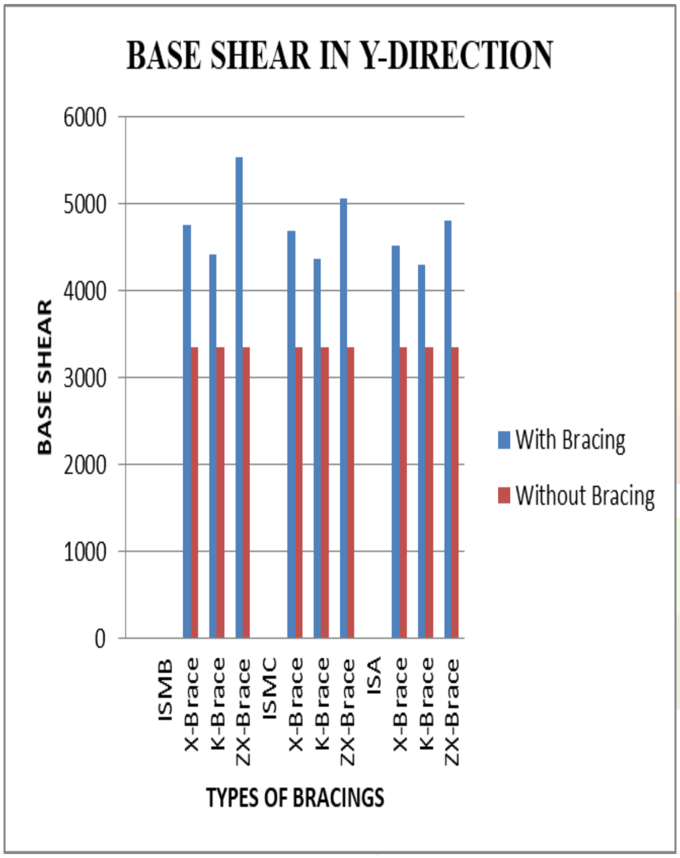

Fig 4. Base Shear of with & without Bracing in Y-Direction

2) ***PUSHOVER CURVES***

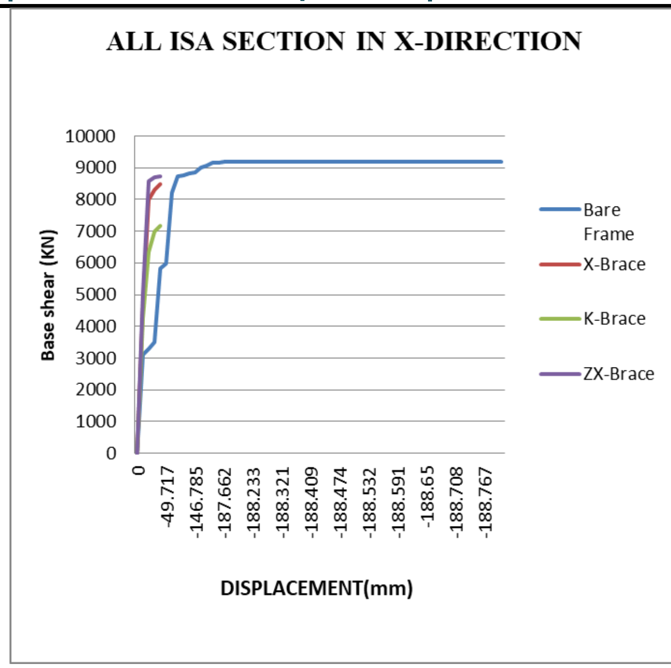

Fig 5. Base Shear Vs Roof Displacement for ISA of with & without Bracing in X-Direction

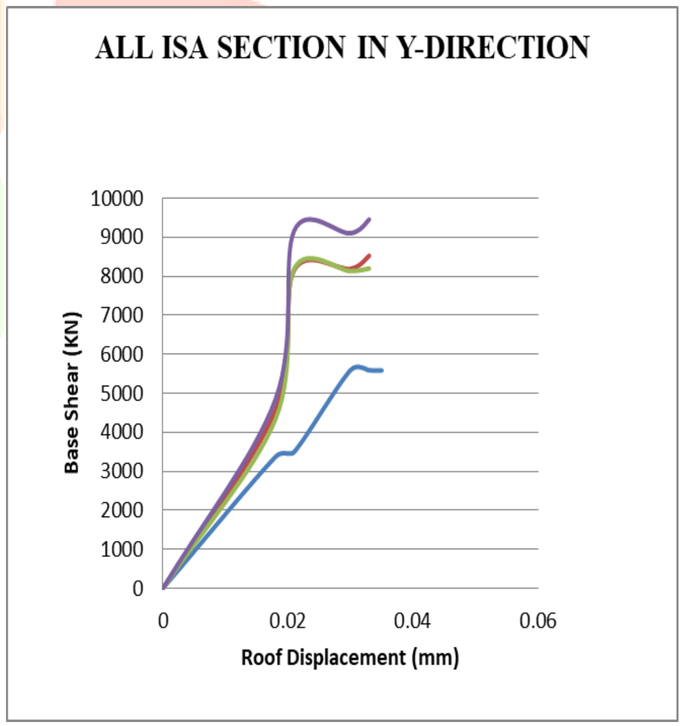

Fig 6. Base Shear Vs Roof Displacement for ISA with & without Bracing in Y-Direction

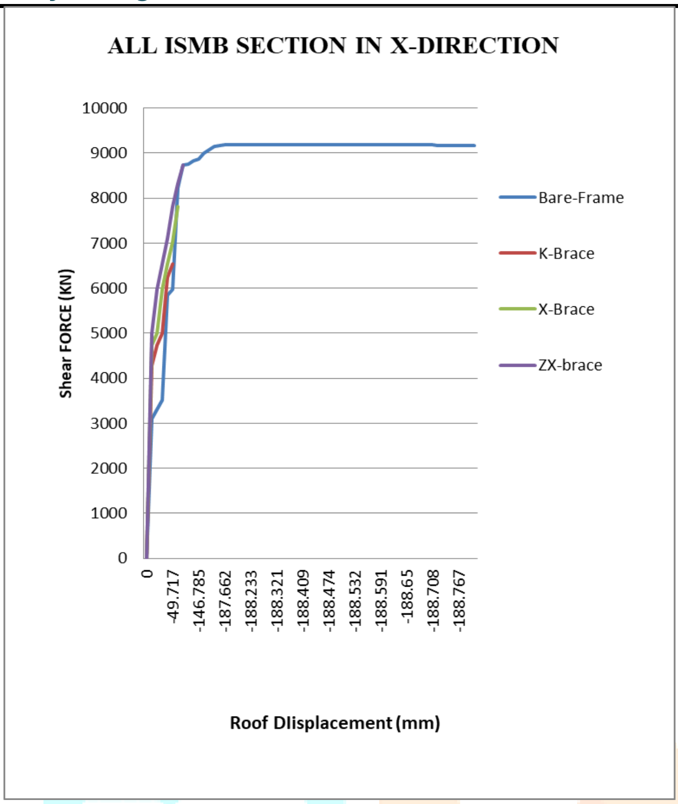

Fig 7. Base Shear Vs Roof Displacement for ISMB with & without Bracing in X-Direction

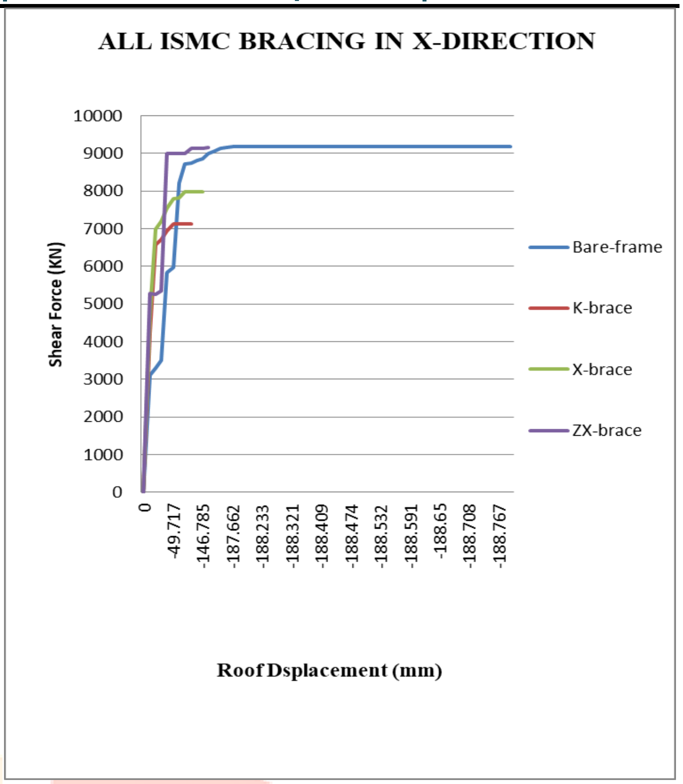

Fig 9. Base Shear Vs Roof Displacement for ISMC with & without Bracing in X-Direction

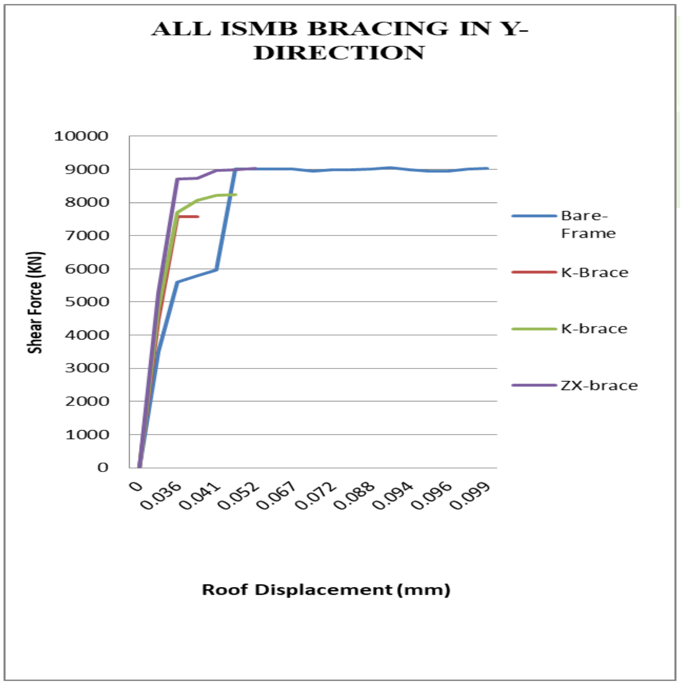

Fig 8. Base Shear Vs Roof Displacement for ISMB with & without Bracing in Y-Direction

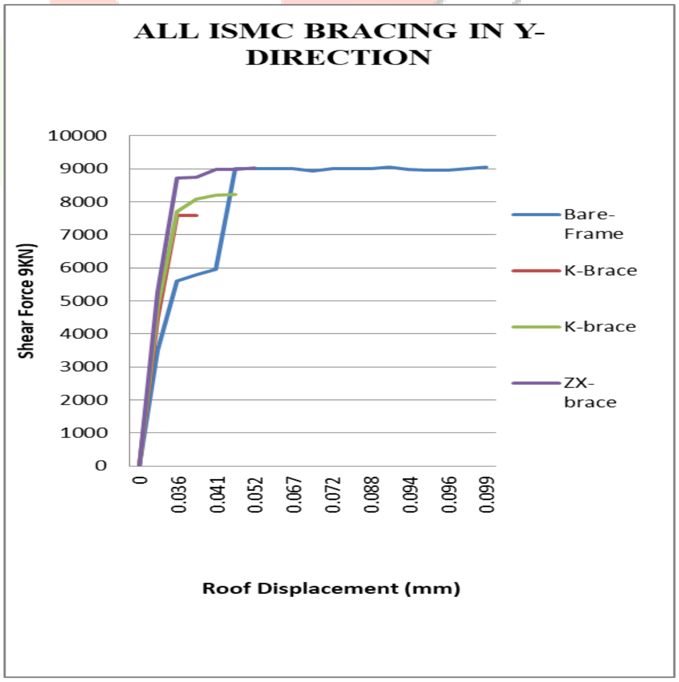

Fig 10.Base Shear Vs Roof Displacement for ISMC with & without Bracing in Y-Direction

3) PERFORMANCE CURVE

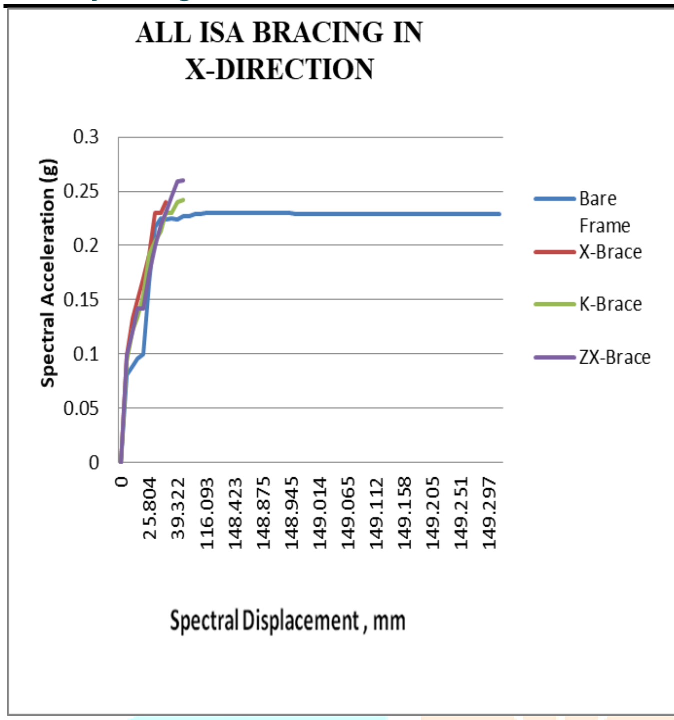

Fig 11. Spectral acceleration Vs Spectral Displacement for all ISA Section with & without Bracing in X-Direction

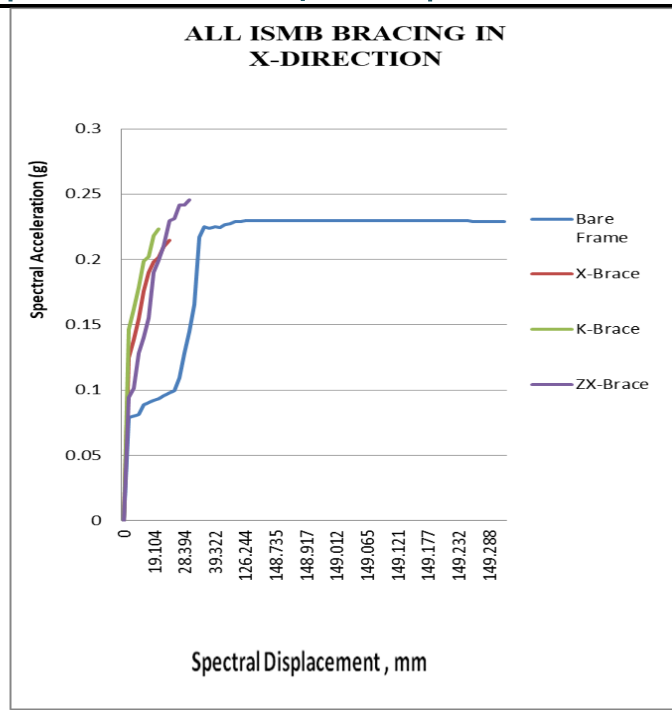

Fig 13. Spectral acceleration Vs Spectral Displacement for ISMB with & without Bracing in X-Direction

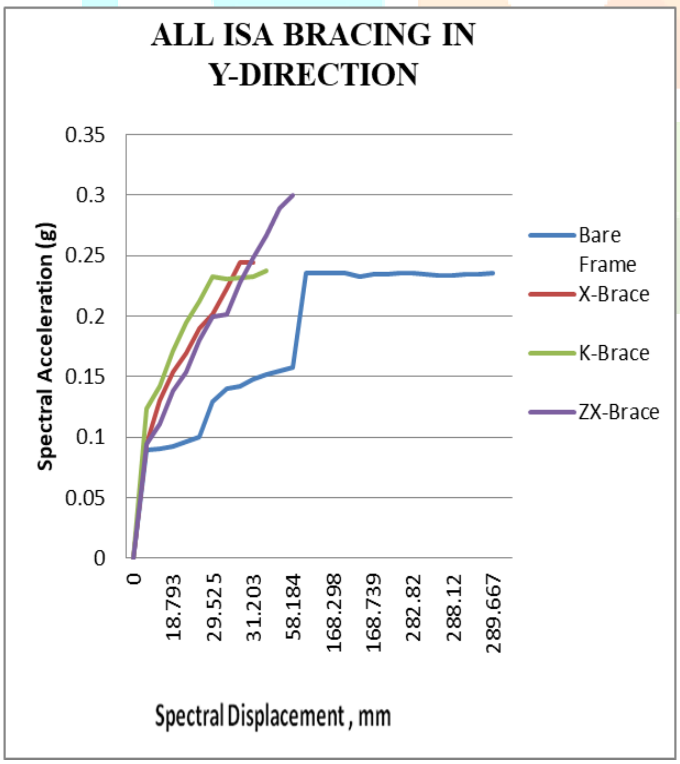

Fig 12. Spectral acceleration Vs Spectral Displacement for all ISA with & without Bracing in Y-Direction

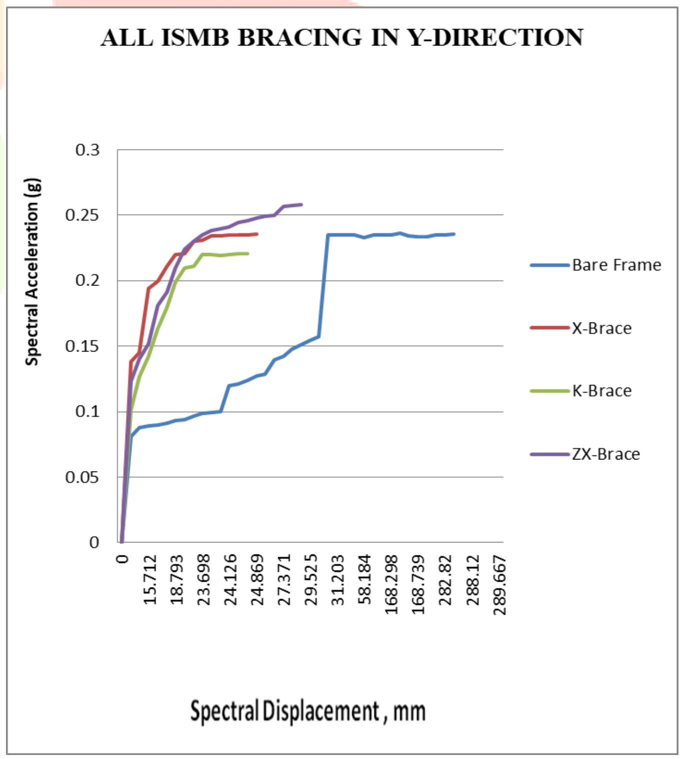

Fig 14. Spectral acceleration Vs Spectral Displacement for all ISMB with & without Bracing in Y-Direction

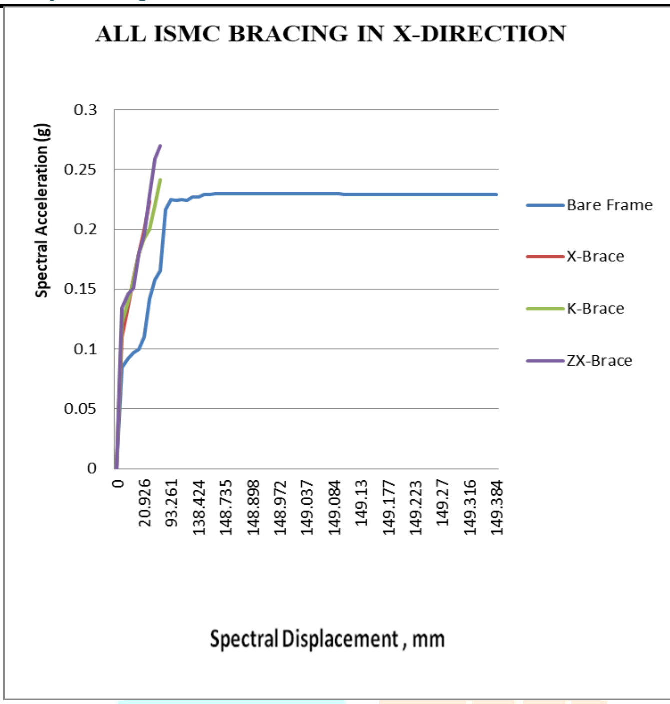

Fig 15. Spectral acceleration Vs Spectral Displacement for all ISMC with & without Bracing in X-Direction

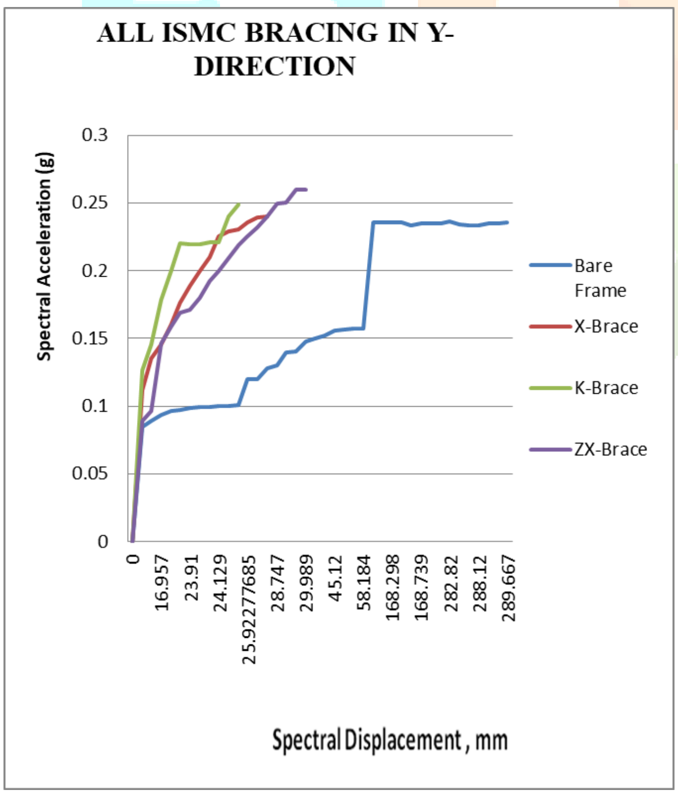

Fig 16. Spectral acceleration Vs Spectral Displacement for all ISMC with & without Bracing in Y-Direction

IV. CONCLUSION

1. The seismic response of the building changes with inclusion of braces in structure.

2. The value of maximum base shear increases in braced structure as compared to un-braced structure. This is due to increased stiffness of building by addition of braced member.

3. From the tables & graphs, it is observed that the displacement of roof storeys of rc frame structure with different bracing system & with different bracing sections is reduced up to 70-80% as compared with bare frame & other sections models

3. Due to inclusion of bracing, the stiffness of building increases, hence vibrations caused because of earthquake reduce thus reducing joint displacement of structure.

4. By providing braces in the frame, the horizontal load at node is distributed among brace members along with beams and columns. Due to provision of the bracing system in the building bending moment comparatively reduced.

5. In seismic analysis for braced and un-braced framed building time period varies with small alteration for all 10 models.

6. On the basis of reduction in joint displacement, base shear, bending moment and axial force, storey drifts. it can be observed that X bracing and K Brace systems are suitable. But the values of base shear and axial forces, bending moment are gives better performance in ZX Brace as compare to X-bracing and the value of joint displacement in X-bracing and K-Brace are nearly in same range. In the case of ZX-Brace, K-bracing for joint displacement, bending moment and axial force are maximum and decrease in base shear as that of X bracing and K-Brace..Hence, comparing all the parameters, it can be concluded that, ZX-brace are more effective than any other bracing systems in the present study and it gives same performance in different section i.e. for channel, angle and beam sections.

7. From the study it is observed that use of number of braces with different section not lead to satisfactory results.

References

[1] Badoux M.Jirsa O (1990).Steel bracing of RC frames for seismic retrofitting. J. Struc. Engng. ASCE, No. 1,11655-74

[2] A Kadid, D.Yahiaoui "Seismic Assessment of Braced RC Frames".The Twelfth East Asia-Pacific Conference on Structural Engineering and Construction, Science Direct, engineering structure 14(2011) 2899-2905.

[3] Hendramawat A Safarizkia , S.A. Kristiawanb, and A. Basuki, "Evaluation of the Use of Steel Bracing to Improve Seismic Performance of Reinforced Concrete Building",The 2nd International Conference on Rehabilitation and Maintenance in Civil Engineering, Science Direct, Procedia Engineering 54 (2013) 447 – 456.

[4] Maheri MR, Kousari R, Razazan M. Pushover tests on steel X-braced and knee-braced RC frames. Eng Struct 2003;25(13):1697–705.

[5] S. C. Pednekar,H. S. Chore,S. B. Patil, "Pushover Analysis of Reinforced Concrete Structures" International Journal of Computer Applications (0975 – 8887),International Conference on Quality Up-gradation in Engineering, Science and Technology (ICQUEST2015).

[6] Mohammed Mubeen, Khalid Nayaz Khan, Mohammed Idrees Khan, "Seismic Analysis of Steel Frames with Eccentric Bracings using Pushover Analysis", International journal of Advanced technology in Engineering and Science, Vol 3, June 2015, Page No 232-237.

[7] Miss. Sayli S Kamble, Prof. Dr. D. N. Shinde, "Performance of RC Frame With and Without Bracing Pushover Analysis" International Journal for Research in Applied Science &Engineering Technology (IJRASET), Volume 4 Issue IX, September 2016 ISSN: 2321-9653.

[8] Abhijeet maske, Nikhil Maske, Preeti Shiras, October-2014, "Pushover Analysis of Reinforced concrete frame structures" "A Case study". International Journal of Advanced Technology in Engineering and Science.

[9] Dr. R. B. Khadiranaikar, Yallappa Hali, "Seismic Performance of RC Frame With Steel Bracings, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 3 Issue 8, August – 2014.

[10] Mohammed Idrees Khan, Mr.Khalid Nayaz Khan, "SEISMIC ANALYSIS OF STEEL FRAME WITH BRACINGS USING PUSHOVER ANALYSIS" International Journal of Advanced Technology in Engineering and Science Volume No.02, Issue No. 07, July 2014