International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 08 |Aug -2016 www.irjet.net p-ISSN: 2395-0072

Seismic Analysis of Steel Frames with Different Bracings using ETSBS Software.

Muhammed Tahir Khaleel[1], Dileep Kumar U[2]

[1]M.Tech Student, Dept of Civil Engg, SCEM, Karnataka, India
[2]Asst Professor, Dept of Civil Engg, SCEM, Karnataka, India

---***---

Abstract – *Lateral stability is important for the steel structures in the seismic zones. Effective way to increase the lateral strength is by means of bracing system. An attempt is made to analyze the effect of seismic force on Regular and Irregular Steel framed high rise building with different bracing system and also to find the best bracing system. The building is modeled and analyzed using ETABS and sections are selected based on their capability to control the maximum lateral storey displacements. The Zone V as per IS 1893-2002 is selected for the study. Analysis is carried out by Equivalent Static Method and Response Spectrum Method. Various parameters such as, displacement and base shear were studied. From the study it can be concluded that for both regular and irregular building, cross bracings are the best bracing system for reducing the storey displacement. It is also observed that base Shear is high in cross bracing system because of the increased stiffness.*

***Key Words*:** *Equivalent Static Analysis, Response Spectrum Analysis, Lateral displacement, Base Shear, Bracing System,.*

1. Introduction

The earthquake in Japan by name Kobe and in the USA by name Northridge were two clear illustrations where we came to know the important of lateral stability in structures constructed using steel. This problem has been a significant subject of consideration for investigators. Finally researchers gave an effective idea of using bracing systems like concentric, eccentric and knee bracing systems. The bracing system provides the structure more capacity to soak up energy while it is under seismic excitation. Steel Structures in tectonic prone zones are needed to be designed such that they resist considerable horizontal loads. The designs of structures require a good amount of balance between strength, stability, and energy Dissipation [1].

A number of structural steel systems (such as ordinary Concentric Braced Frames, Ordinary Moment Resisting Frames, and Eccentric Braced Frames) satisfy a part of these requirements. But none of the mentioned systems are intended to resist a major earthquake within the elastic limit of the materials and will require post-earthquake repairs [2].

Steel has become the predominate material for the construction of bridges, buildings, towers and other structures. Its great strength, uniformity, light weight and many other desirable properties makes it the material of choice for numerous structures such as steel bridges, high rise buildings, towers and other structures. Bracing element in structural system plays vital role in structural behaviour during earthquake [3]. Steel bracing is an effective and economical solution for resisting lateral forces in a framed structure.

In the present study, response of the steel braced frame under Equivalent Static analysis and response spectrum analysis were performed using computer software ETABS 2015.

2.1 Structural Modeling

For the purpose of this study, nine models of high rise steel frame building (G+9) with different types of bracings both regular and irregular models, were selected in order to determine the behavior of structural steel during seismic activity in seismic. The columns are fixed at the ground and are taken as restrains. The building height is 30m with storey height 3m in base as well as typical structure respectively. The length of the building in X-direction is taken as 35m and in Y-direction is taken as 25m. Figure 1 and 2 shows the geometrical configuration of the building. The model was prepared for bare frame and with different bracing systems. Table 1 gives the material properties of the members. The material properties are selected on the basis of displacement limitation and strength as per IS 800-2007.

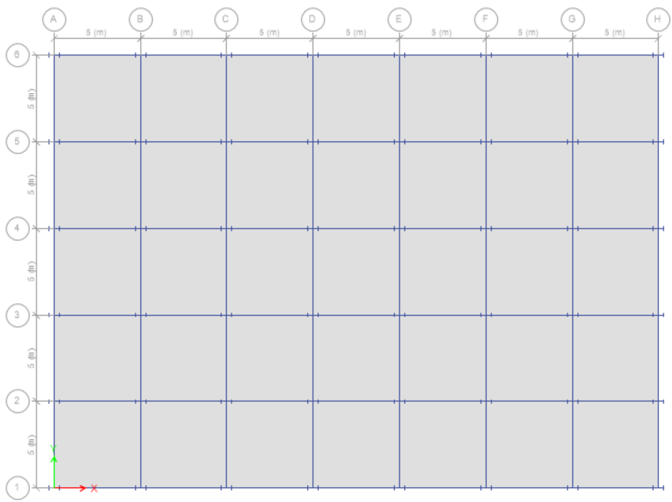

Figure 1: Plan of regular High Rise Steel Frame

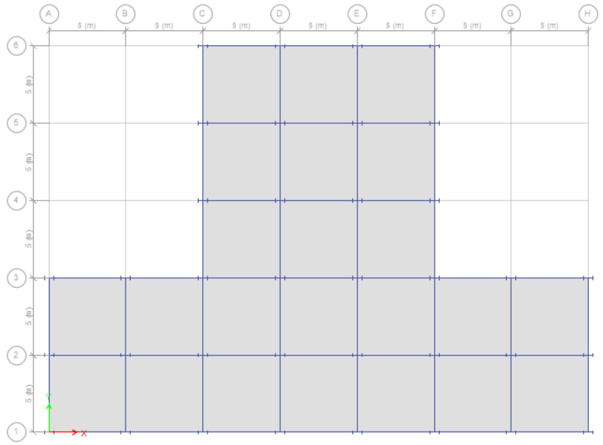

Figure 2: Plan of regular High Rise Steel Frame

Table 1: Material and Geometrical Properties

Serial No	Material Properties	
1	Column Details	ISMB 600
2	Beam Details	ISMB 450
3	Bracing Details	ISMB 250
4	Thickness of Slab	100mm
5	Grade of Steel	Fe 250
6	Distance in X-Direction (Length)	35m
7	Distance in Y-Direction (Width)	25m
8	Distance in Z-Direction (Height)	30m
9	Eccentricity (X&Y direction)	1.25m
10	Eccentricity (Z direction)	0.75m
11	Floor to Floor Height	3m
12	Spacing of Beams	5m

The building is analyzed for the earthquake forces with different vertical bracing system. Both eccentric and concentric bracing systems are selected for symmetric and unsymmetrical building. Table 2 gives the details of different of models modeled with different bracing system. The building is subjected to following Loads as per IS 875 (part 1 and 2)-1987:

- Floor Finish: 1.0 KN/m^2
- Live Load: 4.0 KN/m^2
- Live Load on Roof: 2.0 KN/m^2

Table 2: Details of model with different bracing system

Sl. No.	Regular Building	Irregular Building
1	Regular bare frame	Irregular bare frame
2	Chevron bracing	Chevron bracing
3	Cross bracing	Cross bracing
4	Diagonal bracing	Diagonal bracing
5	Eccentric bracing	Eccentric bracing
6	Eccentric Chevron bracing	Eccentric Chevron bracing
7	K bracing	K bracing
8	Knee bracing	Knee bracing
9	V bracing	V bracing

2.2 Method of analysis

2.2.1 Equivalent Static Analysis

The equivalent static method accounts for the dynamics of the structure in a fairly accurate approach. This method is as per IS 1890-2002.In this analysis the total design base shear (V_B) is determined by, $\mathbf{V_B = A_h \times W}$

Therefore, $\mathbf{A_h = (Z/2) \times (I/R) \times (S_a/g)}$

Where, A_h = Design acceleration spectrum value, using the approximate fundamental natural time period 'T_a'.

W = Seismic weight of the building.

The following assumptions are involved in the Equivalent static procedure,

1. The fundamental mode of the building makes the most significant contribution to the base shear.
2. The total building mass is considered as against the modal mass that would be used in dynamic procedure.

After the base shear force V_B is determined, it should be distributed along the height of the building (to the various floor levels), using following expression,

$$Q_i = V_B \frac{W_i \times h_i^2}{\sum_{j=1}^{n} W_j \times h_j^2}$$

Where, Q_i = Design lateral force at floor *i*.

W_i = Seismic weight at floor *i*.

h_i = Height of floor measured from the base.

n = Number of storey in building.

2.2.2 Response Spectrum Method

This is the most widely used method in seismic analysis. In this method, a multi-storey structure is idealized as multi storey shear building by assuming the mass is lumped at the floor and roof diaphragm levels, that the diaphragms are infinitely rigid and the columns are axially in extensible but laterally flexible. The dynamic response of the system is represented by the lateral displacements of the lumped masses with the number of degrees of dynamic freedom or modes of vibration '*n*' being equal to the number of masses.

This concept provides a conceptual basis for using response spectra based on single mass system for analyzing multi storey buildings. Given the period, mode shape and mass distribution of a multi-storey building, we can use response spectra of a single degree of freedom system for computing the deflected shape, storey accelerations, forces and moments.

The combination method include,

- Absolute - peak values are added together.
- SRSS method.
- CQC method.

Table 3 gives the earthquake parameter where considered in the in the analysis. The zone V is the most vulnerable zone to earthquake damages and the type of the building is Hospital which is a public building.

Table -3: Earthquake Parameter

Serial No	Model Description	
1	Zone	V
2	Zone Factor	0.36
3	Type of building	Hospital
4	Response Reduction Factor	3
5	Importance Factor	1.5
6	Building Height	30m
7	Soil Condition	Medium
8	Damping Ratio	5%

3.0 Results

Seismic analysis of 3D steel framed both regular and irregular building is carried out for the analysis. The buildings, regular as well as irregular are analyzed with bare frame and by providing different types of bracings. The results are tabulated such as, Maximum storey displacement and storey shear is noted

3.1 Base Shear

Table 4 - Base Shear for Regular Building in Zone V by Static Analysis

Serial No	Type of Bracing	Base Shear, V(KN)	
		Without Bracing	With Bracing
1	Chevron Bracing	6113	6188
2	Cross Bracing	6113	6224
3	Diagonal Bracing	6113	6168
4	Eccentric Bracing	6113	6159
5	Eccentric Chevron Bracing	6113	6181
6	K- type Bracing	6113	6169
7	Knee Bracing	6113	6145
8	V-type Bracing	6113	6188

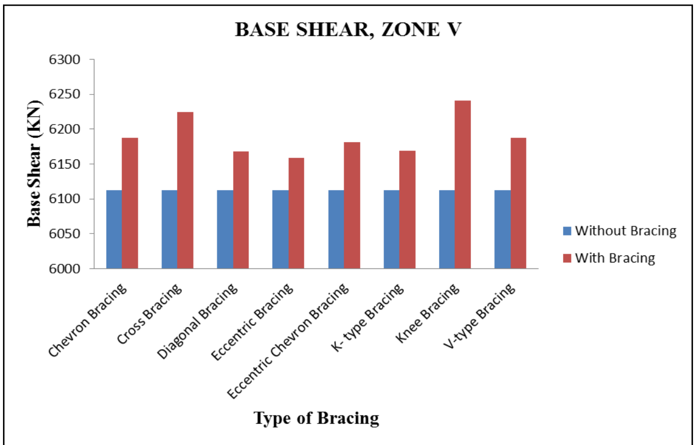

Figure 3: Variation of Base Shear for regular building with Different Bracings in Zone V by Static Analysis

It is observed that the Knee Bracings have more Base Shear compared to other bracings in Zone V by static analysis for regular building. Using Response Spectrum Method, the results observed from table 5, the Cross Bracings gives more Base Shear compared to other bracings in Zone V.

Table 5 - Base Shear for Regular Building in Zone V by Dynamic Analysis

Serial No	Type of Bracing	Base Shear, V(KN)	
		Without Bracing	With Bracing
1	Chevron Bracing	1773.50	4139.19
2	Cross Bracing	1773.50	4182.49
3	Diagonal Bracing	1773.50	3483.32
4	Eccentric Bracing	1773.50	3115.12
5	Eccentric Chevron Bracing	1773.50	2986.72
6	K- type Bracing	1773.50	3484.95
7	Knee Bracing	1773.50	3906.52
8	V-type Bracing	1773.50	4089.82

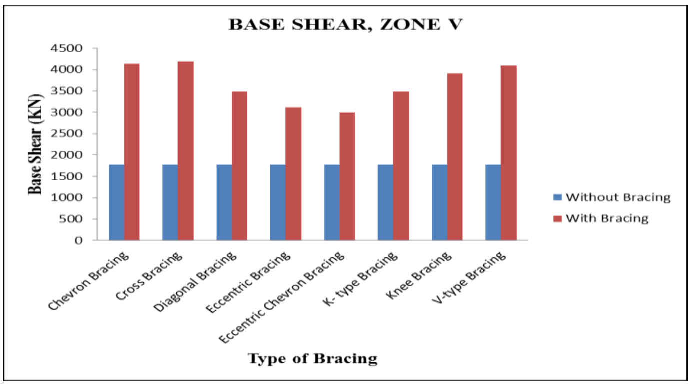

Figure 4: Variation of Base Shear for regular building with Different Bracings in Zone V by Dynamic Analysis

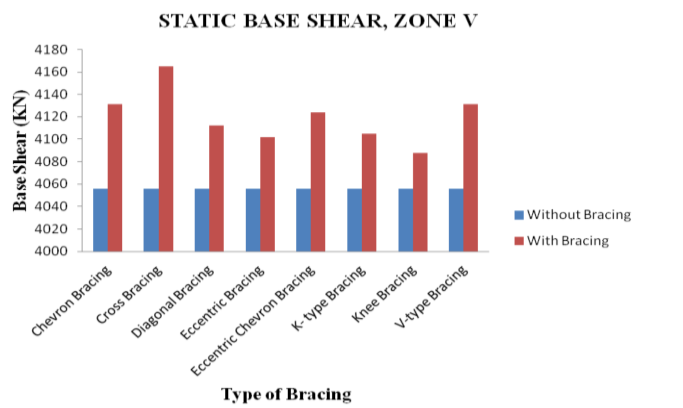

Figure 5: Variation of Base Shear for irregular building with Different Bracings in Zone V by Static Analysis

Table 6 - Base Shear for Irregular Building in Zone V by Static Analysis

Serial No	Type of Bracing	Base Shear, V(KN)	
		Without Bracing	With Bracing
1	Chevron Bracing	4056	4131
2	Cross Bracing	4056	4165
3	Diagonal Bracing	4056	4112
4	Eccentric Bracing	4056	4102
5	Eccentric Chevron Bracing	4056	4124
6	K- type Bracing	4056	4105
7	Knee Bracing	4056	4088
8	V-type Bracing	4056	4131

It is observed that the results obtained for irregular building using Equivalent Static Method, from table 6 and fig 5in Zone V Cross Bracing have more Base Shear and Knee Bracing has the least.

Table 7 - Base Shear for Irregular Building in Zone V by Dynamic Analysis

Serial No	Type of Bracing	Base Shear, V(KN)	
		Without Bracing	With Bracing
1	Chevron Bracing	1231.206	2660.09
2	Cross Bracing	1231.206	2692.77
3	Diagonal Bracing	1231.206	2527.60
4	Eccentric Bracing	1231.206	2224.20
5	Eccentric Chevron Bracing	1231.206	2229.40
6	K- type Bracing	1231.206	1713.69
7	Knee Bracing	1231.206	2668.83
8	V-type Bracing	1231.206	2679.45

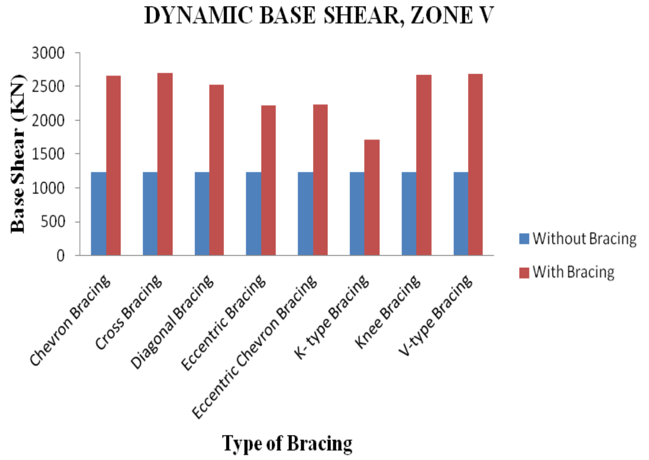

Figure 6: Variation of Base Shear for irregular building for Different Bracings in Zone V

From the table 7 and fig 6 it can be observed that, using Dynamic Method in Zone V the Cross Bracing has the highest amount of Base Shear followed by V-type Bracing.

3.2 Displacement

The top storey displacement is calculated in both regular and irregular building in the x direction by static and dynamic analysis

Table 8 -Displacement (mm) In X-Direction by static analysis for regular building.

Displacement (mm) In X – Direction			
Type of Bracing	Without Bracing	With Bracing	% Difference
Chevron Bracing	86.60	16.20	81.28
Cross Bracing	86.60	14.60	83.13
Diagonal Bracing	86.60	24.43	71.79
Eccentric Bracing	86.60	29.43	65.99
Eccentric Chevron	86.60	31.20	63.97
K type Bracing	86.60	24.12	72.14
Knee Bracing	86.60	19.27	77.75
V type Bracing	86.60	16.82	80.56

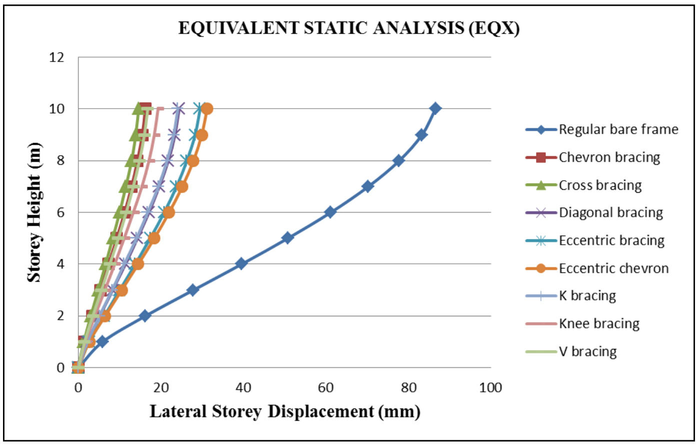

Figure 7: Displacement (mm) in X-Direction for regular building by static analysis

It can be observed by equivalent static method, among all the bracings considered cross bracing gives the least deflection and eccentric Chevron Bracing has the highest deflection for regular building.

Table 9 -Displacement (mm) In X-Direction by dynamic analysis for regular building.

Displacement (mm) In X – Direction			
Type of Bracing	Without Bracing	With Bracing	% Difference
Chevron Bracing	72.12	13.76	80.911
Cross Bracing	72.12	12.40	82.79
Diagonal Bracing	72.12	21.01	70.86
Eccentric Bracing	72.12	25.27	64.96
Eccentric Chevron	72.12	26.33	63.49
K type Bracing	72.12	20.47	71.61
Knee Bracing	72.12	16.36	77.31
V type Bracing	72.12	14.30	80.17

From the Table 9 and Fig 8 cross bracings here gives the least displacement and the displacement is reduced by 82.8% and chevron bracing gives the largest displacement

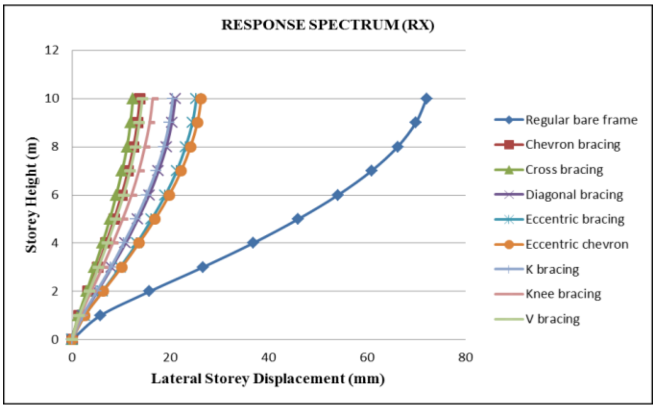

Figure 8: Displacement (mm) in X-Direction for regular building by dynamic analysis

Table 10-Displacement in X-Direction by Equivalent Static Method for irregular building in Zone V:

Displacement (mm) In X - Direction			
Type of Bracing	Without Bracing	With Bracing	% Difference
Chevron Bracing	83.86	14.40	82.82
Cross Bracing	83.86	13.68	83.67
Diagonal Bracing	83.86	20.50	75.54
Eccentric Bracing	83.86	25.55	69.52
Eccentric Chevron	83.86	26.70	68.15
K type Bracing	83.86	34.96	58.31
Knee Bracing	83.86	17.43	79.20
V type Bracing	83.86	15.25	81.80

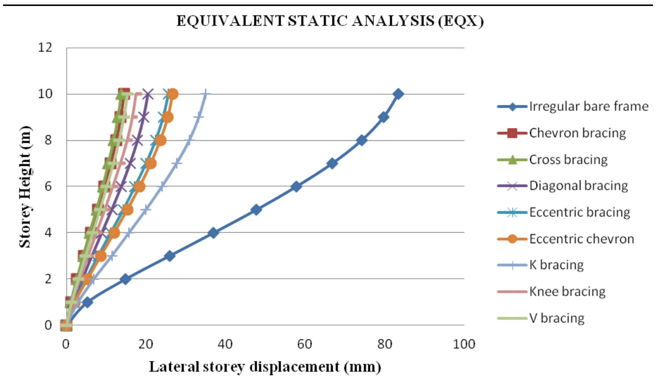

Figure 9: Storey Displacement (mm) in X-Direction for irregular building in Zone V by static anlaysis

From the table 10 using Equivalent Static Method it is observed that, the structure without bracing deflects by an amount of 83.862mm which is within the permissible limits in X-direction. Among all the bracings considered cross bracing gives the least deflection of 13.68mm compared to regular bare frame. K type bracing has the highest deflection of 34.960mm.

Table 11-Displacement (RX) in X-Direction by Response Spectrum for Irregular building:

Displacement (mm) In X - Direction			
Type of Bracing	**Without Bracing**	**With Bracing**	**% Difference**
Chevron Bracing	68.00	13.75	73.89
Cross Bracing	68.00	12.92	80.99
Diagonal Bracing	68.00	19.20	71.75
Eccentric Bracing	68.00	25.97	61.80
Eccentric Chevron	68.00	26.33	61.26
K type Bracing	68.00	39.53	41.86
Knee Bracing	68.00	17.12	74.81
V type Bracing	68.00	14.39	78.83

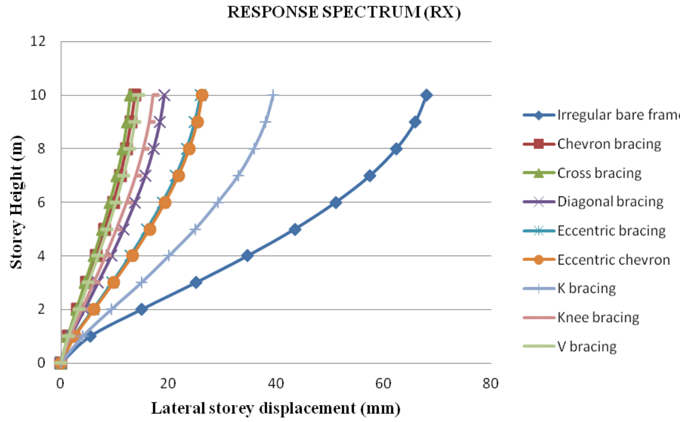

Figure 10: Storey Displacement (mm) in X-Direction for Irregular building.

Using Response Spectrum Method it is observed that, the structure without bracing deflects by an amount of 68.00mm which is within the permissible limits in X-direction. Among all the bracings considered cross bracing gives the least deflection of 12.92 mm as compared to regular bare frame. K type bracing has the highest deflection of 39.53mm.

From this study it can be seen that, cross bracings undergo less lateral displacement than any other bracing system, by using Equivalent Static Method and Response Spectrum Method. It is also observed that, Steel framed buildings with different bracing systems have more base shear than the buildings without any bracings. Among all the bracing system cross bracing give more base shear by static and dynamic analysis.

4. CONCLUSIONS

From the above result it van be concluded that:

- The bracing in the building reduces the storey displacement in both regular and irregular building as compared to the building without bracings for lateral loads.
- For regular and irregular building, Cross bracings gives less storey displacement
- Cross bracings has more base shear and Knee bracing has the least amount of base shear.
- Use of bracing system increases the stiffness of the structure and attracts more lateral force.

As the density of steel is very high when compared to concrete, by using the bracings throughout the periphery of the structure is very uneconomical, hence the bracing has to be used in combination with other earthquake resisting system such as using Base isolators and Dampers.

REFERENCES

[1] **Jagadish J.S, Tejas D Doshi**, “A Study on Bracing Systems on High Rise Steel Structures”, International Journal of Engineering Research and Technology, Vol 2, Issue 7, July 2013, Page No 1672-1676.

[2] **Anitha M, Divya K.K**, “Study on Seismic Behaviour of Knee Braced Steel Frames”, International research journal of Engineering and technology, Volume 2, September 2015, Page No 40-45.

[3] **Krishnaraj R Chavan, H.S Jadhav,** “Seismic response of RC building with different arrangement of steel bracing system”, International journal of engineering research and applications”, Volume 4, July 2014, Page No 218-222.

[4] **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.

[5] **Arjun Mudkondwar, Dr. A.V. Patil** “Performance Analysis and behaviour of steel framed building with reference to variation in bracing type”, International journal of modern trends in engineering and research, Volume 2, April 2015, Page No 153-158.