Seismic Analysis and Design of R.C. Structure with Bracing System

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Abstract - *Bracing component in basic framework plays imperative part in auxiliary behavior amid seismic action. In this study the seismic impact of distinctive sorts of steel bracings was examined. A comparison of knee braced steel outline with other sorts of bracings had been done. Execution of each outline had been considered utilizing non-linear static analysis investigation and nonlinear time history analysis investigation. Different parameters such as displacement and stiffness were considered. Advance optimization think about was carried out to choose the appropriate sort of the bracing design by keeping the inter-story float, add up to horizontal relocation and stretch level inside passable restrain. Point of consider was to compare comes about of seismic examination of tall rise steel building with distinctive design of bracing framework and without bracing system. In the current study the institutional building is considered with X, V, Inverted V bracing and analyzed for response spectrum. The comparison of story displacements, story drifts, story stiffness and story shear is made for the more economic and efficient section.*

Key Words: **Seismic loads, Bracings, Response Spectrum, Story displacements, story drifts, story shears.**

1.INTRODUCTION

Steel has ended up the prevail fabric for the development of bridges, buildings, towers and other structures. Its extraordinary quality, consistency, light weight and numerous other alluring properties makes it the fabric of choice for various structures such as steel bridges, tall rise buildings, towers and other structures. Bracing component in basic framework plays imperative part in auxiliary behavior amid seismic tremor. Steel bracing is a compelling and conservative arrangement for standing up to horizontal strengths in a surrounded structure. Bracings are of diverse sorts, to be specific concentric bracings, offbeat bracings and knee bracings. In concentric bracings, inelastic vitality scattering reaction is by and large destitute due to the conceivable buckling of the corner to corner components in compression. In unpredictable bracings since it assimilates expansive seismic constrain, repair and substitution after a serious seismic tremor is costly and time devouring. As a cure for these entire impediments knee braced outline created.

1.1 Response Spectrum Analysis

This approach permits the multiple modes of response of a building to be taken into account (in the frequency domain). This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonics". Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of in all directions i.e. X, Y & Z and then see the effects on the building. Combination methods include the following:

1. Absolute - peak values are added together
2. Square root of the sum of the squares (SRSS)
3. Complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes.

The result of a response spectrum analysis using the response spectrum from a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, since phase information is lost in the process of generating the response spectrum.

In cases where structures are either too irregular, too tall or of significance to a community in disaster response, the response spectrum approach is no longer appropriate, and more complex analysis is often required, such as non-linear static analysis or dynamic analysis.

1.2 Load distribution

Since bracing interfaces beams, it can be utilized to disseminate the vertical twisting impacts between the fundamental beams, and to guarantee that lateral impacts such as wind loading and collision loading are shared between all the beams. This sharing is especially critical at lines of back, where the impacts of the horizontal loads are regularly stood up to at one settled or guided bearing (depending on the chosen articulation system).

In steel composite bridges amid the "steel only" condition amid development, the primary pillars are especially helpless to wind loading. Bracing can be utilized to share loading between the pillars so that the windward pillar is not carrying the whole wind load. In bridges bended in arrange, bracing can give the 'radial' component of constrain that is result of the changing heading of the bended flange. The compelling couple of the powers at pressure and compression ribs is stood up to by extra vertical twisting impacts in the associated beams.

2. OBJECTIVES OF THE STUDY

1. To know about the seismic impact on the steel bracing frames.
2. Comparative study on structure with X, V and inverted V bracing.
3. To study the mode shapes and response of composite and steel Structure subjected to seismic loads by Response spectrum analysis.
4. To compare seismic execution of knee braced steel outline with diverse sorts of bracings and finding which is the productive one for the seismic response.
5. To observe the structural performance of different building models through response spectrum analysis.
6. To discover the story displacement and comparing the percentile displacement with distinctive sorts of bracings (X, V, inverted V).

3. METHODOLOGY

In the present study, the comparison between three forms of bracings (X, V, INVERTED-V) to a G+10 RCC building and Seismic analysis and design is carried out.

1. Model 1: G+10 RCC building with X Bracing system.
2. Model 2: G+10 RCC building with V Bracing system.
3. Model 3: G+10 RCC building with Inverted V Bracing system.

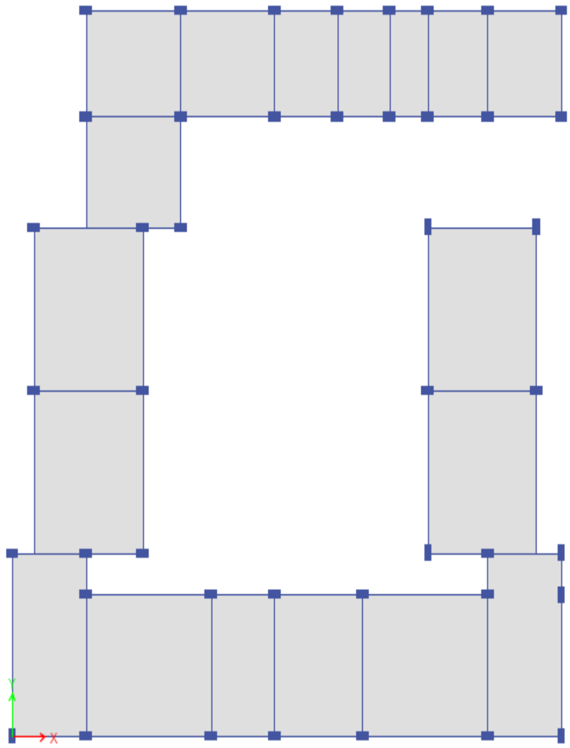

Fig -1: Typical plan for the analysis.

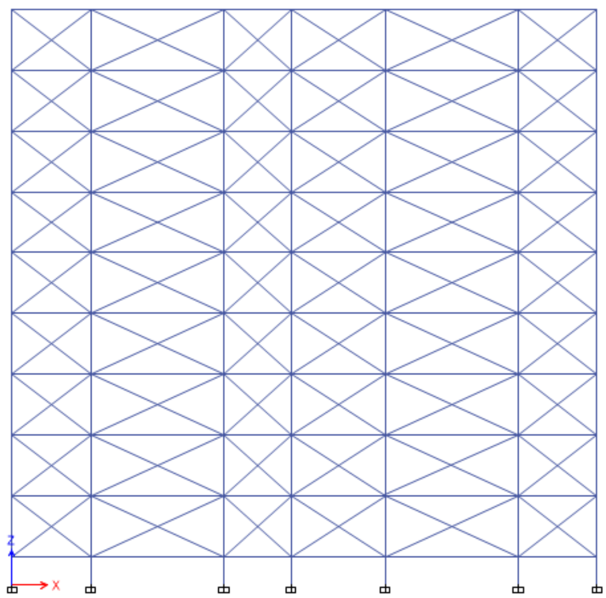

Fig -2: Elevation for the X Bracing model

The beam sections considered for the analysis of the current project are 300mm x 500mm and 350mm x 700mm. Column sections considered are 400mm x 700mm and 400mm x 800mm. ISMB-300 are the bracing sections considered. Grade of concrete of M30 and Fe500 grade steel is considered.

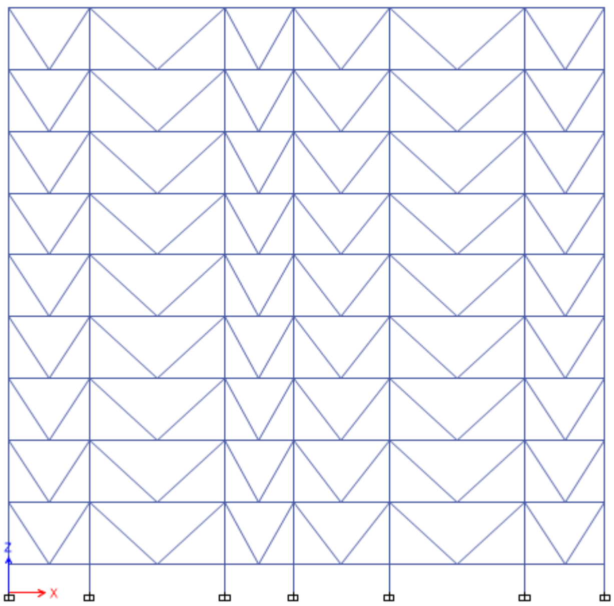

Fig -3: Elevation for the V Bracing model.

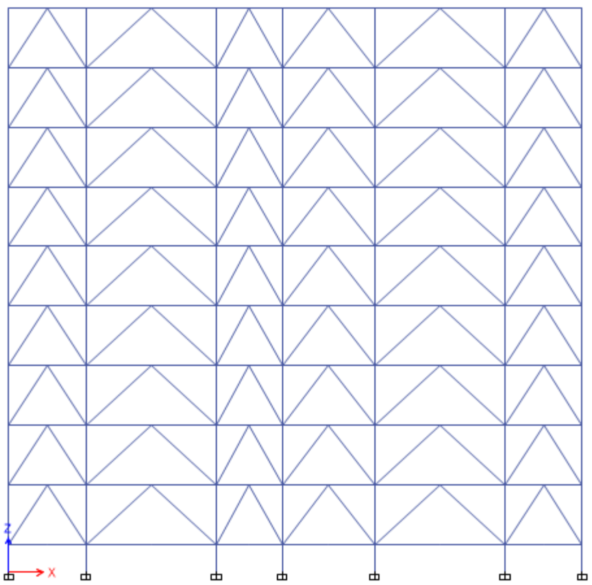

Fig -3: Elevation for the Inverted V Bracing model

3.1 Loadings

The Dead load considered is 3.75 kN/m² as per IS-875 part 1. The live loads considered as per IS-875 part 2. (Table-1). The seismic loads considered were as per IS-1893:2002. Building is considered in the location of Bangalore and is considered that no surrounding obstruction is above 1.5m.

Table -1: Live Loads considered (as per IS-875-part 2).

Occupancy Classification	UDL	Point Load
Class rooms and lecture rooms(not used for assembly purpose)	3.0	2.7
Dining rooms, cafeterias and restaurants	3.0	2.7
Offices, lounges and staff rooms	2.5	2.7
Dormitories	2.0	2.7
Projection rooms	5.0	-
Kitchens	3.0	4.5
Toilets and bathrooms	2.0	-
Store rooms	5.0	4.5
Libraries and archives: 1)Stock room/stack area 2) Reading rooms (without separate storage) 3)Reading rooms(with separate storage) (*6.0 kN/m for a minimum height of 2'2 m + 2'0kN/m* per meter height beyond 2.2m.)	6.0* 4.0 3.0	4.5 4.5 4.0
Boiler rooms and plant rooms – to be calculated	4.0	4.5

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Corridors, passages, lobbies, staircases including fire escapes-as per the floor serviced (without accounting for storage and projection rooms)	4.0	4.5
Balconies	Same as rooms to which they give access but with a minimum of 4.0	

3.2 Load Combinations

From IS 1893(Part 1) 2002 Clause 6.3.1.2

1. 1.5(DL+LL)
2. 1.2(DL+LL+EL)
3. 1.5(DL+EL)
4. 0.9DL* 1.5EL

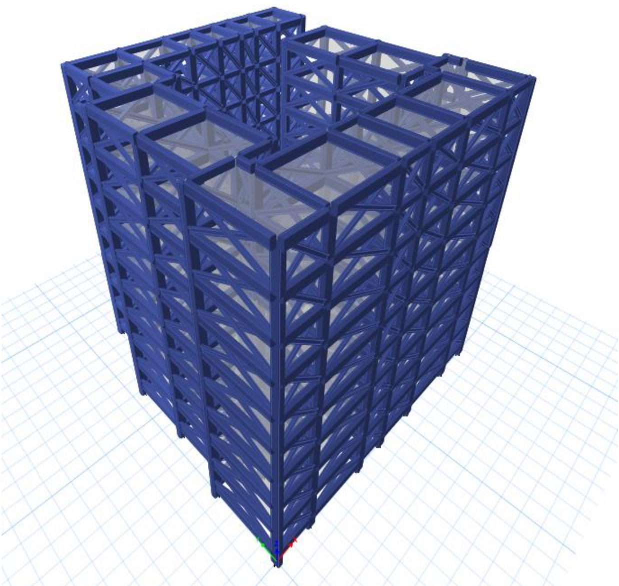

Fig -4: ETABS 3D model of X Bracing model

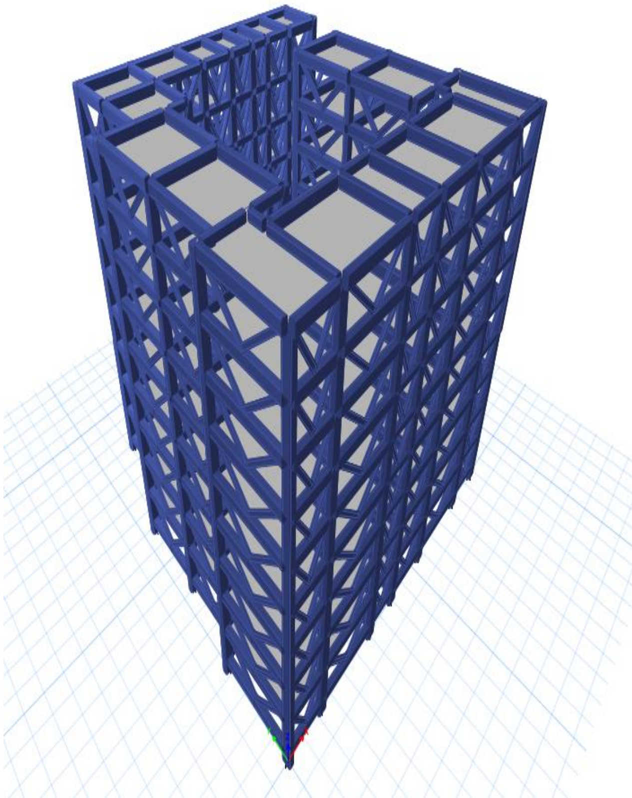

Fig -5: ETABS 3D model of V Bracing model

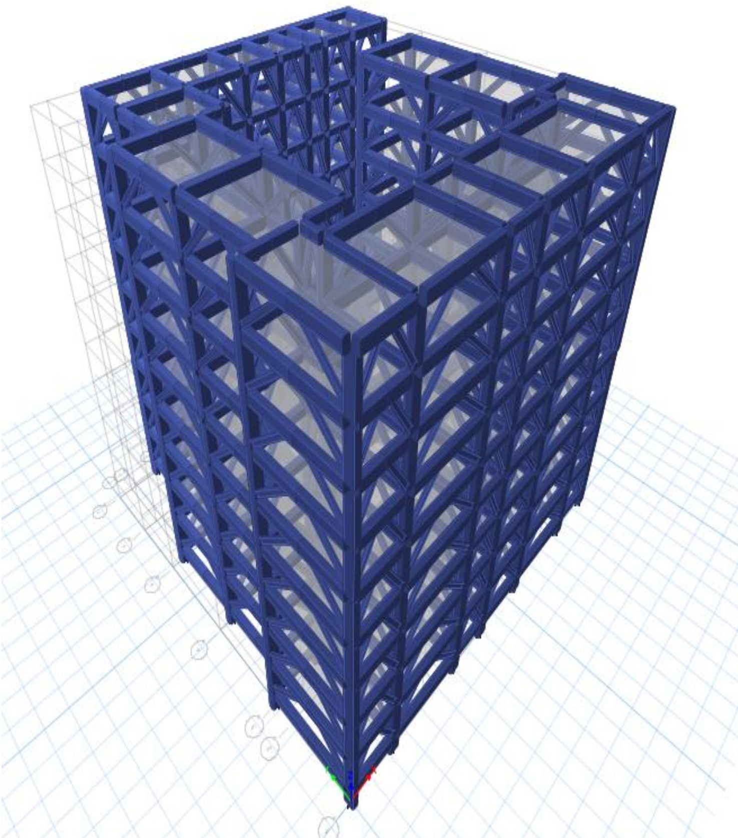

Fig -6: ETABS 3D model of Inverted V Bracing model

3.3 Analysis of the model

The building is analyzed in the ETABS, the 3D structural analysis and FEM software. The results of story displacements, story drifts, story shears, story stiffness and story forces is extracted.

A. Story displacements

Table -2: Story displacements of X- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m	mm	mm
Story 10	30.3	19.683	51.946
Story 9	27.1	18.764	49.264
Story 8	23.9	17.479	45.617
Story 7	20.7	15.835	41.057
Story 6	17.5	13.874	35.708
Story 5	14.3	11.653	29.724
Story 4	11.1	9.23	23.26
Story 3	7.9	6.708	16.621
Story 2	4.7	4.112	9.845
Story 1	1.5	1.906	3.968
Base	0	0	0

Table -3: Story displacements of V- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m	mm	mm
Story10	30.3	25.169	49.476
Story9	27.1	19.276	47.064
Story8	23.9	17.986	43.701
Story7	20.7	16.312	39.424
Story6	17.5	14.301	34.357
Story5	14.3	12.01	28.65
Story4	11.1	9.507	22.471
Story3	7.9	6.87	16.016
Story2	4.7	4.189	9.502
Story1	1.5	1.994	3.66
Base	0	0	0

Table -3: Story displacements of Inverted V- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m	mm	mm
Story10	30.3	39.418	53.556
Story9	27.1	37.408	49.852
Story8	23.9	34.66	45.347
Story7	20.7	31.212	40.117
Story6	17.5	27.157	34.301
Story5	14.3	22.613	28.083
Story4	11.1	17.709	21.646
Story3	7.9	12.674	15.266
Story2	4.7	7.608	9.384
Story1	1.5	2.666	4.93
Base	0	0	0

B. Story drifts

Table -5: Story drifts of X- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m	mm	mm
Story 10	30.3	0.002961	0.001178
Story 9	27.1	0.002948	0.001434
Story 8	23.9	0.002883	0.001663
Story 7	20.7	0.002759	0.001843
Story 6	17.5	0.002577	0.001964
Story 5	14.3	0.002343	0.002025
Story 4	11.1	0.002046	0.002001
Story 3	7.9	0.001728	0.001918
Story 2	4.7	0.001664	0.002096
Story 1	1.5	0.001777	0.003067
Base	0	0	0

Table -6: Story drifts of V- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m		
Story10	30.3	0.000302	0.00171

Story9	27.1	0.000417	0.001903
Story8	23.9	0.000529	0.002064
Story7	20.7	0.000626	0.002174
Story6	17.5	0.000704	0.002228
Story5	14.3	0.000763	0.002228
Story4	11.1	0.000791	0.002141
Story3	7.9	0.000812	0.00212
Story2	4.7	0.000899	0.002268
Story1	1.5	0.001115	0.00204
Base	0	0	0

Table -7: Story drifts of Inverted V- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m		
Story10	30.3	0.001276	0.000835
Story9	27.1	0.001279	0.001078
Story8	23.9	0.001257	0.001367
Story7	20.7	0.001206	0.00161
Story6	17.5	0.001155	0.001804
Story5	14.3	0.001081	0.001944
Story4	11.1	0.000981	0.002024
Story3	7.9	0.000892	0.002038
Story2	4.7	0.000941	0.002025
Story1	1.5	0.001191	0.002122
Story0	0	0	0

C. Story shears

Table -8: Story shears of X- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story10	30.3	4120.19	5283.92
Story9	27.1	8454.09	10798.5
Story8	23.9	12277.64	15602.01
Story7	20.7	15594.31	19731.46
Story6	17.5	18427.41	23241.06
Story5	14.3	20801.81	26179.97
Story4	11.1	22736.29	28589.81
Story3	7.9	24206.46	30454.18
Story2	4.7	25135.54	31696.18
Story1	1.5	25283.27	31948.45
Base	0	0	0

Table -9: Story shears of V- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story10	30.3	932.95	5160.18
Story9	27.1	1933.64	10555.56
Story8	23.9	2838.31	15324.47
Story7	20.7	3637.32	19468.96
Story6	17.5	4328.52	23026.36
Story5	14.3	4912.02	26011.94
Story4	11.1	5390.33	28441.08
Story3	7.9	5757.22	30288.41
Story2	4.7	5995.68	31435.85
Story1	1.5	6040.37	31600.01
Base	0	0	0

Table -10: Story shears of Inverted V- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story10	30.3	4258.62	4729.95
Story9	27.1	8868.22	9838.75
Story8	23.9	13122.49	14525.29
Story7	20.7	16933.89	18705.57
Story6	17.5	20228.01	22310.11
Story5	14.3	22947.42	25289.96
Story4	11.1	25073.98	27642.79
Story3	7.9	26590.04	29355.57
Story2	4.7	27467.42	30412.05

Story1	1.5	27591.67	30611.53
Base	0	0	0

D. Story stiffness

Table -11: Story stiffness of X- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story10	30.3	2315395.88	1660198.99
Story9	27.1	3625725.64	2701847.18
Story8	23.9	4327905.85	3297052.21
Story7	20.7	4785791.17	3706385.4
Story6	17.5	5147435.38	4056533.92
Story5	14.3	5471709.28	4400572.76
Story4	11.1	5900870.51	4825627.65
Story3	7.9	6256352.61	5328630.69
Story2	4.7	6477313.65	5749135.78
Story1	1.5	13949495.4	9092323.05
Base	0	0	0

Table -12: Story stiffness of V- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story10	30.3	1300968.5	2271404.1
Story9	27.1	1997138.4	3483466.2
Story8	23.9	2345141.1	4105969.9
Story7	20.7	2564030.4	4510489.8
Story6	17.5	2730822	4824264.5
Story5	14.3	2870611.2	5095556.6
Story4	11.1	3050469.9	5477644.2
Story3	7.9	3190165	5754108.1
Story2	4.7	3030510.8	5886987
Story1	1.5	5428155.4	14990255
Base	0	0	0

Table -13: Story stiffness of Inverted V- Bracing model.

Story	Elevation	X-Dir	Y-Dir
	m	kN/m	kN/m
Story10	30.3	119712.84	72395.34
Story9	27.1	250107.98	151824.94
Story8	23.9	379014.59	231479.99
Story7	20.7	516816.51	317096.42
Story6	17.5	681005.33	414948.65
Story5	14.3	906931.17	534874.24
Story4	11.1	1227126.2	694721.69
Story3	7.9	1734887.8	960745.02
Story2	4.7	3096261.2	1724016.9
Story1	1.5	14485567.8	8566246.1
Base	0	0	0

4. COMPARISON OF RESULTS

For the comparison, the least dimension of the building is considered. The following is the comparison of the various bracings considered.

Table -14: Comparison of various bracings for story displacements.

Bracing type	Story displacements
X Bracing	19.683
V Bracing	25.169
Inverted V Bracing	39.418

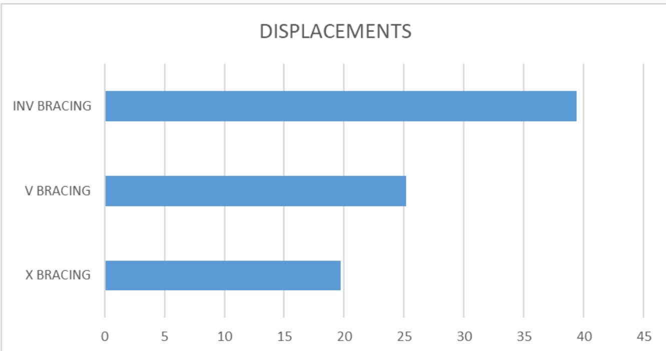

Fig-7: Comparison of various bracings for story displacements.

Table -15: Comparison of various bracings for story drifts.

Bracing types	Story drifts
X Bracing	0.002961
V Bracing	0.00171
Inverted V Bracing	0.001276

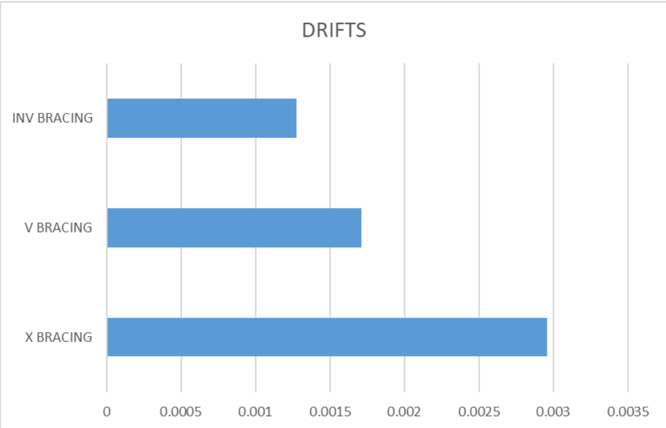

Fig-8: Comparison of various bracings for story drifts.

Table -16: Comparison of various bracings for story stiffness.

Bracing type	Story stiffness
X Bracing	2315395.881
V Bracing	2271404.068
Inverted V Bracing	119712.839

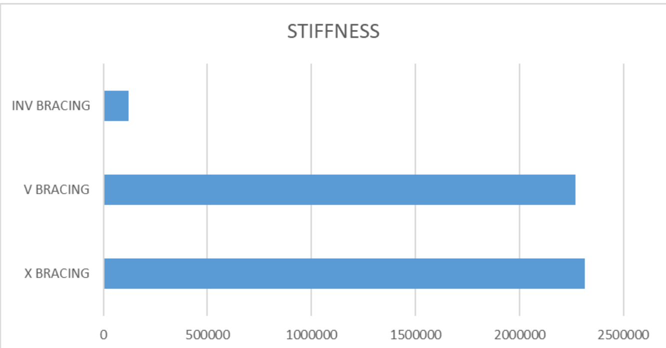

Fig-9: Comparison of various bracings for story stiffness.

5. CONCLUSIONS

1. Dynamic Seismic behavior of Structure with bracing systems are better compared to Non-Braced Structure.
2. Structures with X-Bracing systems exhibits more lateral resistance followed by Inverted V and V bracing systems.
3. The lateral displacements, from the structures compared, the structure bearing X bracing showed the least intensity of the lateral displacements. The structure bearing the V Bracing bearing the intermediate lateral displacements and the structure bearing the Inverted V Bracing shows the maximum intensity of the lateral displacements.
4. The lateral drifts of the structure having X-Bracing in structure was more than the drifts in the V-Bracing building and the Inverted V braced building.
5. The higher magnitude of stiffness was exhibited by the structure having X- Bracing and V-Bracing. Since there is no much difference in the magnitude of the stiffness. The Inverted V-Bracing building model has the least stiffness as compared to the X-Bracing building model and V- Braced building model.
6. The X bracing & V bracing systems shows similar results of story displacements and story stiffness. Also it has concluded that the Inverted V bracing shows the least story displacements, story drifts, story shear and story stiffness.

7. The deflection of the beam for the X bracing has the least value of deflection i.e., 0.804mm followed by the deflection of beam in Inverted V bracing having the deflection of 0.870mm and the beam of V braced building having the deflection of 1.056mm.

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