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Evaluating Seismic Efficiency of Combination of Bracing for Steel Building

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Abstract: Steel structures played an important role in the construction industry.It providing strength, stability, and ductility. A study regarding the seismic response of steel structures is necessary. In the present study, modeling of the steel braced structures with a different combination of bracing and analyses structure using commercially available SAP2000 software. A bracing element in the structural system plays a vital role in structural behavior during an earthquake. In this study there are four types of braces are used. Such as X bracing, V bracing, inverted V bracing, and knee bracing. The combinations from these bracing are X and V type bracing, X and inverted V type bracing, X and Knee type bracing, V and inverted V type bracing, V and Knee type bracing, Knee and inverted V type bracing. Response spectrum method is used for seismic analysis. Comparison between the seismic parameters such as base shear, roof displacement, storey drift, for steel frame with different combination of bracing are studied

Keywords: Steel Frame, SAP2000, Steel Bracing, Base Shear, Roof Displacement, Storey Drift.

I. INTRODUCTION

The primary purpose of all kinds of structural systems used in the building type of structures is to transfer gravity loads effectively. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces. Strengthening of structures proves to be a better option catering to the economic considerations and immediate shelter problems rather than replacement of buildings. Moreover, it has been often seen that retrofitting of buildings is generally more economical as compared to demolition and reconstruction. Therefore, seismic retrofitting or strengthening of building structures is one of the most important aspects for mitigating seismic hazards especially in earthquake prone areas. A bracing element in the structural system plays a vital role in structural behavior during an earthquake. Steel bracing is an effective and economical solution for resisting lateral forces in a framed structure. There are two types of bracing systems, Concentric Bracing System and Eccentric Bracing System. The Bracing is concentric when the center lines of the bracing members intersect. Concentric bracings increase the lateral stiffness of the frame, thus increasing the natural frequency and also usually decreasing the lateral drift. In an eccentrically braced frame, bracing members connect to separate points on the beam/girder. Different type of bracing patterns such as X, V type, Inverted V type and Knee bracing are considered in this work. Steel bracing structure system of building subjected to seismic or lateral loading. Shaji L. and Lakshmi S. [1] analyzed the steel braced structures with a different combination of the bracing structure using commercially available software STAAD pro v8i. A bracing element in the structural system plays a vital role in structural during an earthquake. The combinations from these bracing were X and V type bracing, X and inverted V type bracing, X and Knee type bracing, V and inverted V type bracing, V and Knee type bracing, Knee and inverted V type bracing. Response spectrum method was used for seismic analysis. Comparison between the seismic parameters such as base shear, roof displacement, storey drift, for a steel frame with a different combination of bracing was alone. The authors concluded that using a combination of bracing, the X & inverted V bracing were more effective in basic parameter than other combination.

Anitha M. and Divya K. [2] reported the seismic effect of different types of steel bracings. A comparison of knee braced steel frame with other types of bracings had been done. Performance of each frame had been studied using nonlinear static analysis and nonlinear time history analysis for various parameters such as displacement and stiffness. Steel bracing was an effective and economical solution for resisting lateral forces in a framed structure. Knee braced steel frame had excellent ductility and lateral stiffness. Analyzed of the model was carried out by using commercially available software ANSYS 14.5. The authors concluded that compared to another type of bracings knee bracing performs better during a seismic activity. Mahmoudi M. and Maheri K. [3] analyzed buildings with single and double bracing bays and various stories and different brace configurations using static nonlinear. The number of bracing bays and the height of the building had a low effect on post-buckling over strength factors.
Sabelli et al. [4] resulted in a less favorable seismic response, such as low drift capacity and higher accelerations. CBFs were a common structural steel or composite system in areas of any seismicity. Special Concentrically Braced Frames were a special class of CBF that were proportioned and detailed to maximize inelastic drift capacity. It was experienced that the challenge was to configure for any shape at beam – column intersections. Ali et al. [5] analyzed the evaluation of seismic capacity and demand of structures through a series of nonlinear dynamic analysis using multiple ground records. Many parameters earthquake duration, acceleration peak points, frequency content, and energy content of the record were effective in the analysis. It was concluded that inverted V was more effective in reducing lateral displacement than X-bracing

II. OBJECTIVE OF STUDIES

1. Evaluating the effect of the earthquake on multi storied steel braced structure.
2. Analysis of seismic effect like base shear, story drift, displacement in steel structure with a different combination of bracing.
3. Comparison of seismic performance like acceleration, velocity, a time period with a different combination of the bracing system.
4. Evaluation the effective bracing system for the multistoried building in the seismic prone area.

III. METHOD OF ANALYSIS

A. Equivalent Static Analysis

All design against seismic loads must consider the dynamic nature of the load. However, for simple regular structures, analysis by equivalent linear static methods is insufficient. This is permitted in most codes of practice for regular, low to medium-height buildings. This procedure takes in to account the dynamics of building in an approximate manner. The static method is based on the formulation given in IS codes, thus it is easiest one. The design base shear is computed for the whole building firstly, and it is then distributed along the rise of the building. The lateral forces at each floor levels obtained are distributed to individual's lateral load resisting elements.

B. Response Spectrum Method

Response spectrum method is the linear dynamic analysis method. In this method, the peak responses of a structure during an earthquake is obtained directly from the earthquake responses (or design) spectrum. The representation of the maximum responses of idealized SDOF systems having a certain period and damping, during earthquake ground motion. The maximum response is plotted against the undamped natural period and for various damping values and can be notified in terms of maximum relative velocity or else maximum relative displacement.

IV. STRUCTURAL BUILDING DETAIL

The length and width of the building are 24m and 36m. The height of storey is 3.5m. The building is unsymmetrical to X and Y axis. The nonstructural element and component that do not significantly influence the building behavior were not modeled. The joint between beam and column are rigid. The columns are assumed to be fixed at ground level. In this study, A G+20 storey steel building of 4 bays in X-direction and 6 bay in Y- direction have been considered for the investigation the effect of the combination of bracing. Below table shows details of the building that is used for the analysis of the building. Some identical rolled steel section is used for all bracing pattern. The building has been analyzed using commercially available SAP2000 software, which is based of stiffness matrix method of analysis.

Table 1: Details of the Building

Sr No	Building Description	
1	Bay width	3m
2	Floor to floor height	3m
3	Total height of	15
4	Grade of steel Fe 250	Fe 250
5	Live load	3 KN/m^2
6	Zone	III
7	Zone factor	0.16
8	Reduction factor	5
9	Importance factor	1.0
10	Column details	ISHB 400

11	Beam details	ISMC 400
12	Bracing details	2 ISA 100X100X10
13	Modal Damping	2%

There are the maximum six combinations created from four bracing such as X type, V type, inverted V type, and Knee type. In the present study, modeling of the steel braced structures with a different combination of bracing and analyses structure using Staad software. The combinations of bracing used are
a) X and V type bracing
b) X and inverted V type bracing c) X and Knee type bracing.
d) V and inverted V type bracing e) V and Knee type bracing
f) Knee and inverted V type bracing

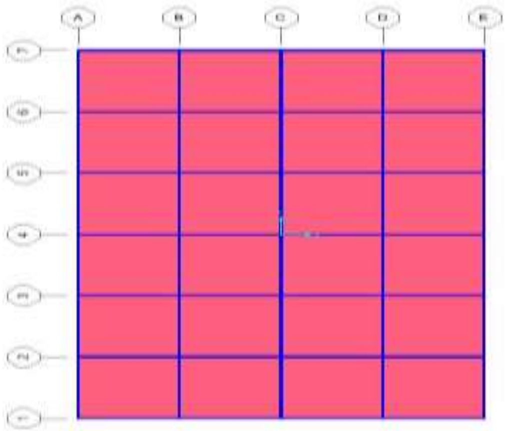

Fig.1: Plan of G+20 multistoried Steel Building in SAP2000

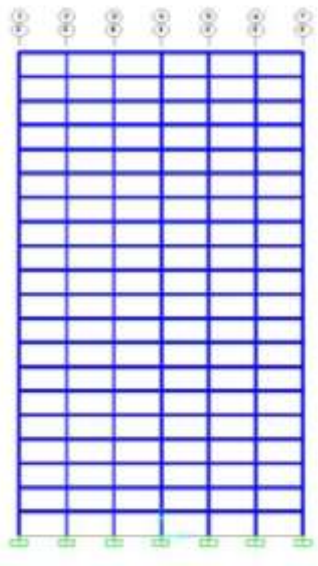

Fig.2: Elevation of G+20 multistoried Steel Building in SAP2000

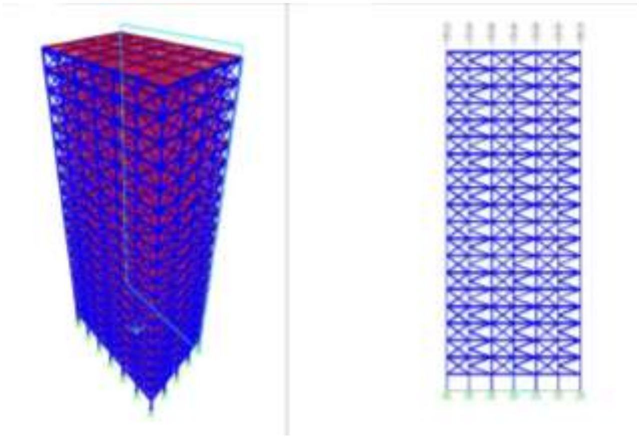

Fig.3: X and K Type Bracing in SAP2000

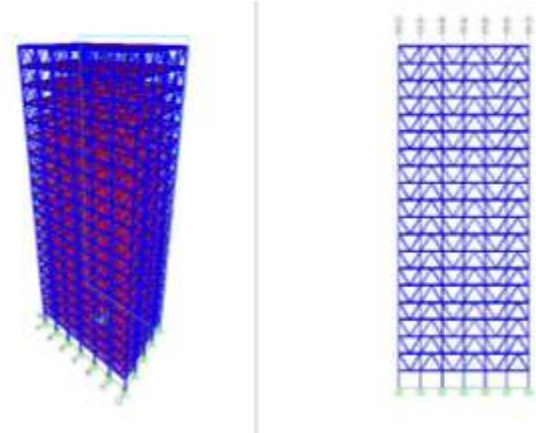

Fig.4: Inverted V and V Type Bracing in SAP2000

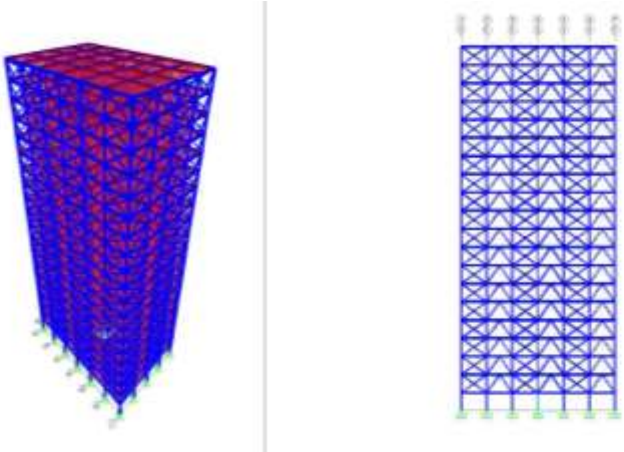

Fig.5: X and Inverted V Type Bracing in SAP2000

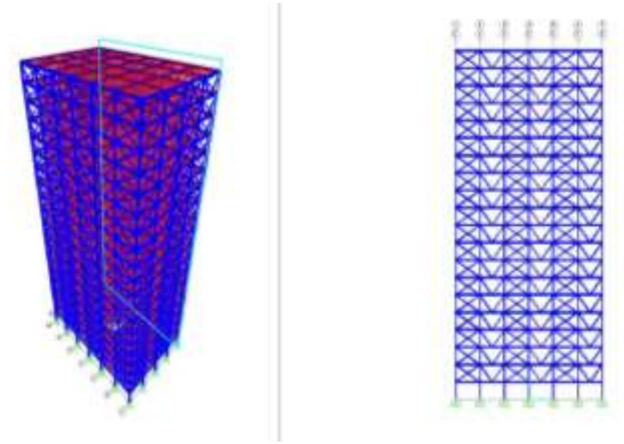

Fig.6: V and X Type Bracing in SAP2000

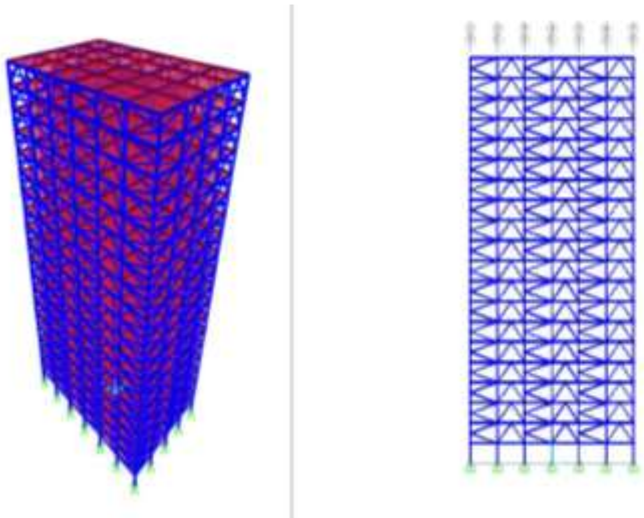

Fig.6: Inverted V and K Type Bracing in SAP2000

V. RESULT AND DISCUSSION

The parametric study of base shear, storey displacement and storey drift of building in different stories by response spectrum analysis for G+ 12 storeys is performed here. The results obtained from the analysis are compared by graphical representation.

A. Comparison of Base Shear

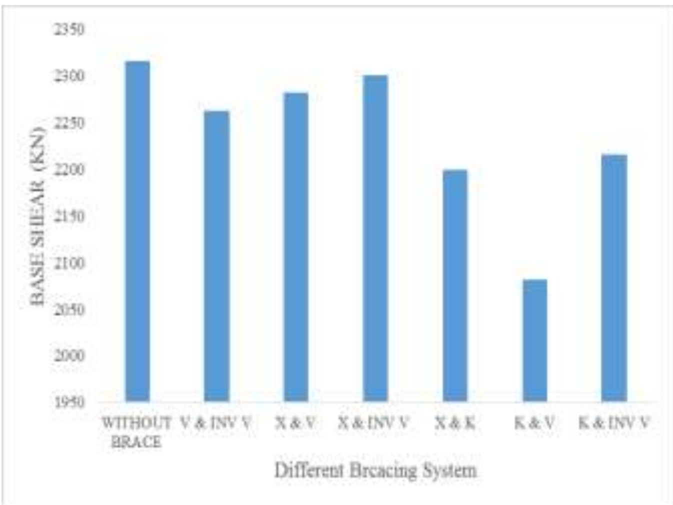

Fig.7: Comparison of Base Shear in SAP2000

Fig 7 shows a graphical representation of base shear of various structures. The graph shows base shear vs different structures as Y-axis and X-axis respectively. Graph shows that K and V combination of bracing has 3% reduction as compared to other combination of bracings

B. Storey Displacements:

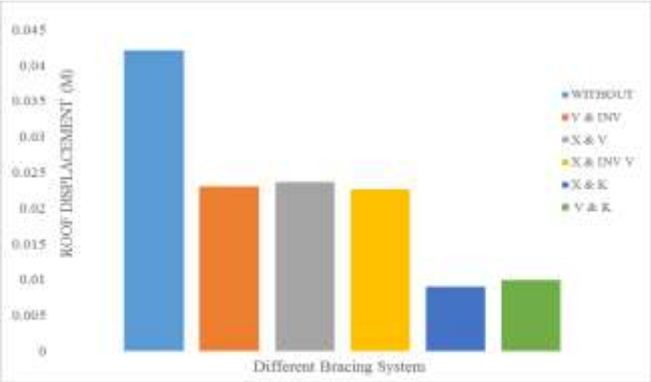

Fig 8: Comparison of Roof Displacement in X- Direction SAP2000

Fig 8 shows graphical representation of displacement of various structures. Graph shows displacement vs top joint structures as Y-axis and X-axis respectively. The graph shows that K and X combination of bracing has 2% and 5% less displacement as compared to other combination of bracings.

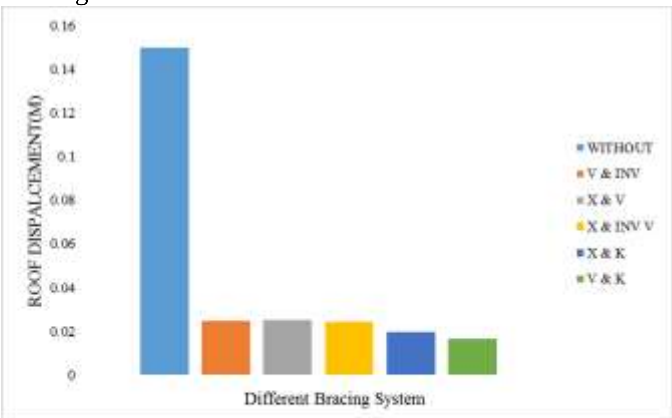

Fig 9: Comparison of Roof Displacement in Y- Direction SAP2000

Fig 9 shows a graphical representation of displacement of various structures. The graph shows displacement vs top joint structures as Y-axis and X-axis respectively. The graph shows that K and V combination of bracing has 7% less displacement as compared to other combination of bracings.

C. Storey Drift

As per clause no 7.11.1 of IS-1893 (Part-1):2002 the storey drift in any storey due to specified design lateral force with a partial load factor of 1 shall not exceed 0.004 times the storey height. Maximum storey drifts for building= 0.004 X h, for 3m storey height it is 0.12m.

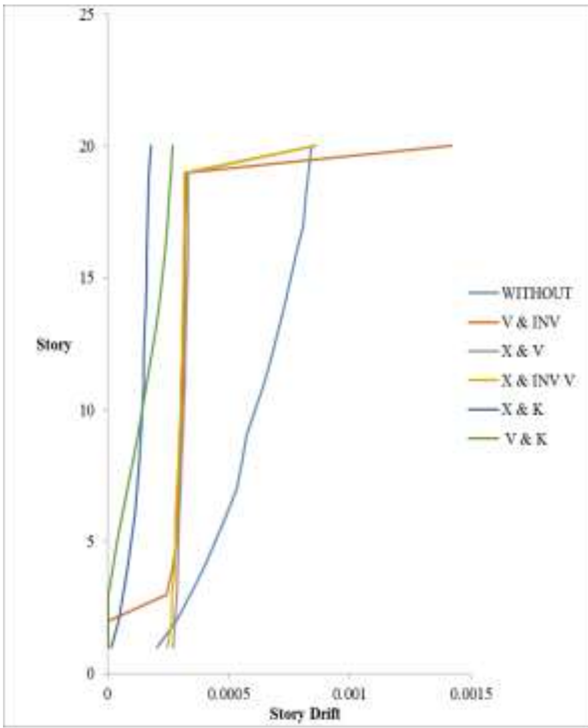

Fig 10: Comparison of Story Drift in X- Direction SAP2000

Fig 10 shows a graphical representation of story drift of various structures. The graph shows story vs top drift as Y-axis and X-axis respectively. The graph shows that K and X combination of bracing has 2% to 2.5% less drift as compared to other combination of bracings.

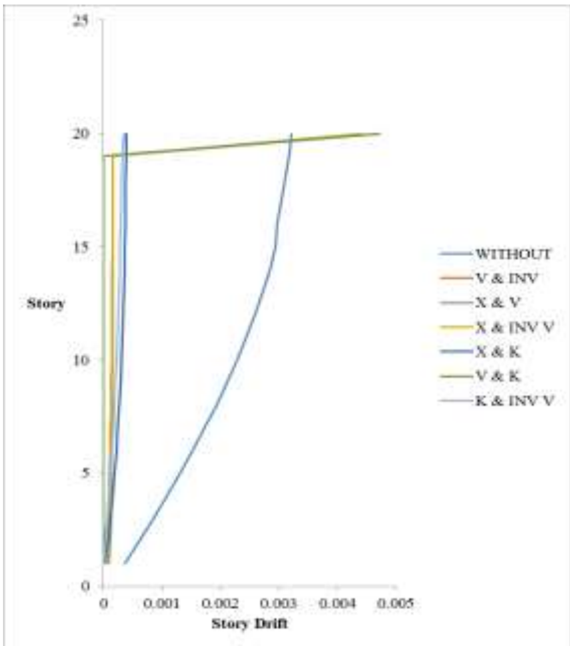

Fig 11: Comparison of Story Drift in Y- Direction SAP2000

Fig 11 shows a graphical representation of story drift of various structures. The graph shows story vs top drift as Y-axis and X-axis respectively. The graph shows that K and X combination of bracing has 1.5% to 2% less drift as compared to other combination of bracings.

D. Acceleration, Velocity, and Displacement

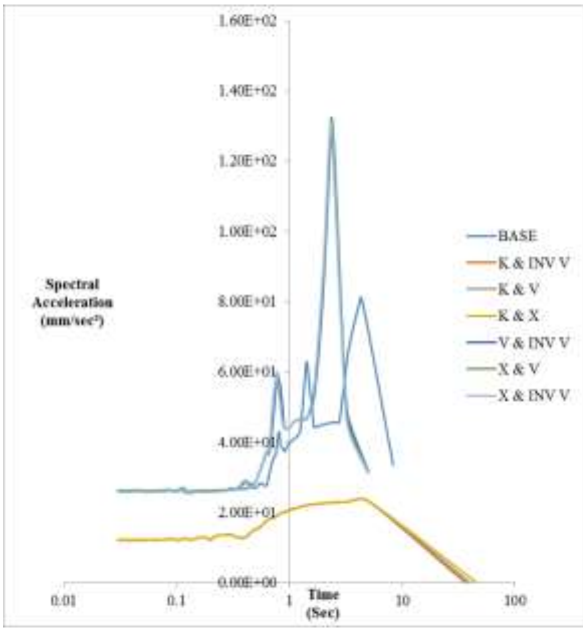

Fig 12: Comparison of PSA for Combination of Bracing in SAP2000

Fig 12 shows a graphical representation of PSA by using Elcentro time history for a different combination of bracing. K bracing has 4% to 6% less value that shown in above graph. The graph shows PSA vs. Time as X-axis and Y-axis respectively.

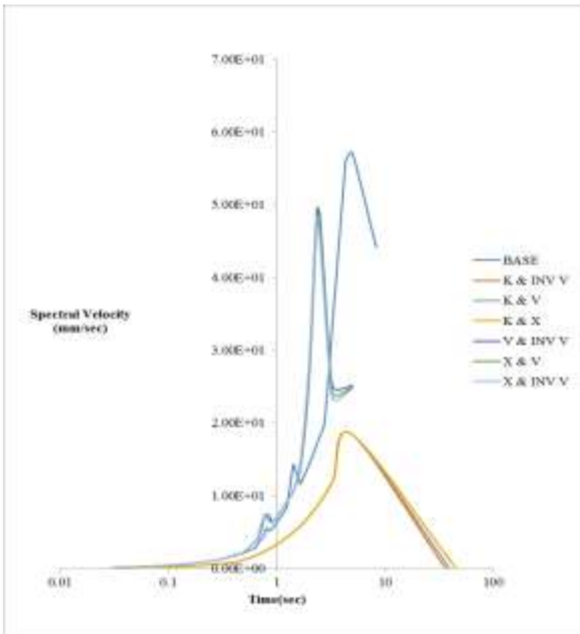

Fig 13: Comparison of PSV for Combination of Bracing in SAP2000

Fig 13 shows a graphical representation of PSV by using Elcentro time history for a different combination of bracing. K bracing has 3% to 5% less value that shown in above graph. The graph shows PSV vs. Time as X-axis and Y-axis respectively.

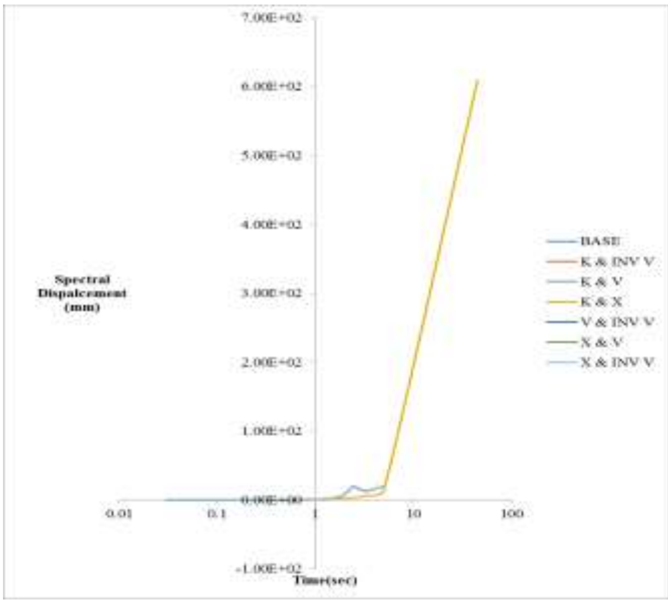

Fig 14: Comparison of SD for Combination of Bracing in SAP2000

Fig 14 shows a graphical representation of SD by using Elcentro time history for a different combination of bracing. K bracing has 1% to 1.8% value that shown in above graph. The graph shows SD vs. Time as X-axis and Y-axis respectively.

Table 2: Damped Period of Different Combination of Bracing

Type of Bracing	Time period (Td) in Sec	Efficiency
K and Inverted V bracing	36.35	23%
K and V bracing	39.51	21%
V and Inverted V bracing	30.75	27%
X and Inverted V bracing	30.54	27.15%
X and K bracing	45.36	18.30%
X and V bracing	30.61	27.12%

The natural time period for these type of steel structure is 8.36 Sec.The application of bracing to the steel structure increases the damped time period as shown in above table. The X and K bracing is shown the good value of the seismic parameter as compared to other combination of bracing. X and K combination of bracing is more efficient for different time history, and it gives less time for Uttarkashi time history.

CONCLUSION

1. The bracing system has a better seismic effect like base shear, Hence, bracing system structure has 3% reduction in results as compared to the different combination of bracing system structure.
2. The bracing system has a better seismic effect like story drift. Hence, bracing system structure has 2% to 2.5% in the X direction and 1% to 1.5% in Y direction less value as compared to the different combination of bracing system structure.
3. The bracing system has a better seismic effect like displacement. Hence, bracing system structure has 2% to 5% in the X direction and 7% in Y direction less value as compared to the different combination of bracing system structure.
4. The comparison of different combination bracing system under seismic performance like spectral acceleration has 4% to 6% reduction in results.
5. The comparison of different combination bracing system under seismic performance like spectral velocity has 3% to 5% reduction in results.
6. The comparison of different combination bracing system under seismic performance like spectral displacement has 1% to 1.8% reduction in results.
7. The comparison of different combination bracing system under seismic performance like damping period shows 4% to 9% reduction in results and from results, K bracing has a lower value than other combination of bracing.
8. From the combinations of bracing compared for shear force, bending moment and plastic hinge formations result with each other which shows that K bracing is more efficient in the seismic prone area.
9. K bracing is 2% to 4% efficient in different seismic prone area than another type of bracings. And also the having good ductility and stiffness.

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