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SIMILITUDE STUDY OF CHEVRON BRACED FRAME STRUTURE

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Abstract - The present study consists of modeling as per IS 800-2007. Model consists of 96 Steel Moment Resisting Frame with V (Chevron bracing) configuration with varying height, loading. Performance of each frame is studied through Response Spectrum analysis, Time History analysis and Equivalent static analysis. For the analysis of G+24, G+29, G+34, G+39, G+44, G+49, G+54, G+59; Steel framed buildings are modeled and each of them have been analyzed for Response Spectrum analysis, Time History analysis and Equivalent static analysis. In this way for a particular height of building 12 cases considering Response spectrum analysis and 12 cases for Time history analysis and 12 cases for Equivalent static analysis have been performed. Earthquake load is applied on model of structure as per IS-1893(2002) for Zone IV in ETABS software. Load combinations for analysis are set as per IS-456(2000). All analysis have been performed using software ETABS 2015 Version 15.0.0. In total,192 cases have been analyzed in this study for following desired outcomes, Top storey displacement, Maximum Bending moment, story drift and Base shear.

Keywords - Equivalent static Analysis; Time history Analysis; Response spectrum analysis; ETABS; Seismic Analysis; High-Rise Building.

I. INTRODUCTION

In the construction industry steel plays an important role. Former earthquakes in India showed, non-engineered structures as well as engineered structures need to be planned in such a way that they start perform considerably good under seismic loading. In Steel moment resisting frames Structural response can be increased by introducing steel bracings in the structural system. Bracing can be applied as concentric bracing or eccentric bracing. There are 'n' number of theories to arrange steel bracings like cross bracing or 'X', diagonal bracing or 'D', and 'V' type or inverse V type bracing. They hold lateral forces by means of flexure and shear generating in beams and columns (frame action). Under severe earthquake loading ductile fracture at beams and columns connections are common. Moment resisting frames have low elastic stiffness. P-Δ effect is an another problem associated with such structures in high rise buildings. So, bracings can be provided to increase the structure response to lateral loading and good ductility properties to perform well under seismic loading concentric. Columns, beams and the bracings are set up to form a vertical truss after that the lateral loading is withstand by truss action. In recent probes of the earthquake, this came across that losses are produced due to the seismic design of structural buildings exercising codal procedures which are not adequate to achieve best functioning while earthquake. So, new design philosophies to expect future performance of the building during earthquake. This is called performance based seismic design. In this, to evaluate the performance of the buildings Pushover and non-linear time history analysis are used [1].

Bracings let the system to obtain a great increase in lateral stiffness with minimum added weight. Thus, it increase the natural frequency and usually decrease the lateral drift, develop ductility through inelastic action in braces. Failure happens because of yielding of trusses in tension or in case of buckling under compression. These failures can be reduce by the use of Buckling Reinforced Braced Frame, BRBs or by Self Centering Energy Dissipating frames, SCEDs. The present study clearly estimate the advantage of concentrically braced steel frames over Steel moment resisting frames. A simple computer based modeling in ETABS. Software is performed for Equivalent static analysis, Response spectrum analysis, and linear Time history analysis subjected to earthquake loading.

While comparing results of three types of bracing system i.e. X bracing system, V bracing system and Inverted V bracing system with unbraced frame in all the types of X bracing system show much promising results it reduces displacement and also drift of storey more than any kind of bracing system. Steel bracing is one of the most effective systems for resisting lateral loads [2]. One study exemplified that linear static analysis consider only 1st order loading effects which is not realistic in case of tall slender structures, but P-delta analysis is for sure get the iterative action as it considers the second order loading effects [3]. The effects of different types of bracing systems in multi storied steel structure is shown by analyzing the G+15 stories steel building models with different bracing systems using software package STAAD. Pro V8i [4]. In references [5] and [6], use of FE based software ETABS 9.5

is elaborated to estimate the response such as base shear, drift ratio, lateral forces etc under dynamic loading. By investigating different types of bracing like concentric crossed X and eccentric V bracing employing HSS sections. It has been determined concentric cross bracing reduces more lateral displacement and so contributes more to structural stiffness of the structure [7]. The structure when subjected to severe earthquake, can deform in-elastically, in such case the seismic response prediction for structures are conducted with considering post-elastic behaviors [8]. Fundamental time period, Natural frequencies and mode shapes, inter story drift, base shear are computed with different pattern of bracing system. Further study was carried out to determine the desirable type of the bracing practice by keeping stress, drift and total lateral displacement within permissible limit [9]. A better understanding of the Indian seismic code IS 1893 has been enriched from a research review [10]. In an experimental study [11] on the seismic performance of the concentrically steel braced frames with cold-formed rectangular inelastic deformation capabilities were found before failure of bracing members and moment resisting frames.

II. MODELLING & MATERIAL SPECIFICATIONS

For the analysis G+24, G+29, G+34, G+39, G+44, G+49, G+54, G+59 steel framed building with and without braced are modeled. Dimensions of the buildings are 20*15*3.5 meters in X direction, Y, Storey height respectively. The plan view is shown in Figure 1. The building is assumed to be located in seismic zone IV and analyzed for medium soil. Seismic parameters have been discussed below in another section. In this study, ETABS 2015:15.2.0 has been employed. For a particular story height say, (G+24), three cases having different position of chevron braced and one case without shear wall has been modeled and each of them has been analyzed for Response Spectrum analysis, Time History analysis and Equivalent static analysis. In this way for a particular height of building twelve cases have been performed. Further, in loading section, seismic load in two direction have been considered. All models have provided with fixed support condition. Thus in total, 192 cases have been analyzed in this study for outcomes like Top storey displacement, Storey drift, Bending moment (X & Y Direction), Torsional moment (Z-Direction), Base Shear.

Outcomes have been shown in the form of tables, bar charts and flow charts on the basis of more than 1920 outcomes. Models with one chevron bracing at every face of structure, also termed as Centered-chevron bracing (CCB), shown in Figure 2 : Braced Positions. This is position no (a). Models with two chevron bracing at every face of structure, also termed as Double Centered-chevron bracing (DCB), this is position no. (b). Models with two chevron bracing at every face of structure but at corner positions, it is position no. (c).

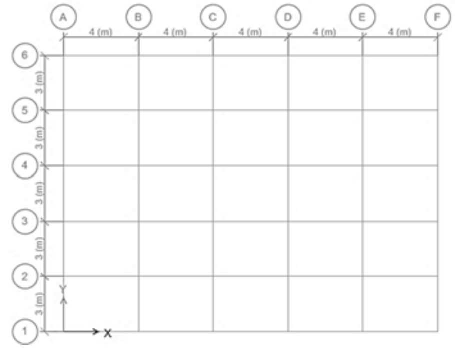

Figure 1 : Plan View

[12] Load acting on the structure are Dead load (DL), Live load and Earthquake load (EL), as per IS: 875. Loading combination of self-weight, dead load, live load and seismic load was taken into consideration according to IS-code 875(Part 5). Some of the values have been calculated manually to give as input to the FE software. Wall load which is (unit weight of brick masonry X wall thickness X wall height, results equals to 7 kN/m (acting on the beam).

Table 1 : Sectional Dimensions

Serial No.	Members	Members Size	Auto Select Size
1	Slab	120mm(Thickness)	ISHB150-450
2	Beam	Auto Select	ISJB150-225
3	Secondary Beam	Auto Select	ISLB75-600
4	Column	Auto Select	ISMB100-600
5	Bracing	Auto Select	ISWB150-600

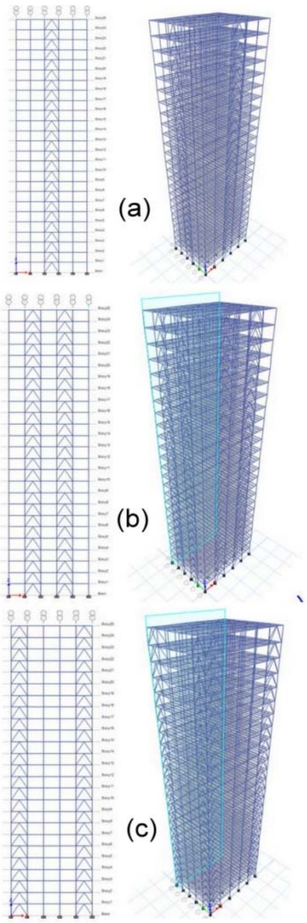

Figure 2 : Braced Positions

Floor Finish equals to1 kN/m^{2,} Live load: 4 kN/m^2 (IS 875 (Part 2) acting on beams. Seismic load is considered along two directions, EQ length and EQ width, using codal provisions [13]. Importance factor as 1 and damping ratio equals to 5%.

III.RESULTS & DISCUSSION

All results have been tabulated and plotted as followings, in all line diagrams below, parameters v/s storey heights are plotted for all

four scenario, without bracing (blue-rhombus), bracing at position 1(red-square), bracing at position 2 (purple-triangle), bracing at position 3 (yellow-cross) under dynamic loadings (EQ-X & EQ-Y) separately.

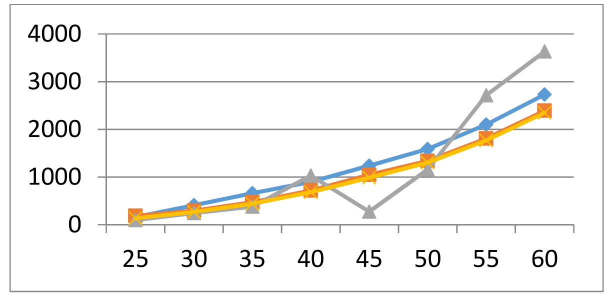

Figure 3 : Maximum Top Story Displacement (mm) v/s Varying Storey Heights for Response spectrum analysis (EQ-X)

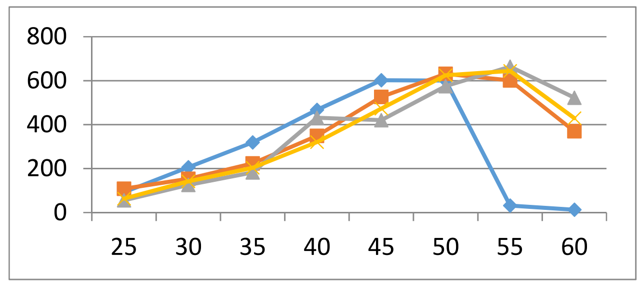

Figure 4 : Maximum Top Story Displacement(mm) v/ Varying Storey Heights for Time history analysis (EQ-X)

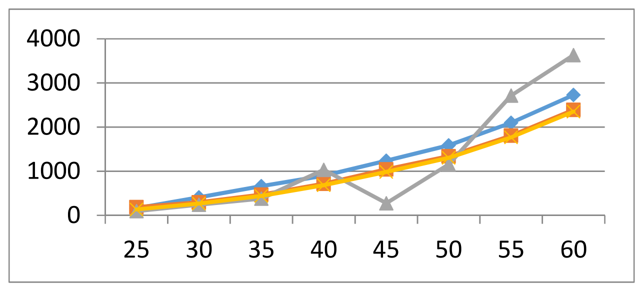

Figure 5 : Maximum Top Story Displacement (mm) v/s Varying Storey Heights for Response spectrum analysis (EQ-Y)

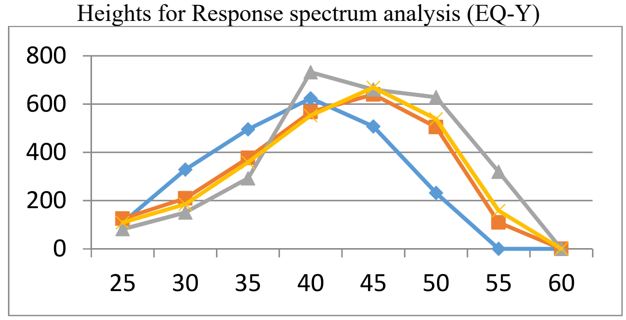

Figure 6 : Maximum Top Story Displacement (mm) v/s Varying Storey Heights for Time history analysis (EQ-Y)

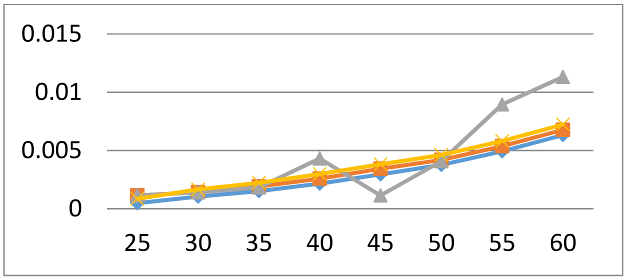

Figure 7: Maximum Story Drift v/s Varying Story Height for Response Spectrum analysis (EQ-X)

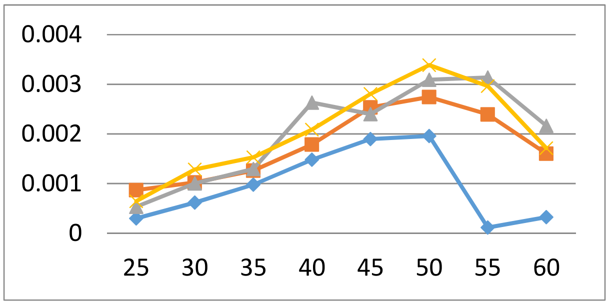

Figure 8: Maximum Story Drift v/s Varying Story Height for Time history analysis (EQ-X)

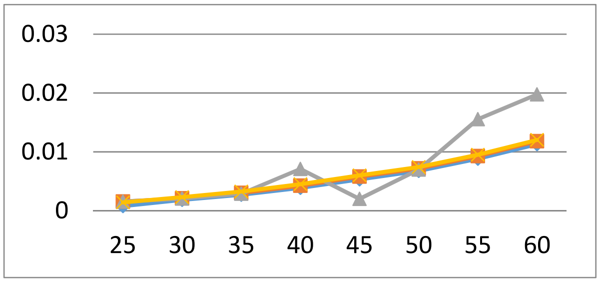

Figure 9: Maximum Story Drift v/s Varying Story Height for Response spectrum analysis (EQ-Y)

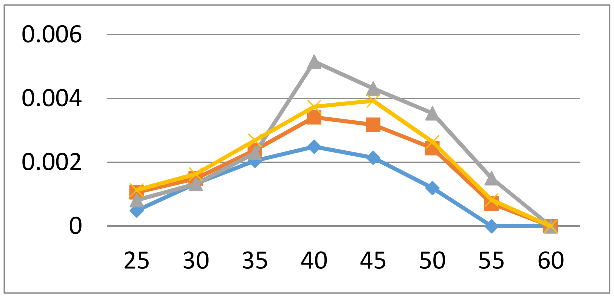

Figure 10: Maximum Story Drift v/s Varying story height for Time history analysis (EQ-Y)

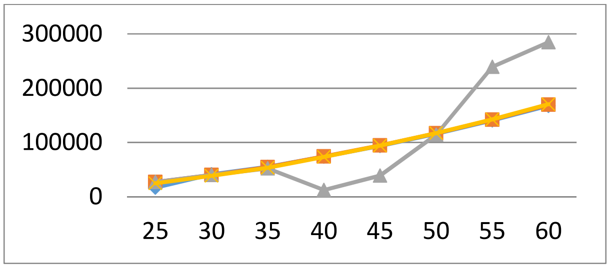

Figure 11: Maximum bending moment (KN-M) about X-direction v/s Varying story height for Response spectrum analysis (EQ-X)

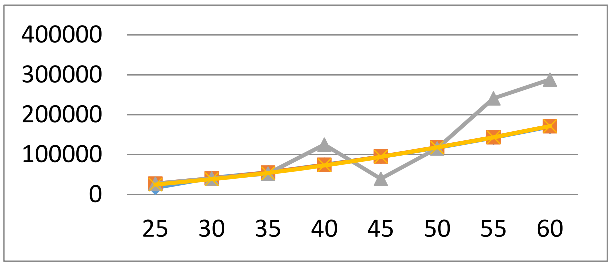

Figure 12: Maximum bending moment (KN-M) about Y-direction v/s Varying Story height for Response spectrum analysis (EQ-X)

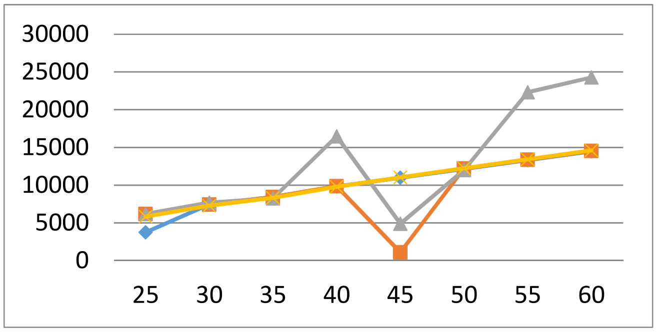

Figure 13: Maximum bending moment (KN-M) about Z-direction v/s Varying story height for Response spectrum analysis (EQ-X)

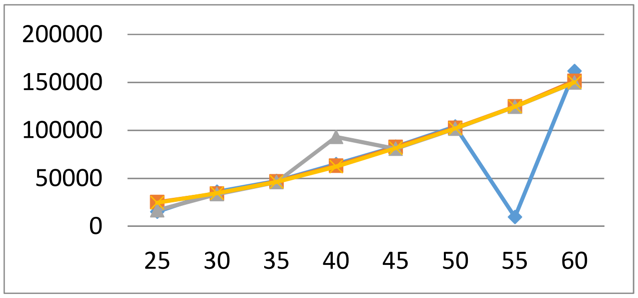

Figure 14: Maximum bending moment (KN-M) about Y-direction v/s Varying story height for Time history analysis (EQ-X)

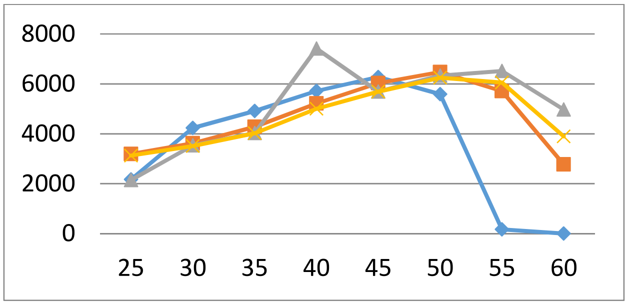

Figure 15: Maximum Bending moment (KN-M) about Z-direction v/s Varying story height for Time history analysis (EQ-X)

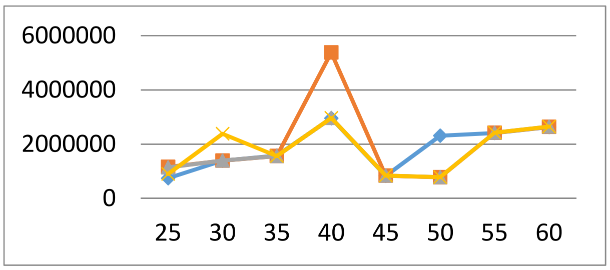

Figure 16: Maximum bending moment (KN-M) about X-direction v/s Varying story height for Equivalent static analysis (EQ-X)

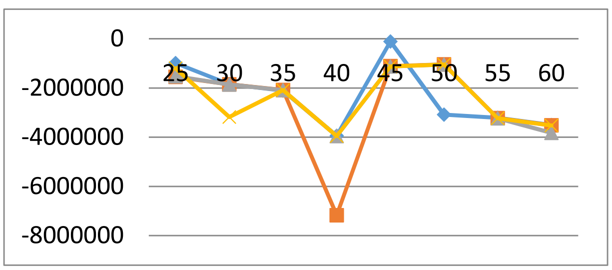

Figure 17: Maximum bending moment (KN-M) about Y-direction v/s Varying story height for Equivalent static analysis (EQ-X)

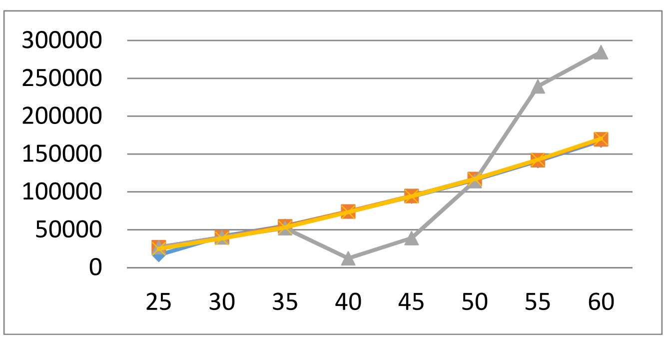

Figure 18: Maximum bending moment (KN-M) about X-direction v/s Varying story height for Response spectrum analysis (EQ-Y)

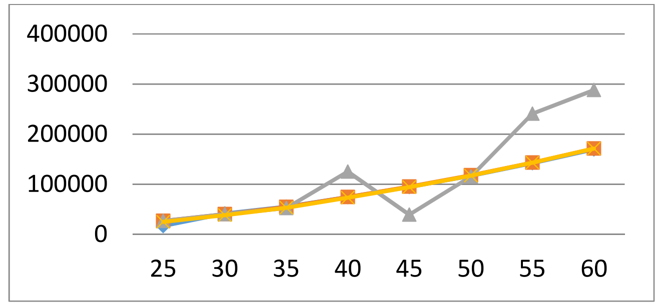

Figure 19: Maximum bending moment (KN-M) about Y-direction v/s Varying story height for Response spectrum analysis (EQ-Y)

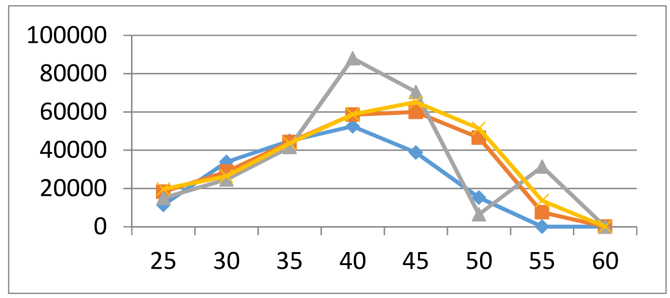

Figure 20: Maximum Bending moment (KN-M) about X-direction v/s Varying story height for Time history analysis (EQ-Y)

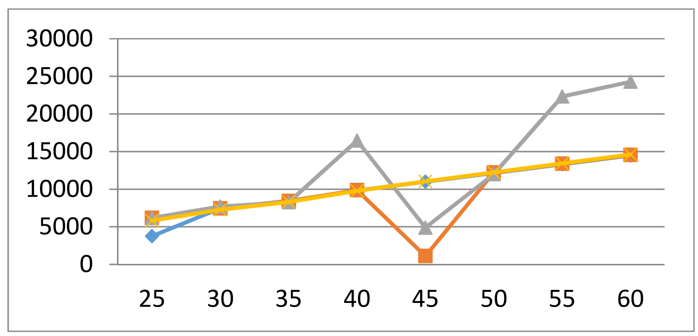

Figure 21: Maximum bending moment (KN-M) about Z-direction v/s Varying story height for Response spectrum analysis (EQ-Y)

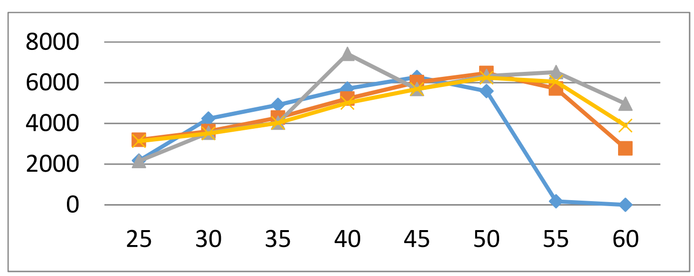

Figure 22: Maximum bending moment (KN-M) about Z-direction v/s Varying story height for Time history analysis (EQ-Y)

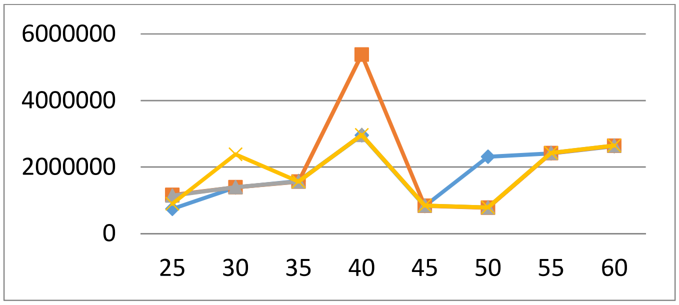

Figure 23: Maximum bending moment (KN-M) about X-direction for Equivalent static analysis ()EQ-Y

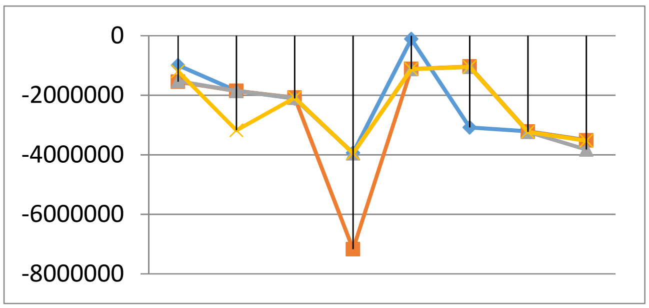

Figure 24: Maximum Bending moment (KN-M) about Y-direction v/s Varying story height for Equivalent static analysis (EQ-Y)

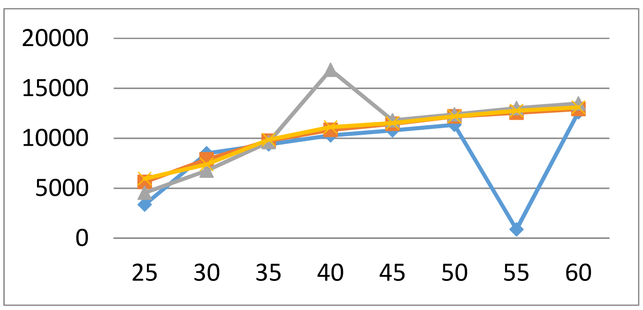

Figure 25: Maximum bending moment (KN-M) about Z-direction v/s Varying story height for Equivalent static analysis (EQ-Y)

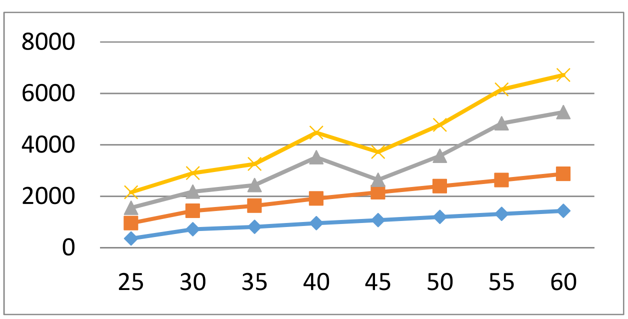

Figure 26: Maximum Base shear (KN) FX v/s Varying story height for Response spectrum analysis (EQ-X)

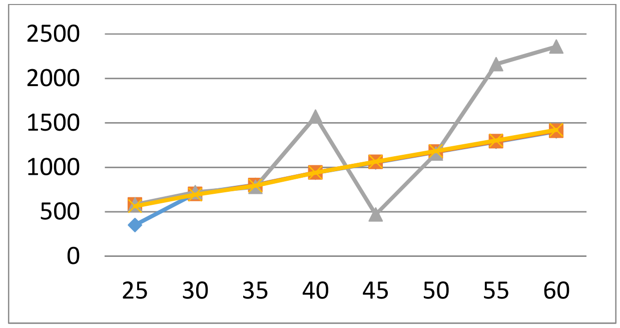

Figure 27: Maximum Base shear (KN) FY v/s Varying story height for Response spectrum analysis (EQ-X)

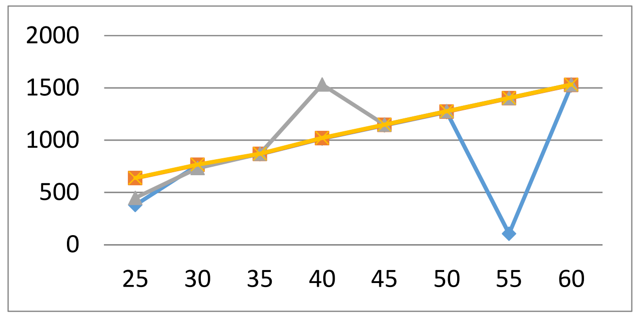

Figure 28: Maximum Base shear (KN) FX v/s Varying story height for Time history analysis (EQ-X)

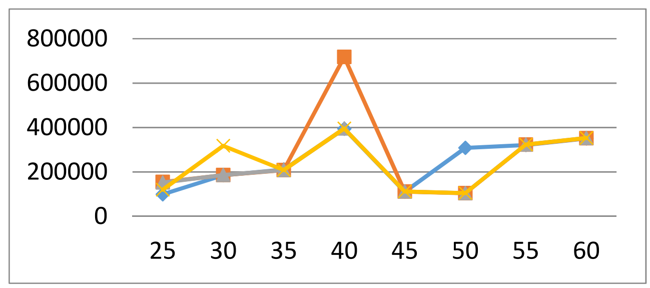

Figure 29: Maximum Base shear (KN) FZ v/s Varying story height for Equivalent static analysis (EQ-X)

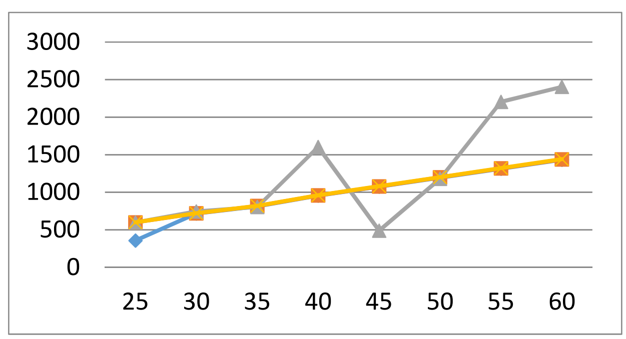

Figure 30: Maximum Base shear (KN) FX v/s Varying Story height for Response spectrum analysis (EQ-Y)

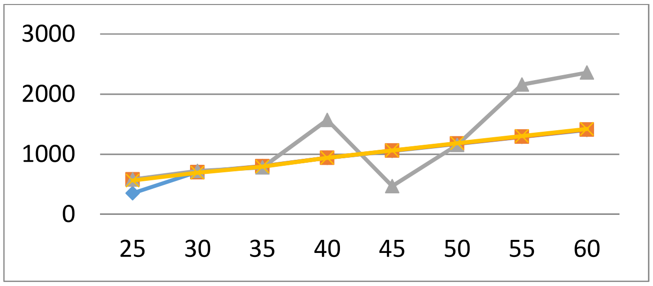

Figure 31: Maximum Base shear (KN) FY v/s Varying story height for Response spectrum analysis(EQ-Y)

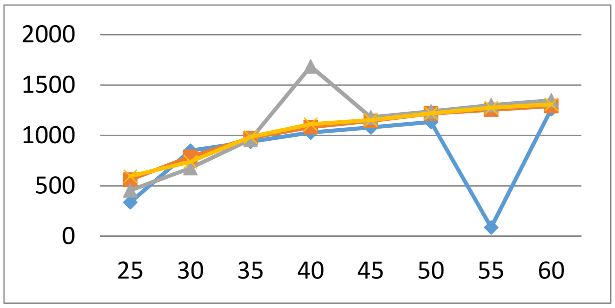

Figure 32: Maximum Base shear (KN) FY v/s Varying story height for Time history analysis (EQ-Y)

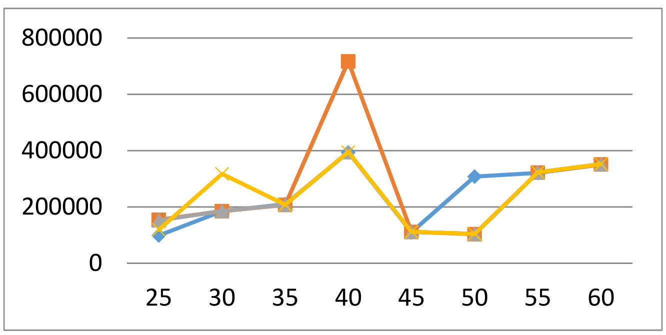

Figure 33: Maximum Base Shear (KN) FZ v/s Varying story height for Equivalent static analysis (EQ-Y)

IV. CONCLUSIONS & FUTURE SCOPE

The selected frame models were analyzed using, Response Spectrum analysis, Time History analysis and Equivalent Static analysis. The 1st model was an asymmetric plan with a without braced moment resisting frame and then it was braced with chevron bracing at three different bays. The chevron bracings increased the stiffness and the frequency of the frame. Chevron bracing at corner is more stiffer than location. Hence, for corner chevron bracing maximum base shear was obtained as compared to central chevron braced model, another bay chevron bracing model and model without bracing. On analyzing 1920 data

- Model was a symmetric plan and a plane frame was used for, Response Spectrum analysis Time History analysis and Equivalent Static analysis was performed. The frame had same inverted V bracing (chevron bracing) configuration but varied in height.
- Also at the same floor, it was observed that the story drift in the larger height building was much more compared to smaller height.
- A chevron bracing system will decrease the story drift but an increased height will increase the story drift leading to the problems like P-Δ effect.
- A larger height model was more stiffer as compared to smaller one and hence had more base shear.
- Chevron Bracing decrease the lateral displacement of the moment resisting frame.
- More stiffer the frame lesser is the story drift.
- Bracings also increase the shear force and bending moment capacity of the columns. Braced steel frame have more base shear than unbraced frames.
- Corner chevron bracing undergo more base shear than other two chevron bracing models.
- Bracings reduce the lateral displacement of floors.
- Corner chevron bracing undergo lesser lateral displacement than other two chevron bracing models.
- Corner chevron braced stories will have more peak story shear than unbraced and other two chevron braced frames.
- Axial forces in columns increases from unbraced to braced system.
- Under the same chevron bracing system and loading, system with larger height or more number of stories will have more base shear than the smaller one.
- Under the same chevron bracing system and loading, system with highest, more number of storey will undergo large lateral displacement on the same storey than the smaller one.
- About the whole of performance of corner chevron braced building better than other two braced building.
- For braced building, the storey drift is getting low when it is compared to the unbraced building which shows that the overall response from the structure decreases.

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