Seismic Evaluation of RC Building Connected with and without Braced Friction Dampers

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Abstract - *The work is concerned with the comparison of the performance evaluation of RC symmetric and asymmetric buildings connected with and without friction dampers. The method carried out in terms of equivalent static, response spectrum and pushover analysis according to IS 1893:2002(part l) code. G+10 storey buildings respectively are considered for the analysis. In this analysis for friction damper buildings, the dampers are connected at corners of all the buildings. The comparison of equivalent static method, response spectrum and pushover analysis method by using finite element software package ETABS is used to perform the modelling and analysis of G+10 storey buildings by considering the seismic zone IV as per IS 1893:2002(part 1) code. For analysis various IS codes have been referred. For Gravity load combination IS 456:2000 and for 0.9, 1.2 and 1.5 seismic load combinations as per IS 1893:2002 (part 1) code is referred. In this study building model analysis carried out namely gravity, equivalent static, response spectrum and pushover analysis in longitudinal direction & transverse. Results of these analyses are discussed in terms of the storey displacement, storey drift and base shear. From these results it is concluded that storey displacement and storey drift will be more in regular buildings compare with the friction damper buildings, whereas the base shear will be less in regular buildings compare with the friction damper buildings. When we provide Friction Dampers, the Base Shear of the building increases 20.95% and Presence of friction dampers in the building reduces the lateral displacement of the building of 32.34% and Lateral Displacement of Equivalent Static analysis is lesser than Response Spectrum analysis of 23.34%.*

***Key Words*: Base Shear, Lateral Displacement, Storey Drift, Friction Dampers, Pushover analysis.**

1. INTRODUCTION

In recent years due to the development 0f design technology and material qualities in civil engineering, the structures (high rise buildings, long span bridges) have become more light and slender. This will cause the structure to develop the initial vibrations. Earthquakes are the Earth's natural means of releasing stress. When the Earth's plates move against each other, stress is put on the lithosphere. When this stress is great enough, the lithosphere breaks or shifts. When the break occurs, the stress is released as energy which moves through the earth in the form of waves, which can be felt and called as an earthquake. There are many different types of earthquake: tectonic, volcanic, collapse and explosion. The type of earthquake depends on the region where it occurs and the geological make-up of that region. The most common are tectonic earthquakes these occurs when the rock in the earth's crust break due to geological forces created by movement of tectonic plates. Another type volcanic earthquake occurs in conjunction with volcanic activity. Collapse earthquakes are small earthquakes in underground caverns and mines. Explosion earthquakes results from explosion of nuclear and chemical devices.

2. ENERGY DISSIPATORS

Energy dissipation is often called as a damping which may be defined as the process of decreasing seismic energy and converting to other forms. Energy dissipation devices can improve the structure's performance without a complete redesign. Energy dissipation exists in real structures. However, it must be in the form of equal and opposite forces between points within the structure

3. LINEAR STATIC ANALYSIS

Here the total design lateral force or design base shear along any principal direction is given in terms of design horizontal seismic coefficient and seismic weight of the structure. Design horizontal seismic coefficient depends on the zone factor of the site, importance of the structure, response reduction factor of the lateral load resisting elements and the fundamental period of the structure. The procedure generally used for the equivalent static analysis is explained below.

4. PUSHOVER ANALYSIS

The Pushover Analysis or Non–Linear Static analysis Procedure is defined in the Federal Emergency Management Agency document 356 (FEMA 356) as a non–linear static approximation of the response a structure will undergo when subjected to dynamic earthquake loading. The static approximation consists of applying a vertical distribution of lateral loads to a model which captures the material non–linearity of an existing or previously Designed structure, and monotonically increasing those loads until the peak response of the structure is obtained on a base shear vs. roof displacement plot.

5. METHODOLOGY AND MODELLING

5.1 ETABS

The entire analysis has done for all the 3D models using ETABS 9.0.4 non-linear version software. The results are tabulated in order to focus the parameters such as time period, story shear, story drift and lateral displacement.

5.2 Model Description

Type of building	G+10 storey reinforced structure.
Height b/w the floor	3.0 m
Ground floor height	3.0 m
Wall thickness	300 mm
Unit weight of R.C.C (IS 875-1987, P-1)	25 kN/m^3
Unit weight of bricks (IS 875-1987, P-1)	18 kN/m^3
Grade of concrete (M25)	25 N/mm^2
Grade of steel (Fe415)	415 N/mm^2
Size of beam	300x900 mm
Size of column	450x900 mm
Thickness of slab	150 mm
Live load	3 kN/m^2
Floor finishes	1.25 kN/m^2

5.3 Plan and 3d View of Models H, L, Rectangular, C Shape Buildings

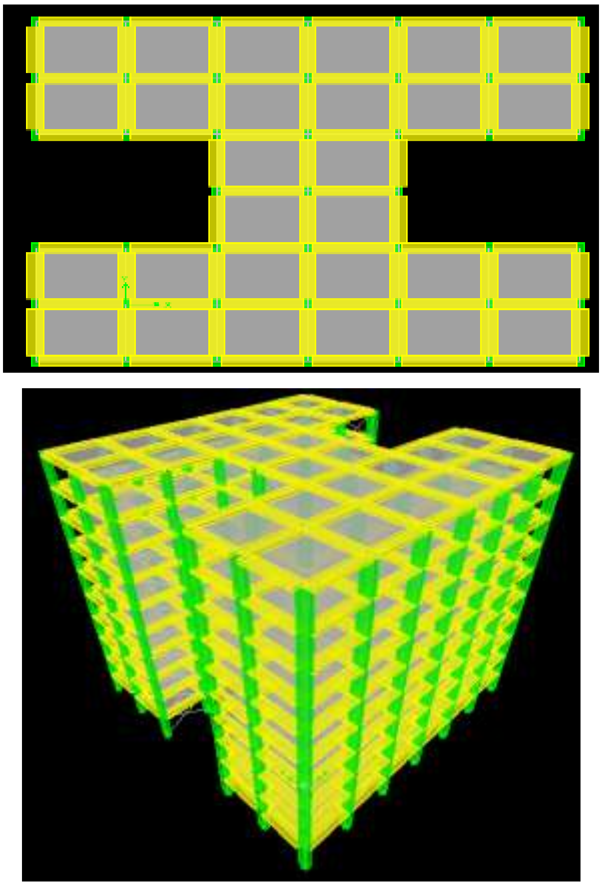

Fig 1: Plan and 3D view of H-Shaped Building

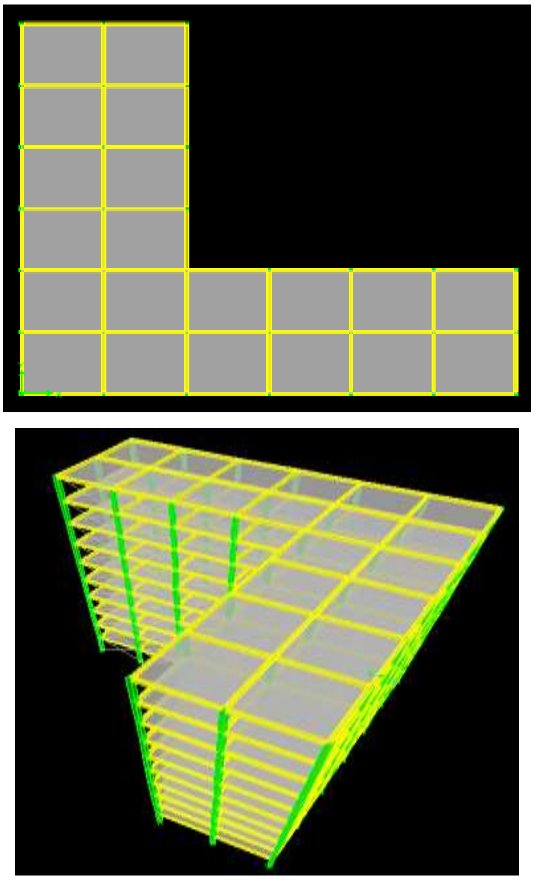

Fig 2: Plan and 3D view of L-Shaped Building

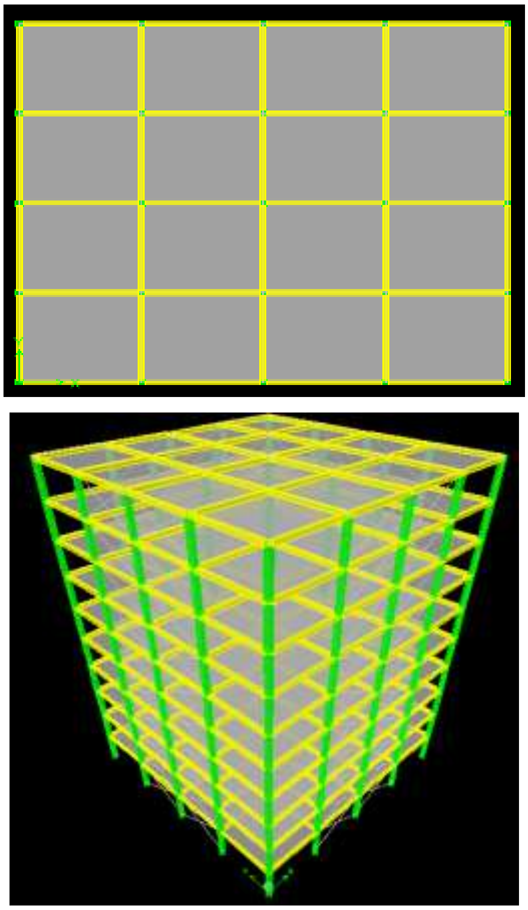

Fig 3: Plan and 3D view of Rectangular Shaped Building

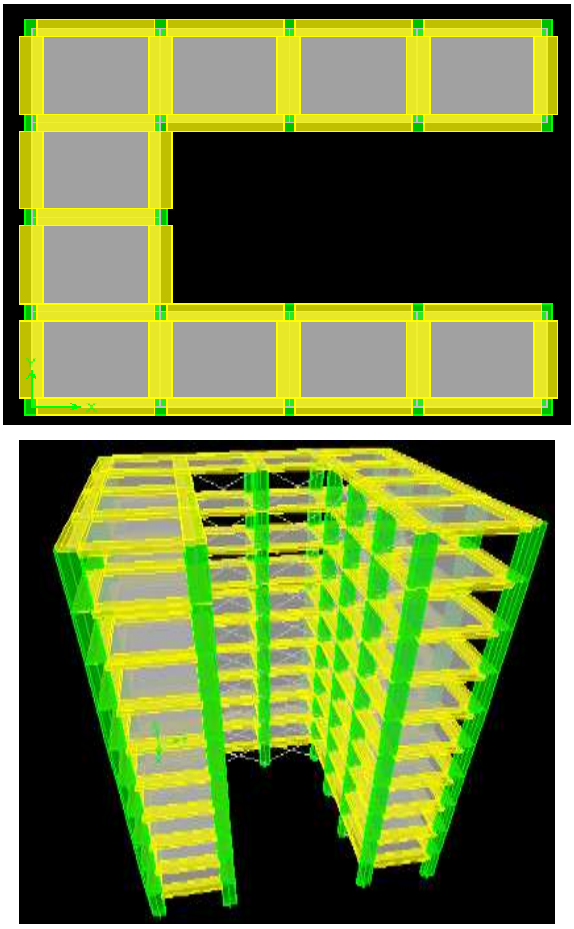

Fig 4: Plan and 3D view of C-Shaped Building

6.0 RESULTS AND DISCUSSIONS

Table1: Base Shear By Response Spectrum And Equivalent Static Analysis

Shapes of buildings	With damper				Without damper			
	EQX (kN)	EQY (kN)	RESX(kN)	RESY(kN)	EQX (kN)	EQY (kN)	RESX(kN)	RESY(kN)
H shape	708.70	769.74	635.98	650.59	686.26	675.26	532.30	736.91
L shape	750.55	750.55	666.58	666.58	654.31	654.31	570.34	570.34
Rectangular shape	692.12	633.13	593.77	549.16	595.88	536.89	497.54	452.92
C shape	705.95	723.7	626.98	637.77	635.55	655.34	557.58	584.37

The above tables provides the comparison of Base Shear for G+10 storied building with and without friction dampers in X and Y direction for both Equivalent static and Response spectrum analysis. Hence Base Shear obtained from the Equivalent Static method are larger than the dynamic response method. From the above tables it is evident that when the story height goes on increasing the Base Shear increases and also when we provide Friction Dampers , the Base Shear increases.

6.2 LATERAL DISPLACEMENTS

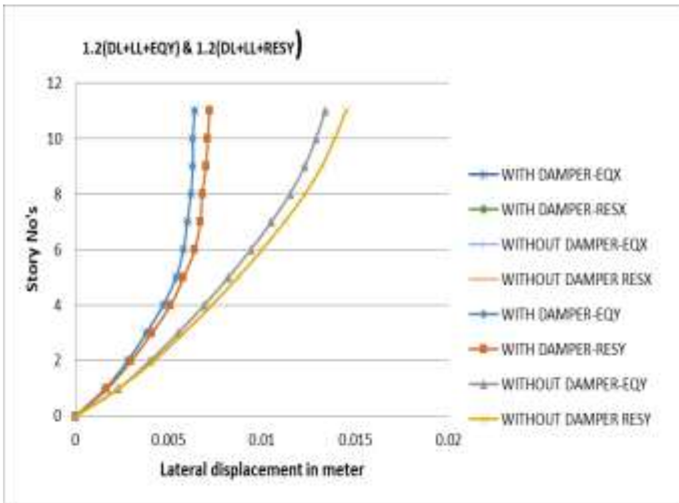

Chart 1: Lateral Displacements for H Shape

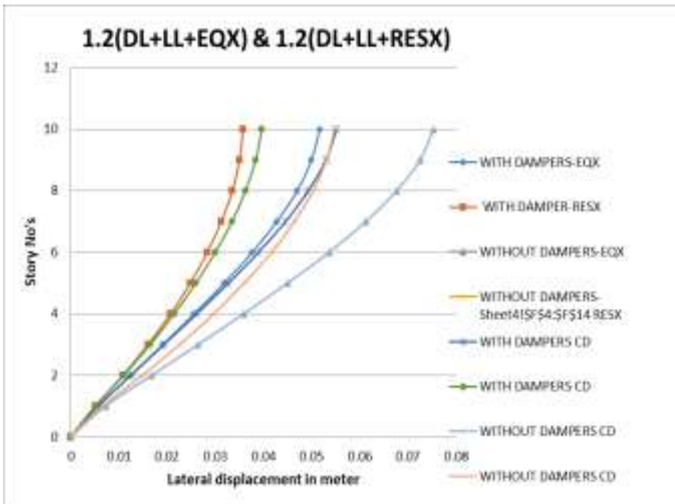

Chart 2: Lateral Displacements for L-Shape

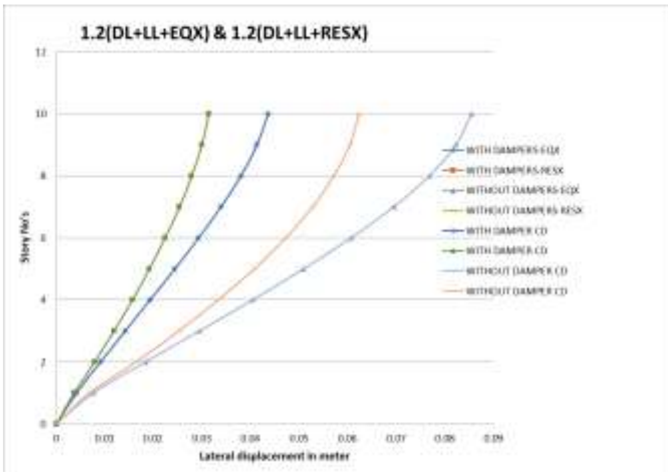

Chart 3: Lateral Displacements for Rectangular Shape

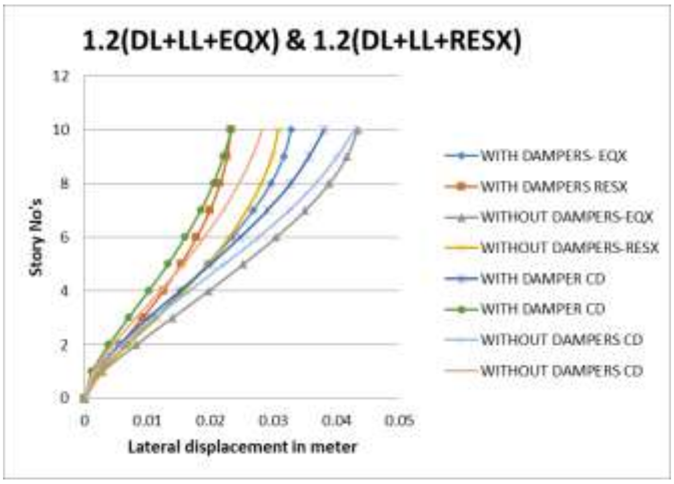

Chart 4: Lateral Displacements for C Shape

From the above figures it is observed that due to presence of friction dampers the lateral displacement of the building got reduced. And also we can notice that Lateral Displacement of Equivalent Static analysis is lesser than Response Spectrum analysis

6.3 STOREY DRIFTS

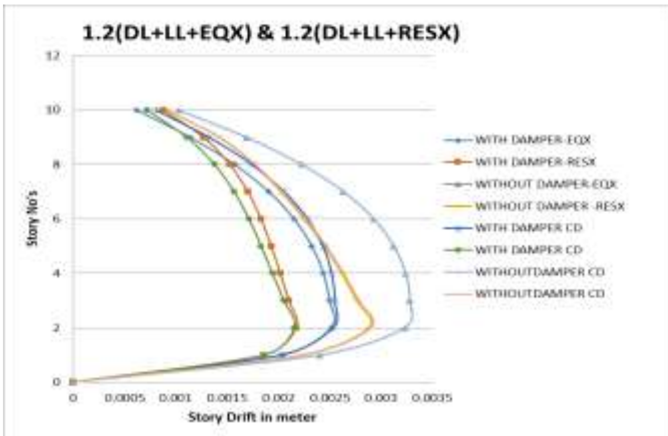

Chart 5: Storey Drifts for H Shape

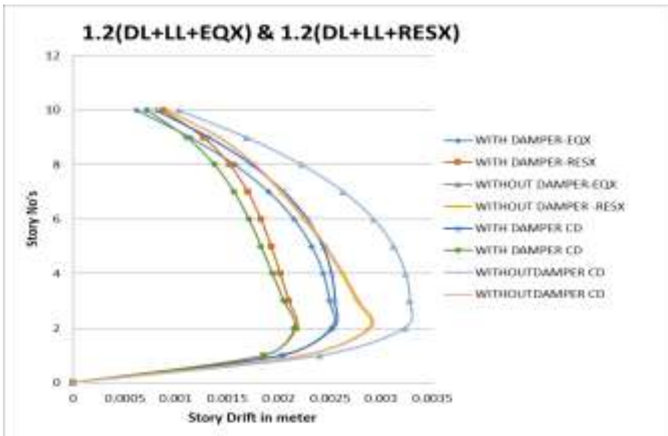

Chart 6: Storey Drifts for L Shape

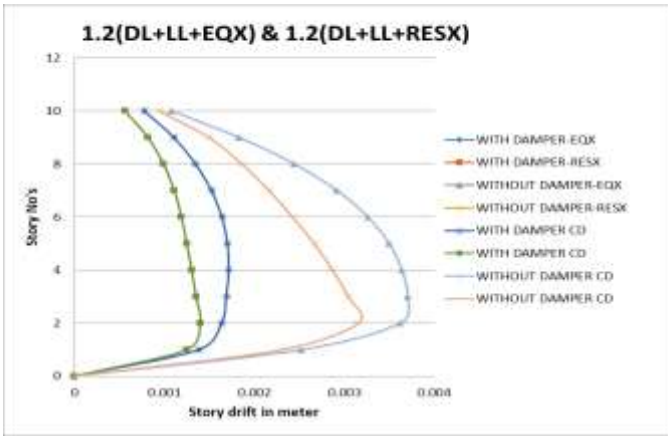

Chart 7: Storey Drifts for Rectangular Shape

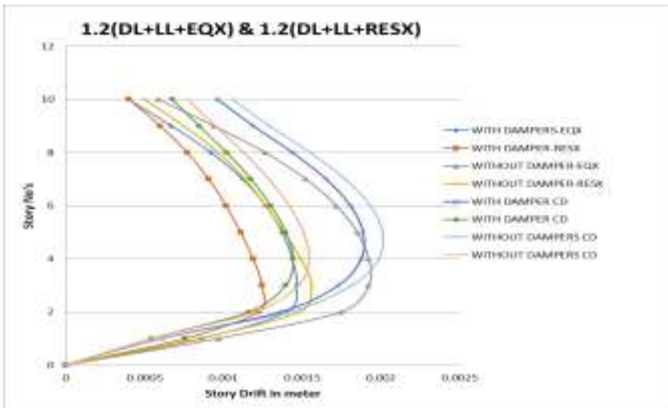

Chart 8: Storey Drifts for C Shape

The Story Drift obtained for equivalent static method and response spectrum method for G+10 story building models, along X and Y direction both with and without friction dampers are plotted in graphs above. From the above figures it is observed that due to presence of friction dampers the Story Drift of the building got reduced. And also we can notice that Story Drift of Equivalent Static analysis is lesser than Response Spectrum analysis.

6.4 Pushover Curves for H,L,C, Rectangular Shapes of Buildings.

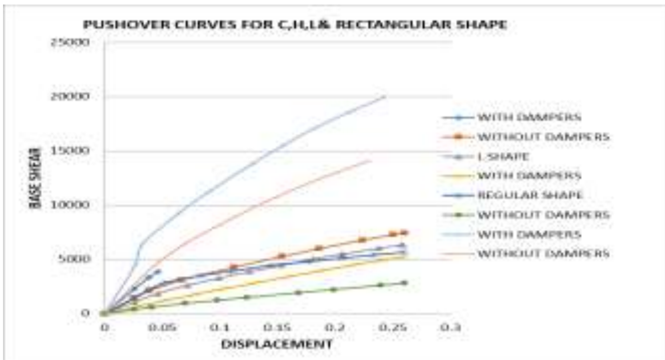

Chart 9: Pushover Curves for H,L,C, Rectangular Shapes of Buildings.

The Base Shear and Roof Displacements obtained in Non-linear static Pushover Analysis for G+10 story building models, along X and Y direction both with and without friction dampers are plotted in graphs above. From the above figures it is evident that the buildings without Friction Dampers takes lesser base force even at higher displacements. But the buildings with Friction Dampers takes higher base force even at lesser displacements.

6.5 CAPACITY CURVES

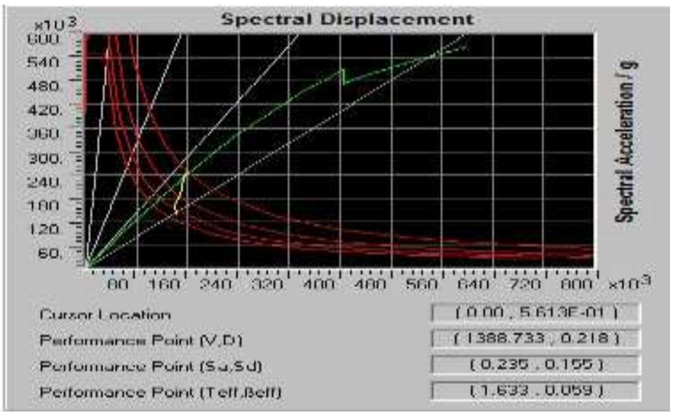

Fig 5: Capacity curve for H-shaped building with Friction Dampers.

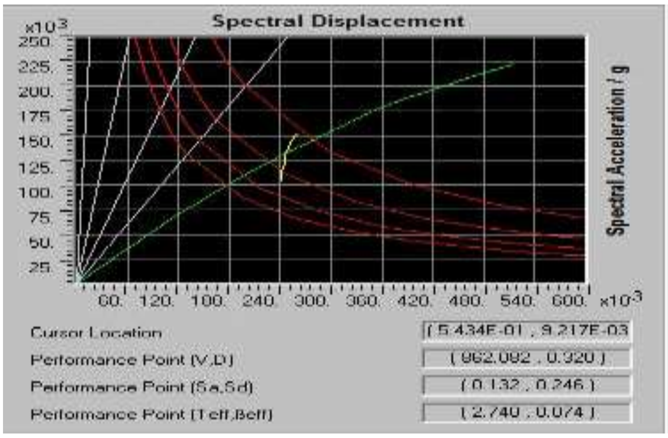

Fig 6: Capacity curve for H-shaped building without Friction Dampers.

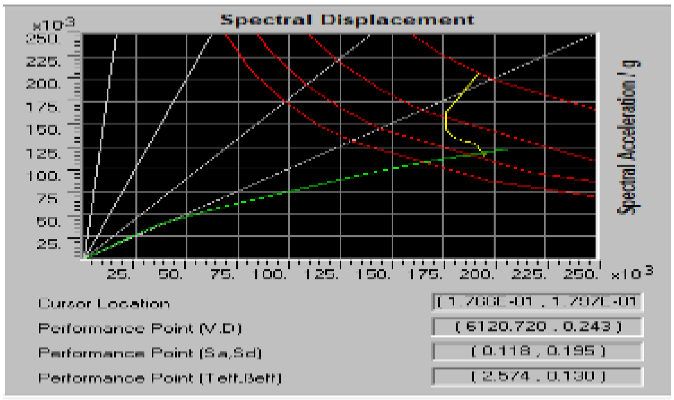

Fig 7: Capacity curve for L-shaped building with Friction Dampers.

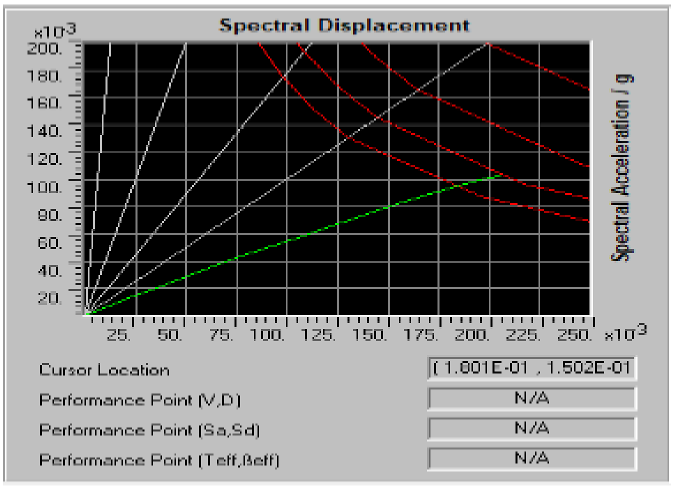

Fig 8: Capacity curve for L-shaped building without Friction Dampers.

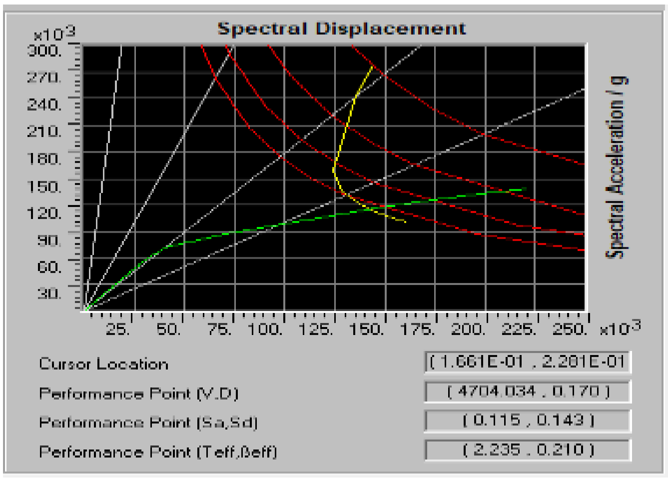

Fig 9: Capacity curve for Rectangular shaped building with Friction Dampers.

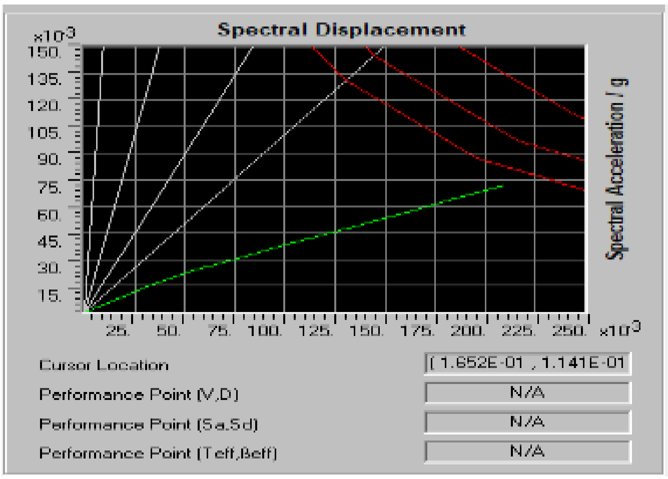

Fig 10: Capacity curve for Rectangular shaped building without Friction Dampers.

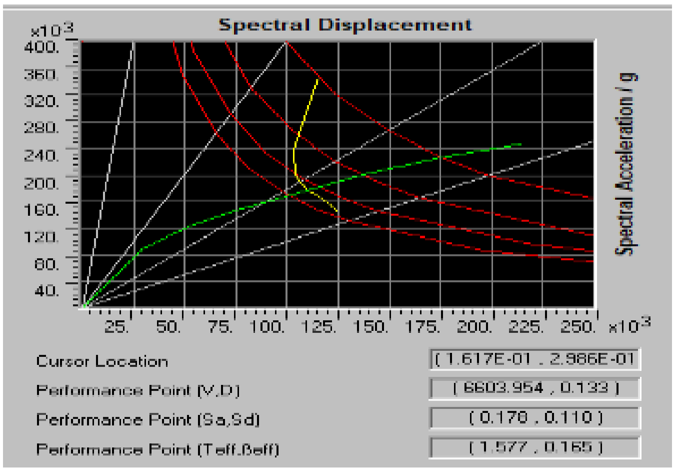

Fig 11: Capacity curve for C-shaped building with Friction Dampers.

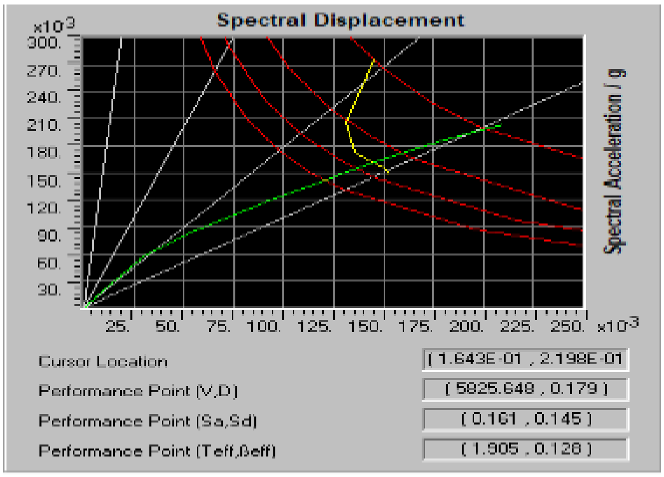

Fig 12: Capacity curve for C-shaped building without Friction Dampers.

The Capacity and Demand graphs obtained in Non-linear static Pushover Analysis for different plan shapes with and without friction dampers are shown in figures above. From the above capacity curves it is evident that the buildings without Friction Dampers takes lesser base force even at higher displacements. But the buildings with Friction Dampers takes higher base force even at lesser displacements.

7. CONCLUSIONS

1. Base Shears obtained from the Equivalent Static method are larger than the dynamic response method.
2. It is evident that when the story height goes 0n increasing the Base Shear increases.
3. When we provide Friction Dampers, the Base Shear of the building increases 20.95%.
4. Presence of friction dampers in the building reduces the lateral displacement of the building of 32.34%.
5. Lateral Displacement of Equivalent Static analysis is lesser than Response Spectrum analysis of 23.34%.
6. Presence of friction dampers in the building reduces the Story Drift of the building.20.79%
7. Story Drift of Equivalent Static analysis is 32.78% lesser than Response Spectrum analysis.
8. From the Non-Linear static pushover analysis we can conclude that the building without Friction Dampers takes lesser base force even at higher displacements. But the buildings with Friction Dampers takes higher base force even at lesser displacements.

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