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Seismic Evaluation of Reinforced Concrete Building with Friction Dampers

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Abstract: The IS-1893:2016 specifies various limits to the structures keeping in mind various safety point. Architect plan building without understanding the consequences of if any sudden change occurs in stiffness of structure especially during earthquake. With increase in infrastructural demand need for response control is increased .The paper mainly emphasized on use of one such device friction damper for response control of structure. The project aims to minimize the displacement and inter-story drift of the structure by applying dampers to the structure. Also to study various responses such as base shear, shear force, bending moment, axial force of buildings. The paper consist of G+5 and G+10 storey building analysed with response spectrum method and time history methodin ETABS software. Comparison of result is done in the form of story drift, base shear ,axial force and bending moment. From result obtained it is conclude that story displacement in friction damper buildingis reduce whereas base shear is less in building without damper.

I. INTRODUCTION

When mechanical engineers are busy with providing shock absolver to vehicle, similarly it is done to the building. Thus use of one such friction damper is discussed in this paper. The analysis mainly deals with study of G+5 and G+10storey building with and without friction damper modelled in ETABS software for zone IV . A 16m x 20m plan for different storey structure having 4m x 5m bay is modelled in ETABS.Here we considered a 3-D RC frame with the dimensions of 4 bays @ 4m in x-axis and 4 bays @ 5m in y-axis. The z axis consisted of G+5 and G+10 floors. The plinth height is 2.5m and rest of the floors had a height of 3.5m.Loads considered are taken in accordance with the IS-875(Part1, Part2) . Load combination that is applies to the structures are taken from IS1893:2016(part I). Dampers that are applied to the structure are modelled as link element in ETABS software. Link properties of friction damper are self-mass and damping coefficient is calculated using formulae. Dampers are applied to all the outer face of building and also at centre in plus sign form.This buildings models are analysed by response spectrum method and time history method in finite element software package, ETABS version 16.2. Analysis is done in software and results are discussed in term of, story drift , base shear, axial force and bending moment. Seismic analysis is used to determine the response of particular structure when subjected to some action. G+5 and G+10 storey building are analysed by Response spectrum Method(RSM) and Time History Method (THM).Response Spectrum Analysis is a dynamic-linear method determines the statistically likely response of structure to seismic loading. This method is extremely efficient and considers the dynamical behaviour of the structure. The main purpose is to evaluate the time variation of stresses and deformations in structures caused by dynamic loads. The response spectrum technique is simplified case of modal analysis. The modes of vibration are determined in period and shape in the usual way and the maximum response magnitudes corresponding to each mode are found by reference to a response spectrum. Computer analysis is done to determine these modes for a structure. For each mode, a response is taken from design spectrum. It is based on the modal frequency and the modal mass. Time History Analysis is an important technique for structural seismic analysis especially when the evaluated structural response is nonlinear. This technique involves the step by step response of structure to seismic ground motion and other type of loading.

II. LITERATURE REVIEW

H Eramma, H Pulakeshi had conducted a study on Seismic Performance Evaluation Of Reinforced Building Connected With And Without X-Braced Friction Dampers. Their findings are base shear increases with the increase of mass and stiffness of friction dampers. And the buildings with friction dampers are more vulnerable compared to buildings without friction dampers. S. S. Sanghai described Severe ground shaking induces lateral inertial forces on buildings, causing them to sway back and forth with amplitude proportional to the energy fed in. If a major portion of this energy can be consumed during building motion, the seismic response can be considerably improved. The way this energy is consumed in the structure determines the level of damage. The use of bracing systems equipped with dissipative devices is relatively new technique for the earthquake protection of buildings that has been considered in several recent experimental and theoretical studies. Dr. H. R. Prabhakara etal said that Necessity to implement seismic codes in building design, the earthquakes is like wake-up call. For this a better method of analysis such as static analysis, dynamic analysis and time history analysis must be adopted for performing the structures seismic risk assessment .The modelling and analysis is done with software and the results that is, seismic parameters such as Time period, Base shear, Lateral displacement and Inter storey drift are tabulated and then comparative study of structures with and without Friction dampers has been done. Manjunatha Guddappa Battikoppa compared 10 story "L" shape and "T" shape building with equivalent static method , response spectrum method and time history method. And concluded that torsion in building is reduced by adding damper. Sandeepkumar.D.S, etal had conducted a study On Seismic Assessment Of Multi-Storey Symmetric And Asymmetric Buildings With And Without Friction Dampers. Their findings are the maximum response is observed in 1.5 (DL + EQL) combination and Natural time period increases with increases height but when provided with damper it decreases. Sergio Pastor Ontiveros-Pérez etal proposes a method for simultaneous optimization of placement and forces of friction dampers using the Firefly Algorithm and drawn found that in all cases studied the proposed methodology proved to be very effective in reducing the dynamic response, reaching reductions of over 70%, and in a worst case scenario, reached reductions in the order of 54%. Finally it is possible to design friction dampers through an economical and effective way. A.K. Sinha and Sharad Singh had conducted a study on Seismic Protection Of Reinforced Frames Using Friction Dampers. The paper discusses building with regular plan and measures 21x 21 m^2. The total height of the building is 40.2 m. The height of 1st floor from ground floor is 3.2 m and the foundation is at 2 m below the ground floor. The modal analysis carried out for 12 modes in each case for frame with and without supplemental damping. The conclusions are time history plot of roof displacement shows considerable reduction by use of dampers. Babak Esmailzadeh Hakimi etal studied case study of structural rehabilitation of 2 schools with 2 and 3 stories, against seismic effects. The conclusion drawn are an increase of about 30% in relative drifts has been resulted from large deformation (P-Δ) effects. Decrease in higher story strengths provides them with higher potential of energy dissipation. A. Filiatrault etal had conducted a study on Seismic Design Spectra For Friction-Damped Structures with objective to provide practicing engineers with a simple and direct approach to the seismic design of friction-damped braced frames. The hysteretic properties of the friction dampers are derived theoretically. The total energy dissipated by friction in an FDBF is equal to the product of the slip load and the total slip travel of each friction damper, summed over all the dampers. K. Sandeep Kumar had conducted a Study On Analysis And Design Of Multi Storied Building For Vertical And Horizontal Loading With And Without Dampers Using Sap2000 . and said that earthquakes are the most unpredictable and devastating of all natural disasters, which are very difficult to save over engineering properties and life, against it. K.S. Ahmed etal studied the seismic behaviour of a 30-story 3D steel frame. The study locates the damper in top three floors for to enhance its seismic behaviour. A comparison of time history analysis with and without damper compares the significant parameters such as story displacements, joint acceleration, and base shear. From the overall discussion and analysis of study they said that seismic performance of a building can improve by installing energy dissipating device (damper) as it absorbs and dissipate energy during an earthquake.Naser Shabakhty etal had conducted a study on Effect Of The Improved Pall Friction Damper On The Seismic Response Of Steel Frames. The studied frame had 6 stories (3 m in height) and 3 openings (4 m in width) analysed by non-linear time history analysis. Final conclusions achieved by Improved Pall Frictional Dampers are significantly reduces base shear in the frame. also it reduces total and relative displacement in stories. IPFD reduces total and relative displacement in stories.

III. METHODOLOGIES FOR SEISMIC EVALUATION

The properties of the material that are finalised before analysis of structure are the grade of steel used is Fe 415 and grade of concrete for beam is M25 whereas for column is M30.

A. Details of Structure

i)	Structure		:-	OMRF
ii)	Number of storey		:-	G+5,G+10 & G+15
iii)	Type of building		:-	Regular in plane
iv)	Storey height	Ground storey	:-	2.50m
v)		Upper storey	:-	3.50 m
vi)	Type of building use		:-	Residential building
vii)	Seismic zone		:-	IV

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B. Loading Data

Loads acting on the structure are dead load (DL), Live load and Earthquake load (EL).

1) Self-weight comprises of the weight of beams, columns and slab of the building.
2) Dead load: 4.125kN/m^2 (IS 875(Part1)).
3) Live load: Floor load: 2.5kN/m2 and Roof load: 1.5 kN/m^2 (IS 875 (Part 2).
4) Seismic Load: Seismic zone: IV (Z=0.24), Soil type: I, Importance factor: 1, Response reduction factor: 5, IS 1893(Part-1):2016.

C. Link (friction Damper) Properties

1) Link properties of friction dampers are self -mass, effective stiffness and damping coefficient.

   Stiffness of structure = $\frac{AE}{L}$.......... (i)

   Where, E=young modulus of concrete

   L= length of column

   A=Cross section area of column

2) Damping co-efficient is determined from eq. (ii) .Damping co-efficient is a function of structure mass and stiffness.

$$\text{Damp Co-efficient} = 2\sqrt{stiffness\ K * Mass}$$

$$= 2\sqrt{K * M} \quad ....(ii)$$

Where K= stiffness of damper

m=mass of damper

As per literature study mass of damper is taken as 30% of mass of structure.

a) Effective stiffness: -2.985x10^{10}kN/m
b) For G+5 storey
   Mass of damper: -5585.14 kg
   Coefficient of damping: -25.56 x10^{6}kN-s/m
c) For G+10 storey
   Mass of damper: -10409.088 kg
   Coefficient of damping: -34.89x10^{6}kN-s/m

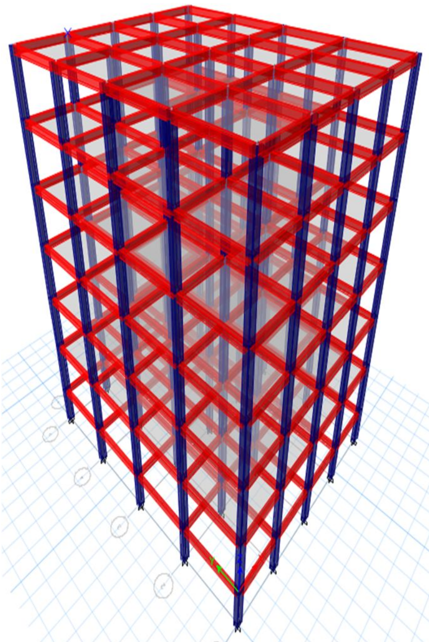

Fig.1-G+5 story building without damper

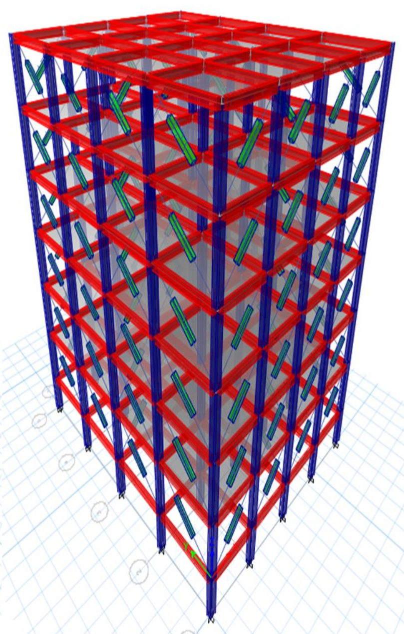

Fig.2-G+5 story building with damper

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IV. RESULT AND DISCUSSION

The result obtained after the analysis of G+5 reinforced concrete building by Response Spectrum Method **(RSM)**andTime History Method **(THM)** are in terms of base shear ,story drift, bending moment and axial force .

A. Base Shear

The base shear is a function of mass, stiffness, height, and the natural period of the building structure. In dynamic response spectrum, all the modes of the building are considered, and first mode governs in the shorter buildings and as the storey increases for tall buildings, the flexibility increases and higher modes come into picture. Hence base shears obtained from the time history method and response spectrum method are approximately same.

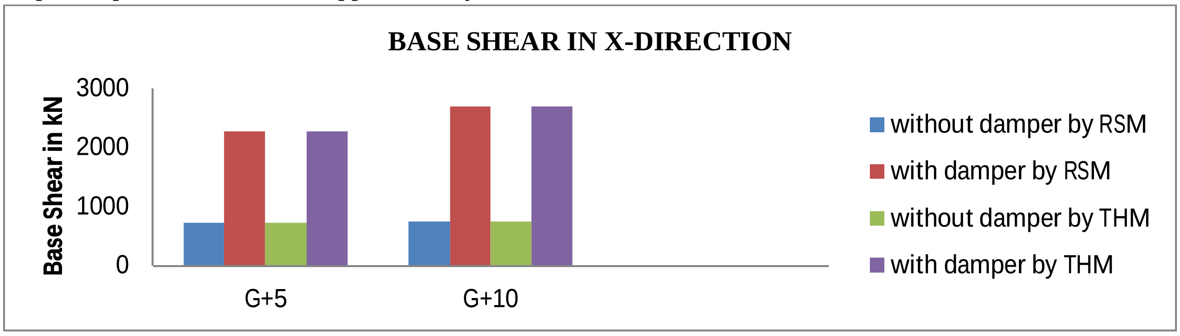

Fig.3. Base shear in X-direction for G+5 and G+10 story building

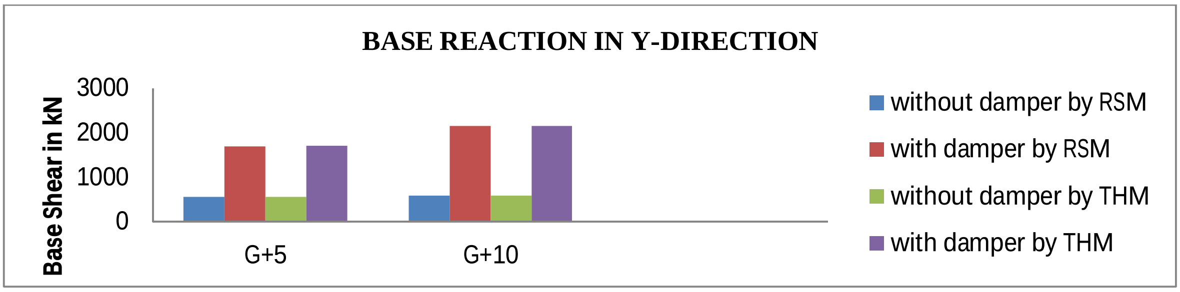

Fig.4. Base shear in Y-direction for G+5 and G+10 story building

B. Axial Force

Fig.5 and 6 shows the graphical results of axial force for G+5 and G+10 building connected with and without damper . It is observed that axial force goes on increasing as we goes towards bottom story .on comparison on building connected with and without damper it is observed that axial force for building with damper are on higher side than building without damper.

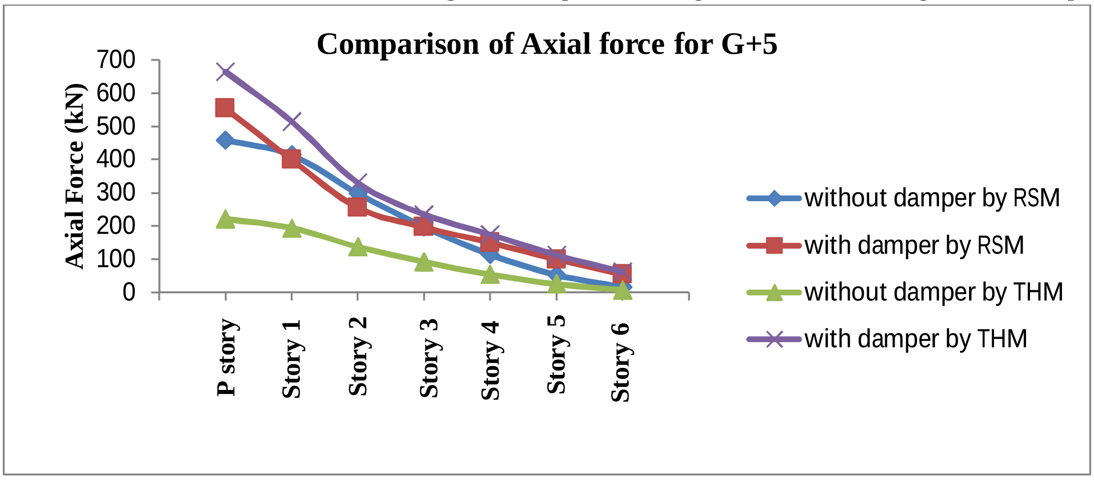

Fig.5.Showing Axial Force for G+5 story building

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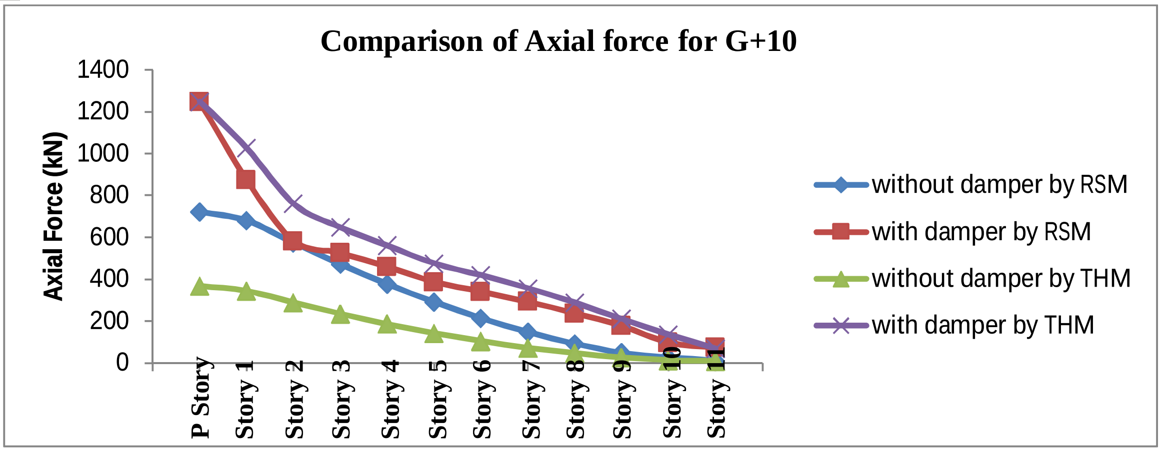

Fig.6.Showing Axial Force for G+10 story building

C. Bending Moment

Fig.7 and 8 shows the bending moment of building G+5 and G+10 analysed by RSM and THM . It is observed that bending moment obtained for building without damper is less than for the building with damper.

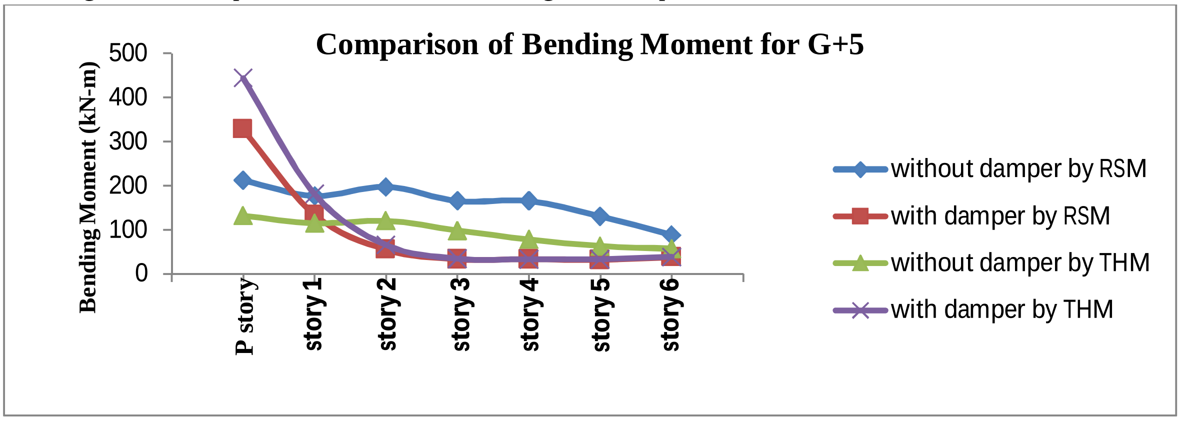

Fig.7.Showing Bending Moment for G+5 story building

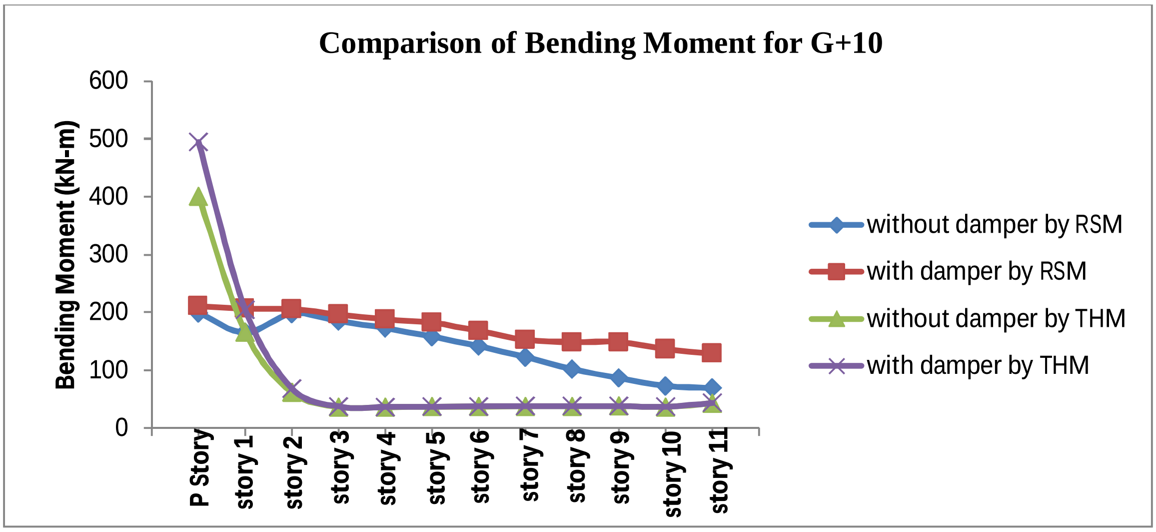

Fig.8.Showing Bending Moment for G+10 story building

D. Storey Drift

Fig 9 and 11 shows the result of story drift in X -direction for G+5 and G+10 story building whereas fig 10 and 12 shows story drift in Y- direction for G+5 and G+10 story building . From the result obtained it is observed that story drift for building without damper is having maximum drift when compared with building with damper.

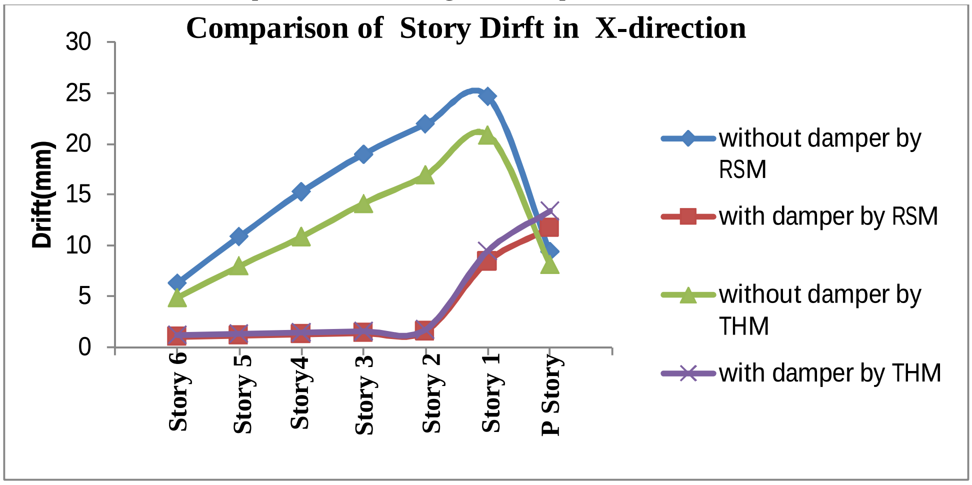

Fig.9.Showing Story Drift for G+5 story building in X-direction

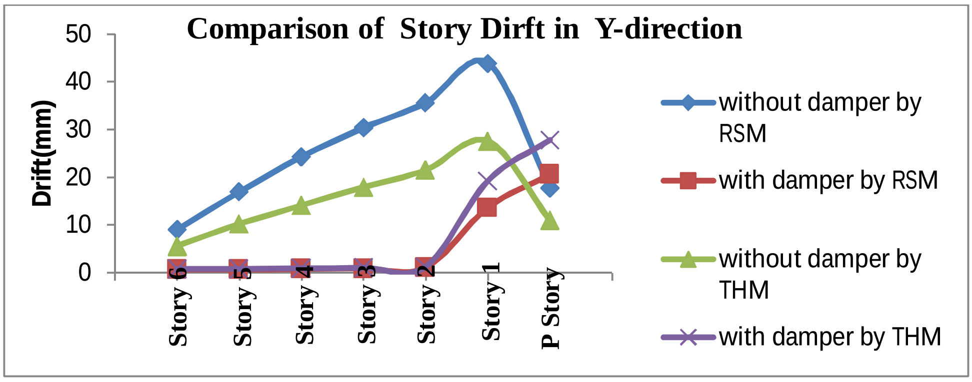

Fig.10.Showing Story Drift for G+5 story building in Y-direction

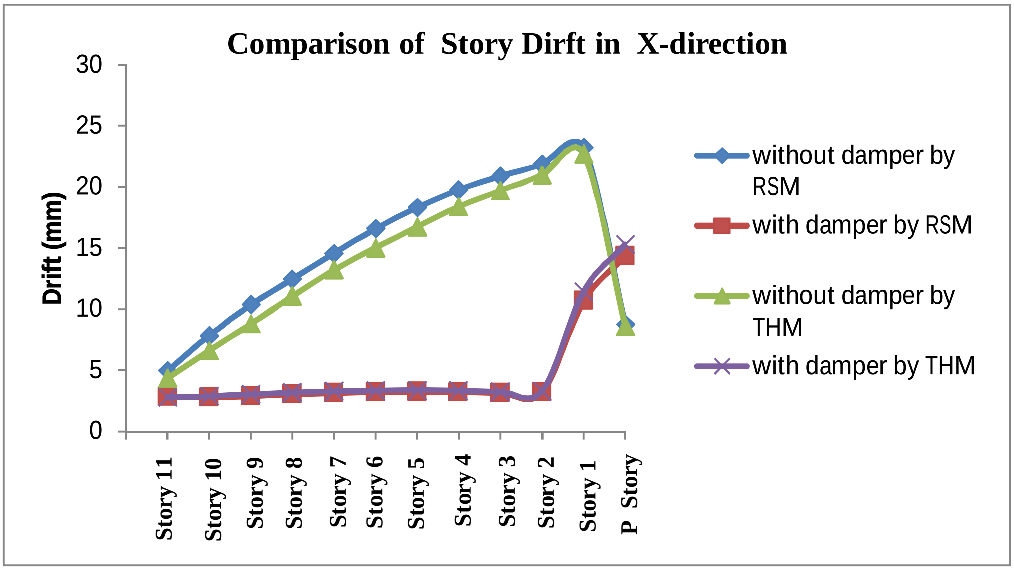

Fig.11.Showing Story Drift for G+10 story building in X-direction

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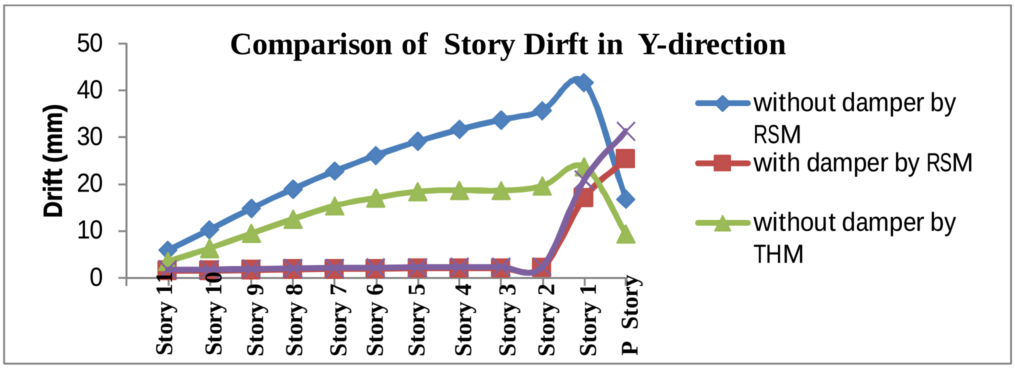

Fig.12.Showing Story Drift for G+10 story building in Y-direction

V. CONCLUSION

On analysis of G+5 and G+ 10 stories building with and without friction damper following conclusion are drawn**.**

A. It is observed that result obtained by connecting damper to the building satisfy's the aim .
B. The result shows that, the buildings without friction dampers are more defenceless compared to buildings with friction dampers.
C. Time history is best method to visualized the performance level of a building under give earthquake zone .
D. For more important structure time history analysis should be performed as it predict structural response more accurately as compared to response spectrum method .
E. As bending moment in column is more due to more displacement due to which secondary forces get generated.

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