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Seismic Response of Soft Storey Buildings with Viscoelastic Dampers

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***Abstract*- The study about past earthquakes revealed that, buildings with soft storey had collapsed more while compared to other buildings. Buildings with soft storey has disastrous effect than other ones during earthquake.In the present study, seismic response of soft storey structures fitted with Viscoelastic dampers (VED) had been studied. This dampers can also be used as a retrofitting technique to the existing structures. Different models were developed by considering various damper configurations viz. single diagonal bracing, chevron bracing and double diagonal bracing considering varying damping coefficients. Dynamic analysis was carried out by considering various time history analysis by using ETABS software.Results obtained from software for models with and without damper had been analysed in terms of top story displacements, inter-storey drifts and roof accelerations. Present study helped to identify that the use of VED can significantly reduce the response of earthquake to soft storey structures.**

Key words: Dampers; Viscoelastic; Earthquake response; soft storey

I. INTRODUCTION

A. Soft storey

Soft storey buildings are having storey's with relatively less stiffness compared to the storey above or below. This low stiffness story is flexible and weak making it more vulnerable to earthquake.According to ASCE,a soft storey has lateral stiffness less than 70% of that of the storeymmediately above, or less than 80% of average stiffness of thethree storeys above.

Soft storey buildings behave like an inverted pendulum. Current design practice only take bare frame for design consideration and thus neglecting the reduction in stiffness like open ground storey buildings.open ground storey buildings with infill walls in upper storey behave like an inverted pendulum. The ductility demand thus caused by this reduced stiffness are not satisfied by the conventional design methods. New techniques like seismic retrofitting with dampers can also be used in soft storey buildings to absorb the energy.Present study involves soft storey buildings with viscoelastic dampers and a comparison of these different damper configurations.

Figure 1: Soft storey building failure.

B. Viscoelastic Damper

Viscoelastic dampers reduce vibration of the buildings and they were previously used in reduction of wind induced vibration of the building. VEDs show property of the material as a material which shows both elasticity and viscosity. The material of VEDs are acrylic copolymers.Viscoelastic device generates force which is proportional to velocity of the device.

Where k is the spring stiffness, □□ is the deformation across the spring, C is the damping coefficient, V is thevelocity across the damper and α is the dampingexponent. The damping exponent must be positive. Thepractical range is between α = 0.2 and 2.0. In the presentstudy α is taken as unity.

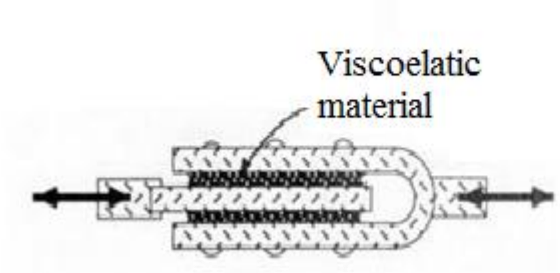


Fig 2: General VED

II. ANALYTICAL STUDY USING ETABS:

A. Method of study:

The model of the soft storey structure is created in ETABS. Material and member properties are then defined and assigned to the model. Base of the models are considered to be fixed. Vertical loads are assigned to the model and linear time history analysis is carried out on the model considering three different accelerograms. Model of the soft storey structure fitted with VED in different configurations are then created. Dampers are modelled as link element. Linear time history analysis is carried out on the models fitted with VED. Response of the soft storey structure without VED is then compared with the soft storey structure fitted with VED in terms of top storey deflection, inter storey drift and roof acceleration.

Models considered for study:

1. Two dimensional seven storey steel structure with and without damper configurations
2. Three dimensional seven storey steel structure with and without

B. Description of two dimensional steel structure:

The basic structure considered is a 7 storey steel frame, as shown in Fig. 3 which was initially studied by Tezcan & Oluca (2003). This model was adopted from the verification model of SAP 2000 program. The young's modulus of steel is considered as 200 GPa. Storey height of first two floors is 4.12 m and rest is 3.96 m with a bay width of 9.15 m. The structure is subjected to loads as shown in Fig.4. The member properties are as shown in Fig.4. The structure is retrofitted with VED in various configurations such as single diagonal bracing, K bracing and double diagonal bracing as shown in Fig.5 .and the damping coefficients of the dampers are varied from 500 to 5000 kN-s/m and equal structural stiffness of 25000 kN/m.

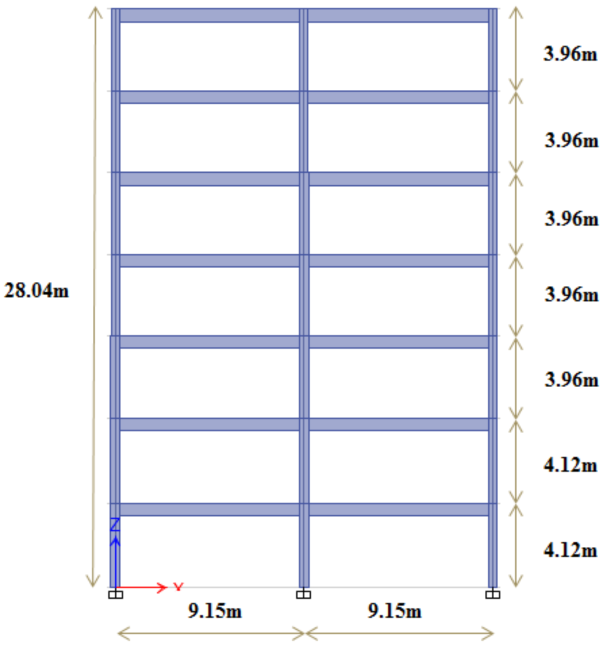


Fig 3: Frame dimensions.

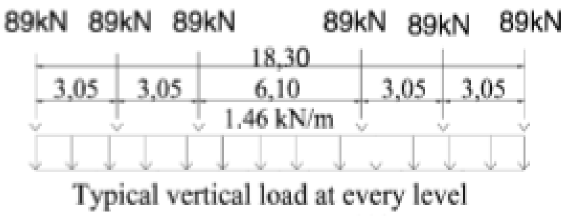
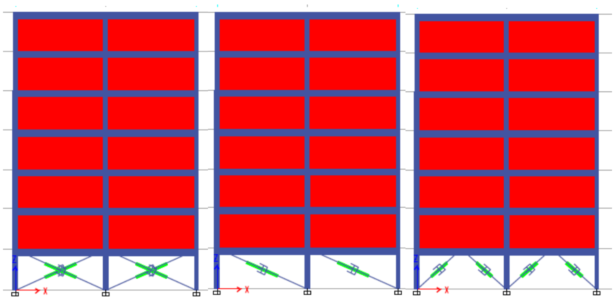


Fig 4: loading of the structure



(1)2B 2D (2) 2B1D (3) 2B K

Fig 5: Damper configurations in double bay

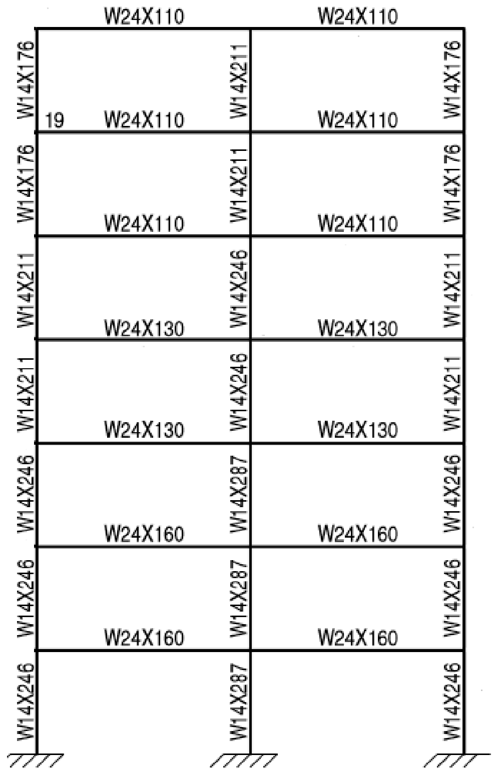


Fig 6: Member sections

C. Description of three dimensional steel structure:

Fig.7 represents the plan of the steel structure used in the study. The structure has a storey height of 4.12 m for first two floors and 3.96 m for rest of the floors. The young's modulus of steel is considered as 200 GPa. The beam carries uniformly distributed load of 1.46 kN/m. It also carries a concentrated load of 89 kN at every interval of 3.05 m. The beam and column sections are as mentioned in Fig. 4. VEDs are provided in both bays along X direction and in all bay along Y direction. These dampers are provided only at the outer bays. The damping coefficients of the damper are varied from 1000 to 10000 kN-s/m.

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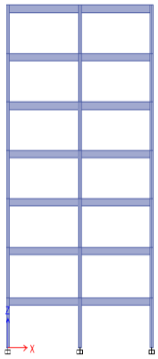


Fig 7: Elevation along x

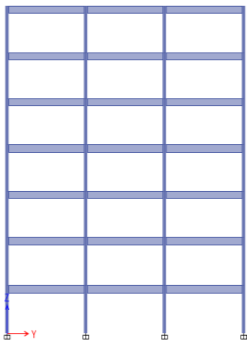


Fig 8: Elevation along y

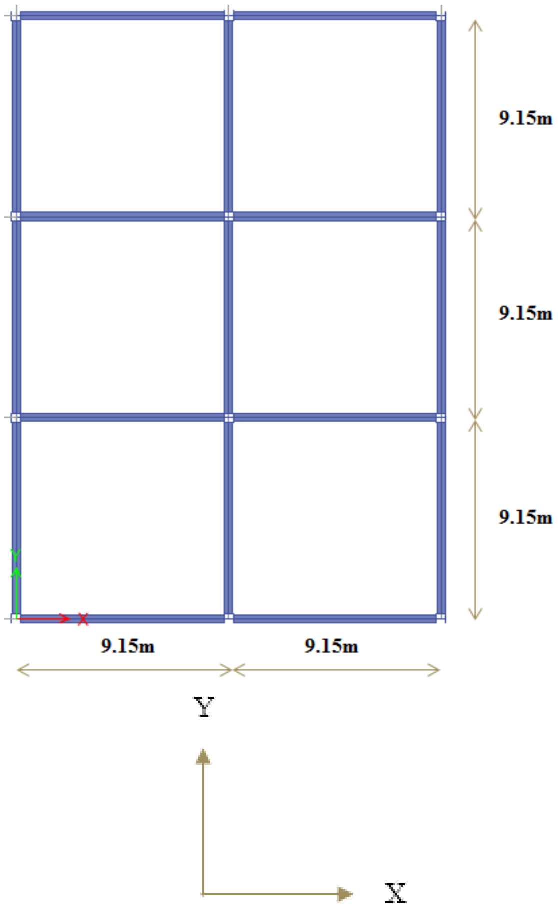


Fig 9: Plan of 3dimensional model

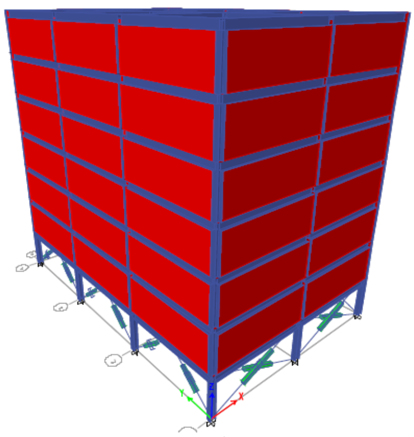


Fig 10: Isometric view of 3dimensional model

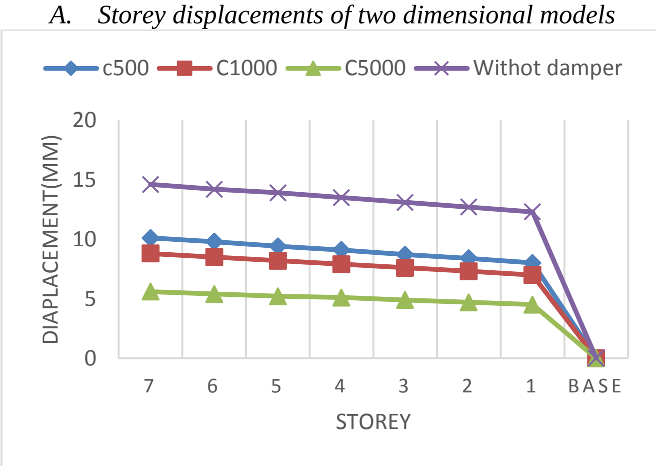
D. Earthquake Accelerograms:

The acceleration time history data used for the analysisare taken from records of past earthquakes occurred in the California. The first two accelerograms, LA03 (El Centro Array 5, James Road) and LA06 (El Centro Array 6) are takenfrom the1940 El Centro earthquake with a peak groundacceleration (PGA) of 0.386g and 0.23g respectively.Here LA represents Los Angeles. The thirdaccelerogram LA14 (Northridge, LA County Fire Station) is from the 1994 Northridge earthquake with aPGA of 0.64g.

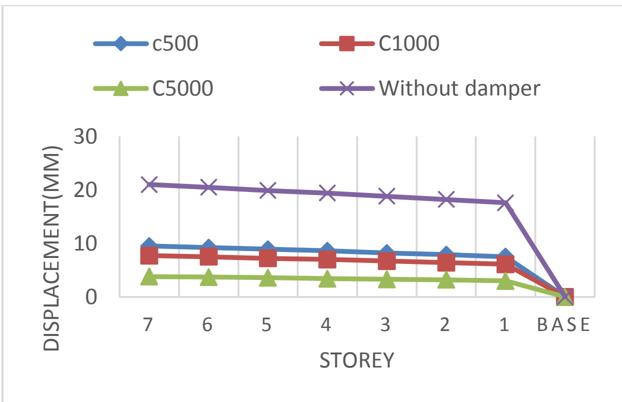
III. RESULTS AND DISCUSSIONS

A linear time history analysis was carried out on the soft storey structure with VED and without VED considering the three different accelerograms and their responses are studied. The Figures shown below represents the storey displacement of the soft storey structure fitted with VED in double bay double diagonal bracing (2B 2D),double bay single diagonal bracings(2B 1D), and double bay k bracings for earthquakesLA 03, LA 06 and LA 14 respectively.From these Figures it can be seen that 2B 2D structure achieves significant reduction in top storey displacement of more than 30%, 50% and 70% for damping coefficients 500, 1000 and 5000 kNs/m respectively

A. *Storey displacements of two dimensional models*



Graph 1: LA-03 2B 1D



Graph 2: LA-06 2B 1D

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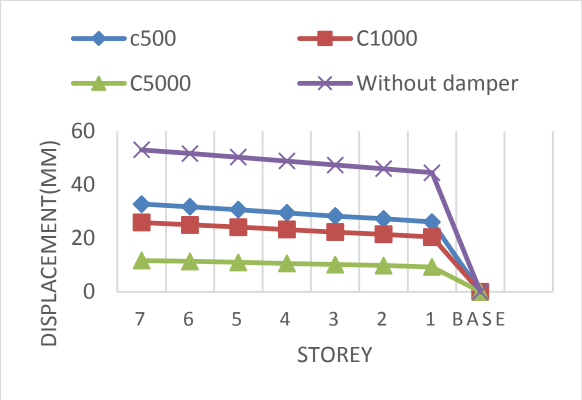
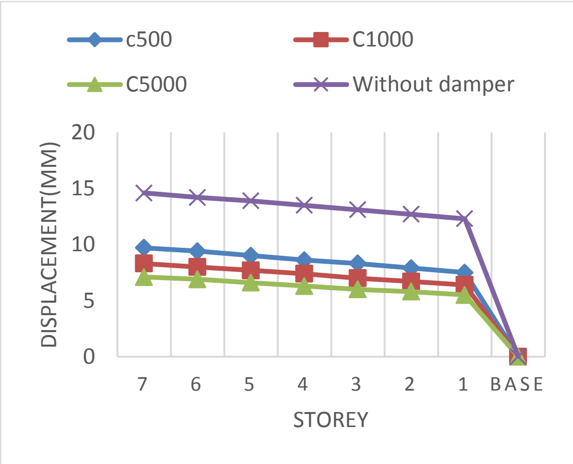
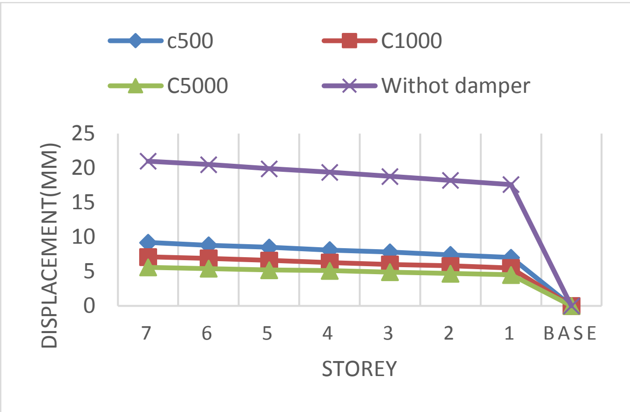


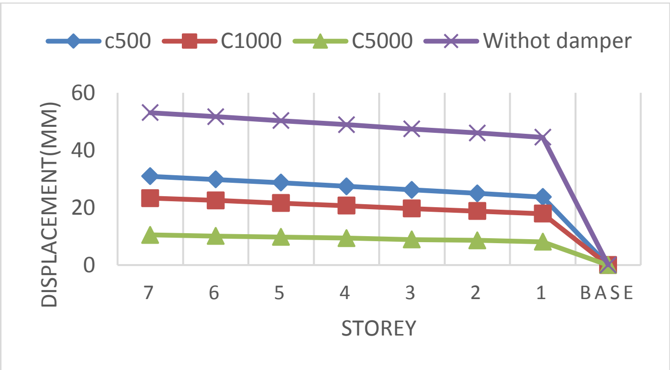
Graph 3: LA-14 2B 1D



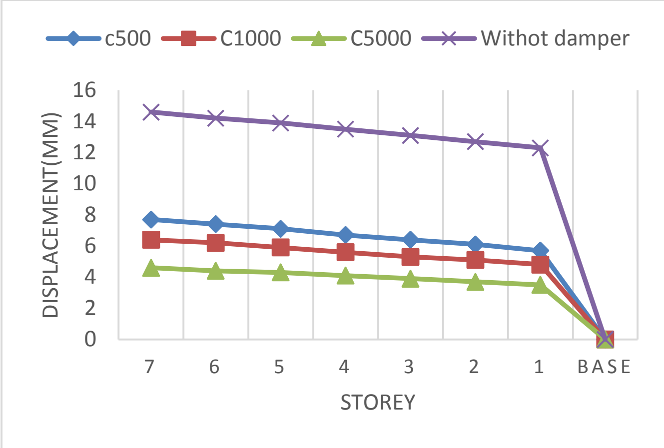
Graph 4: LA-03 2B K



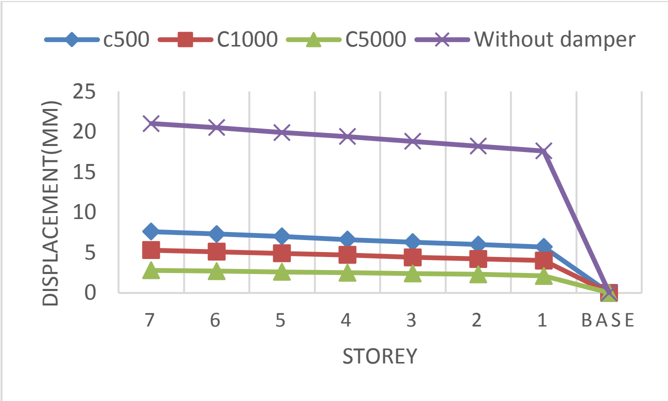
Graph 5: LA-06 2B K



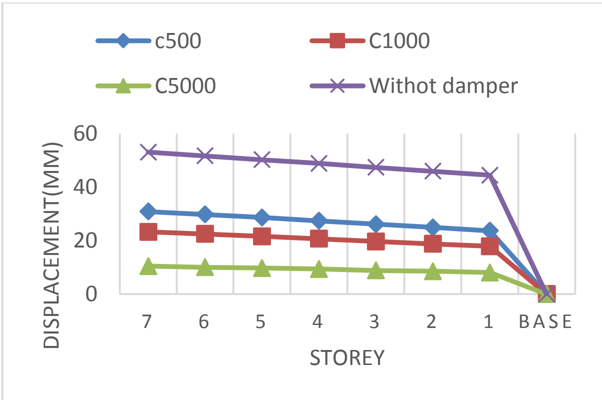
Graph 6: LA-14 2B K



Graph 7: LA-03 2B 2D



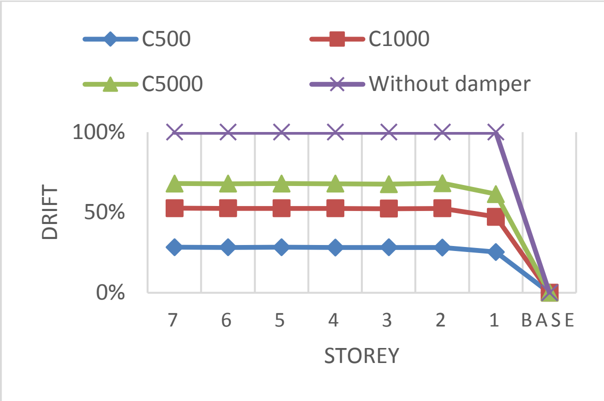
Graph 8: LA-06 2B 2D



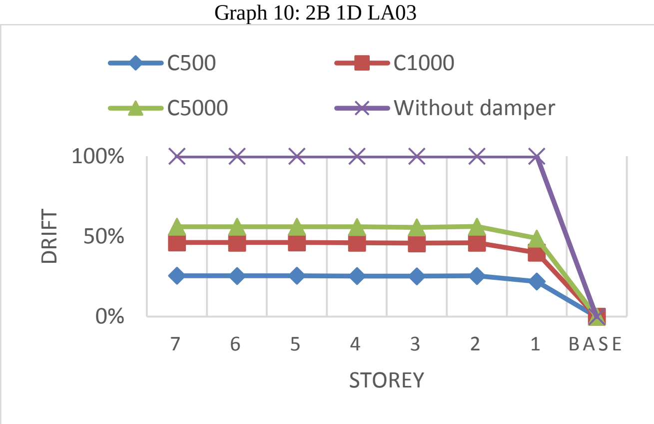
Graph 9: LA-14 2B 2D

The graphs below represents the inter storey drifts in percentage compared to the model without damper. The inter storey drift reduction shown here is of the double bay single diagonal configuration.

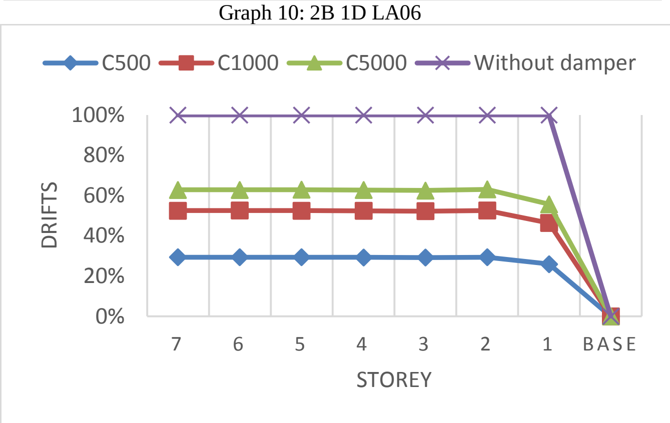
B. *Storey drifts of two dimensional model*



Graph 10: 2B 1D LA03



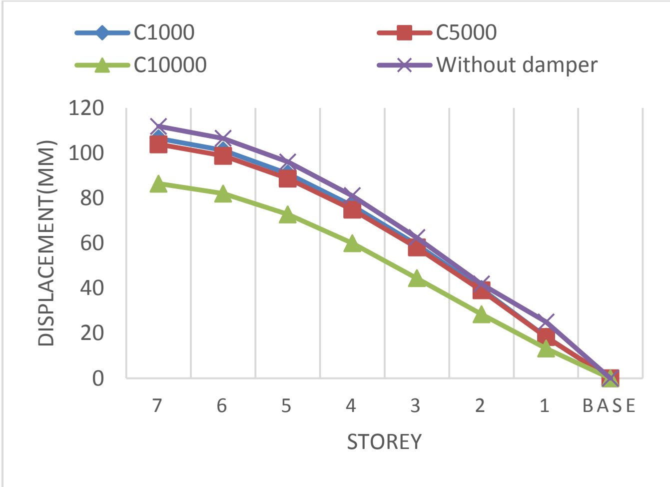
Graph 10: 2B 1D LA06



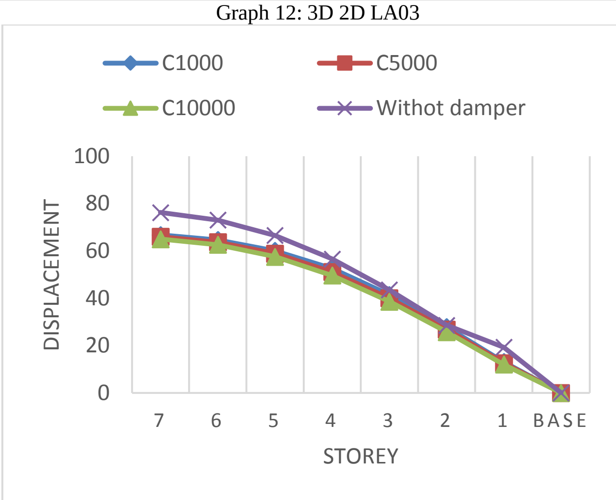
Graph 11: 2B 1D LA14

Results of the analysis of three dimensionalstructure did not show significant structure response reduction compared to the two dimensional model. This variation may be due to the placing of dampers only at outer bays and also design check of the bare frame model taken from the referred main paper were not structurally adequate. However there is a reduction in response of the structure regarding the storey displacement and roof accelerations. The graphs below shows some of the structural responses and their reduction with different damping coefficients. The double diagonal and k damper configuration is taken for the three dimensional analysis.

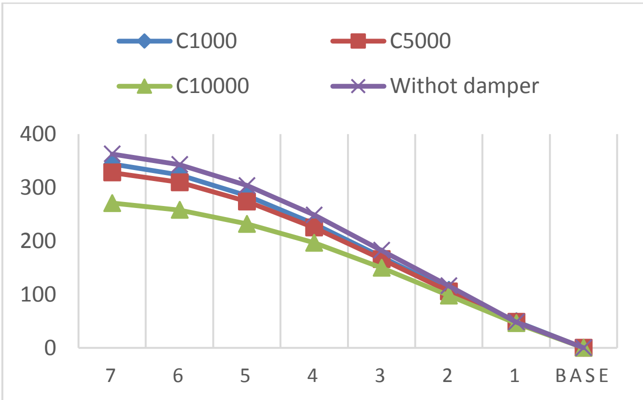
C. *Storey displacement of three dimensional model.*



Graph 12: 3D 2D LA03

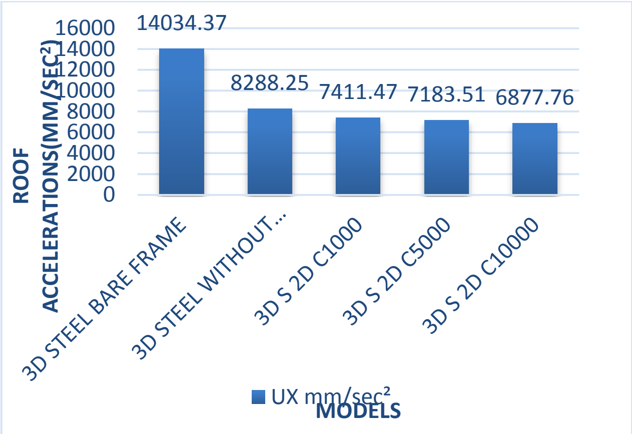


Graph 13: 3D 2D LA06



Graph 14: 3D 2D LA 14

D. Roof accelerations of the three dimensional model.



Roof accelerations have shown significant reduction in the storey response compared to bare frame and no damper models.

IV. CONCLUSION

Viscoelastic damper offers a significant seismic response reduction of the buildings.VEDs are maintenance free and easy to install compared to the other dampers.one of the main advantage of VEDs is that they absorb even minor vibrations whereas frictional dampers, yielding dampers absorb seismic energy only after a particular limit of energy.

The two dimensional model analysis shows that dampers reduce the displacement so that it is under the storey drift limit as mentioned in IS-1893(part-1): 2002 and also the story stiffness is under the limit as mentioned in IS-1893(part-1): 2002. The reduction of this displacement of storey is to an extent of 70% compared to the storey displacement of soft storey model without damper.

Because of the ease of installation and from the current study of analysis VEDs can also be used as a retrofitting techniques to the existing structures which is not structurally adequate after inspections.

The three dimensional model can reduce reduction in the storey displacement if they are provided with damper configurstion on both inner and outer bays and also if they are structurally safe in design check of the bare frame model.

REFERENCES

[1] Tezcan S S and Ozan Oluca, "Reduction of earthquake response of plane frame buildings byviscoelastic dampers", *Engineering Structures 25,2003.*

[2] Symans M D, "Energy dissipation systems forseismic applications : current practices and recentdevelopments", *Journal of Structural Engineering*,pp. 3-21, 2008

[3] Goplakrishnan N and Prakashvel J,"Case studies of seismic resistant design with viscoelastic dampers and base isolatore", CSIR-Structural Engineering Research Centre, Chennai, 2014.

[4] Samali B and Kwok K C S, "Use of viscoelastic dampers in reducing wind- and earthquake- induced motion of building structures", *Engineering structures*,vol.17, pp. 639-654, 1995.

[5] Shen K L and Soong T T, " Seismic behavior of reinforced concrete frame with added viscoelastic dampers", vol. 17, No. 5, pp, 372-380, 1995.

[6] Kasai K and Fu Y , "Comparative study of framesusing viscoelastic and viscous dampers", *Journal ofStructural Engineering*, pp. 513-522, 1998.

[7] Saidi I, Gad E F, Wilson J L and Haritos N, "Development of passive viscoelastic damper to attenuating excessive floor vibrations", *Engineerignstructur33 ,2011*