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Analysis of G+42 R.C.C Structure Using Viscoelastic Damper

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***Abstract* – This paper describes the seismic and wind analysis of an R.C.C high rise structure with added viscoelastic dampers. It shows the results of the seismic and wind response of an R.C.C (G+42) storey structure with and without the use of viscoelastic dampers. When passive energy dissipating devices such as viscoelastic damper is provided to the structure, the seismic forces such as absolute displacement, absolute acceleration, storey drifts are considerably reduced. It also shows the comparison of viscoelastic damper with different stiffness and damping coefficient values. Analysis is carried out using ETABS.**

***IndexTerms* – Viscoelastic damper, damping, high rise structure, energy dissipating device, storey displacement.**

I. INTRODUCTION

In recent years, the concept of structural control has taken a central role in the seismic design of civil structures. The idea is that a safer and more economical design can be achieved by adding to the system innovative devices to reduce the forces and deformations in structures. By modifying the dynamic properties of the system, these devices aim to control the response and the energy dissipation demands of the structural members. The operation of these special devices is initiated by the motion of the structure and, guided by the control scheme. They reduce the overall response of the system and thus meet the design goal in mitigating seismic damage. Various response control methods have been implemented in the design procedures and can be generally divided into three groups: passive control, active control, semi-active control. Among these methods, passive control devices were developed the earliest and have been more commonly in practice for seismic design because they require minimum maintenance and need no external power to operate.

High rise buildings built in seismic areas is a challenge for the designers, since they have to reduce the vibration induced by both, strong winds and earthquakes. In such cases dampers are very effective. Damper devices are easy to manufacture and can be easily implemented in the structure. Dampers are economical to manufacture due to its availability.

The main objective of this paper is to generate fundamental information on the seismic and wind performance of high rise R.C.C building having passive damping device, viscoelastic damper.

Following are the objectives of the present work,

- To perform quasi-static analysis according to response spectrum curves and wind analysis with and without the use of viscoelastic damper.
- Modeling of viscoelastic damper in ETABS software.
- Study of results in terms of storey displacement, storey drift, storey acceleration.
- To assess how the variation of placement of dampers affect the seismic response of the building.

II. METHODOLOGY

Viscoelastic dampers are non load carrying element and are designed such that a part of the mechanical energy of the building motion is transferred into heat which results in a reduction of the amplitude of the vibratory motion. The medium in which this transfer of energy takes place is a viscoelastic material.

The mechanical properties of viscoelastic materials are complex and may vary with environmental temperature and excitation frequency. The best method of evaluating the properties of the damper is to generate the hysteresis loop by subjecting the centre part of the damper (Figure 1) to a periodic displacement then plotting this and corresponding shear force on an x-y axis (Figure 2) for one cycle. The area of hysteresis loop represents the actual energy lost or damped. The damper properties given in the table are taken from literature of “Comparative Study on Seismic Behavior of RC Framed Structure Using Viscous Dampers, Steel Dampers and Viscoelastic Dampers” by X.L. Lu, K. Ding, D.G Weng, K. Kasai & A.Wada and Design Guidelines by Trevor E Kelly, S.E Holmes Consulting Group.

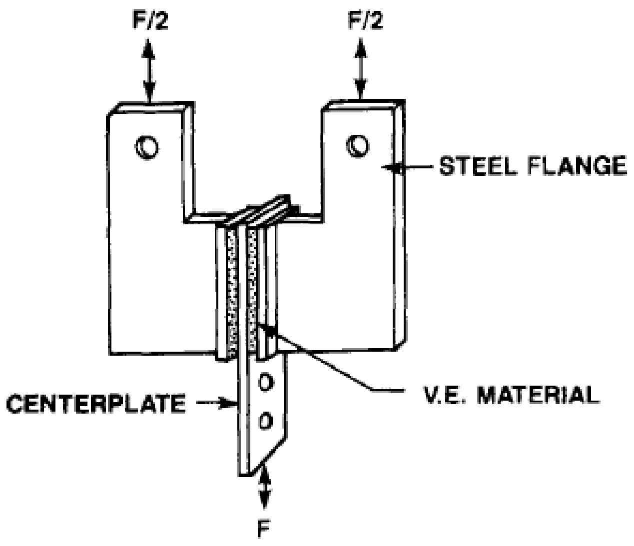

Fig.1 Layout of Viscoelastic Damper

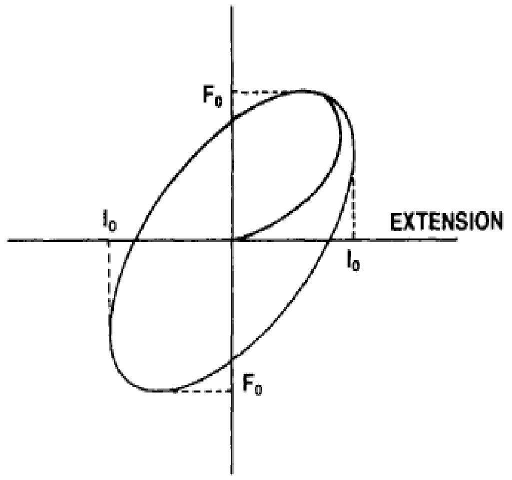

Fig.2 Layout of Viscoelastic Damper

TABLE I
DETAILS OF STRUCTURE

Plan Dimensions	21.9m x 19m
Building Heights	Total building height above ground is 139.3m and floor to floor height is 3.3m.
Dead load and live load	Floor finish=1.5KN/m^2 Live load=2KN/m^2 (general)
Seismic load	Seismic Zone=3,Response reduction factor R=4.5,Soil type=1,Importance factor I=1,Soil type=1,Damping=5%
Wind Load	V_b=44m/s, category=3,class=C Gust factor as per clause 8 of IS 875
Damper Properties	Stiffness, K=20000 KN/m Damping coefficient, C=10000 KN-sec/m which is referred as D1 and K=57000 KN/m C=12000 KN-sec/m which is referred as D2
Analysis Software	ETABS 9.7.4

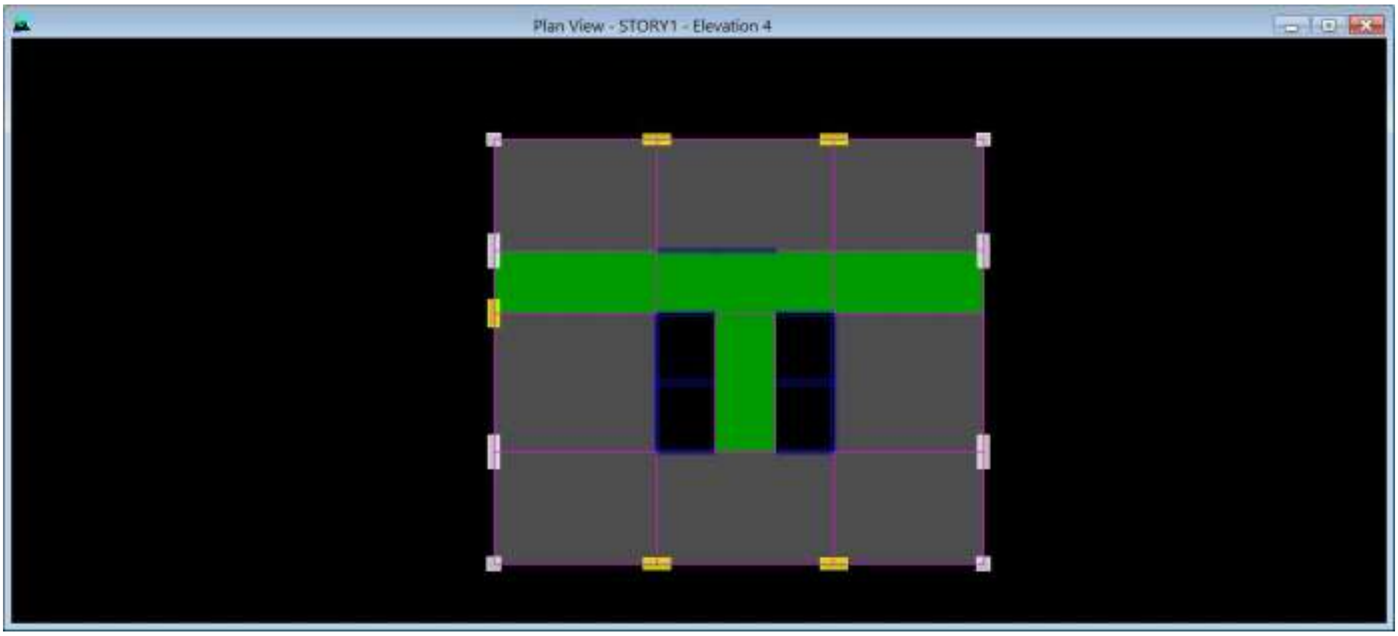

Fig.3 Plan of structure in ETABS

III. RESULTS

For the comparison of results obtained from analysis in ETABS, firstly comparison of top storey displacement for seismic analysis is done considering with and without viscoelastic dampers. Then comparison for top storey displacement with and without dampers is done for wind analysis. Finally the dampers are placed, first at top 25 stoteys and then from 7th storey to 32nd storey to obtain the suitability of damper location.

1. RESPONSE SPECTRUM ANALYSIS RESULTS

TABLE II
(%) REDUCTION IN STOREY DISPLACEMENT DUE TO VISCOELASTIC DAMPER

Dampers	**X-Direction (%)**	**Y-Direction (%)**
D1	17.99	3.52
D2	18.75	4.08

It can be observed that absolute displacement reduces effectively by 17.99% and 3.52% for x and y direction respectively for D1 and by 18.75% and 4.08% for x and y direction respectively for D2.

2. WIND ANALYSIS RESULTS

Following table shows comparison of top storey displacement with and without viscoelastic dampers.

TABLE III
(%) REDUCTION IN STOREY DISPLACEMENT DUE TO VISCOELASTIC DAMPER

Dampers	**X-Direction (%)**	**Y-Direction (%)**
D1	19.05	4.28
D2	19.94	4.44

It can be observed that absolute displacement reduces effectively by 19.05% and 4.28% for x and y direction respectively for D1 and by 19.94% and 4.44% for x and y direction respectively for D2.

3. DAMPER PLACEMENT AT DIFFERENT LOCATIONS

A. DAMPER PLACEMENT FOR TOP 25 STOREYS

TABLE IV
(%) REDUCTION IN STOREY DISPLACEMENT DUE TO VISCOELASTIC DAMPER

Dampers	**X-Direction (%)**	**Y-Direction (%)**
D1	5.36	1.45
D2	7.81	1.89

It can be seen that displacement at top gets reduced by considerable amount but overall displacement reduction throughout the structure is less.

A. DAMPER PLACEMENT FROM STOREY 7 TO STOREY 32

TABLE V
(%) REDUCTION IN STOREY DISPLACEMENT DUE TO VISCOELASTIC DAMPER

Dampers	**X-Direction (%)**	**Y-Direction (%)**
D1	6.63	1.93
D2	9.60	2.52

It can be seen that displacement at top gets reduced by considerable amount and overall displacement reduction throughout the structure is more as compared to the previous case.

IV. CONCLUSION

- The results show that, response of the structure can be greatly reduced by using viscoelastic dampers.
- Properties of dampers i.e stiffness and damping coefficient are highly sensitive to temperature changes but comparatively less sensitive to frequency change.
- The best suited position for damper placement is at the point of maximum inter-storey drift than at the point of maximum absolute displacement.
- The base shear of the structure reduces considerably by using viscoelastic dampers.
- Instead of providing dampers to all over the structure we can obtain overall reduction in displacement of the structure by providing dampers at point of maximum inter-storey drift.

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