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PERFORMANCE ANALYSIS OF HIGH RISE RCC FRAME STRUCTURE USING VARIOUS TYPES OF DAMPERS

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Abstract - *In recent years, the concept of structural control has taken a central role in the design of civil structures. The philosophy is that a safer and more economical design can be achieved by adding innovative devices to the system 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 are 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.*

***Key Words*: RCC frame structure, Passive damper**

1. INTRODUCTION

Advances in new materials, the progress in new structural systems, as well as the developments in computational software and design methods, have made possible the construction of extremely tall buildings in modern days. However, the race toward new heights has not been without its challenges. The ever-increasing height of the tall structure poses considerable challenges for structural engineers and researchers in this field. Among the many difficult technical problems involved in design, the effects of wind and earthquakes on these structures are definitely the most critical issues. The most important task to be overcome is, both the criteria of serviceability and safety (strength) must be carefully considered and satisfied in the design. For modern buildings become taller, they also become more flexible and slender. Such structures are almost always sensitive to wind excitations, and therefore service ability becomes a critical issue. Under most circumstances, the inherent damping in a high rise building itself is not sufficient to satisfy the serviceability requirements. In addition, it has been shown that earthquakes are able to generate base shears up to a magnitude comparable to that of the notional horizontal load, which is sometimes even greater than the wind loading. In particular, high-rise buildings can be very sensitive to dynamic excitations by earthquakes. Therefore, in order to reduce the dynamic responses of high rise structures to meet the serviceability criterion, many strategies are considered in terms of increasing the structural damping to achieve the goal.

1.1 OVERVIEW

Considering the ever increasing population, and increased industrial demand, there has been a boom in the construction industry. Economics and safety are the priorities for any structural engineer, which has cleared the way for more specific and sound structures. Various types of commercial and residential buildings are equipped with different types of base isolation techniques and damping systems. This has intensified the production and use of dampers in the western countries; where in optimum placing of the dampers has become an integral part of the building design. In India too, modern constructions have seen implementing these techniques, thus promoting the need for study and analyzing of methods of resisting seismic waves.

As per the standard codes, a structure that can resist the highest earthquake that could possibly occur in that particular area can be called as an earthquake resistant structure. However, the most efficient way of designing earthquake resistant structure would be to minimize the deaths as well as minimize the destruction of functionality of the structural element. The most disastrous thing about earthquake is its unpredictability of time and place of occurrence. This poses a great challenge to the economy and safety of the structure. It requires that the elements of the building, be designed to expiate the energy received by earthquakes to minimize the damage caused.

1.2 TECHNIQUES TO RESIST EARTHQUAKES

Various response control methods have been implemented in the design procedures and can be generally divided into three groups: passive control, active control, and semi-active control. Among these schemes, passive control devices were developed the earliest and have been used more commonly in practice for design, because they require minimum maintenance and need no external power supply to operate.

1.3.1 DAMPERS

Viscoelastic Damper

Viscoelastic(VE) damper is one of the best appropriate dissipation devices. This type of damper dissipates the building's mechanical energy by converting it into heat. Several factors such as ambient temperature and the loading frequency will affect the performance as well as the effectiveness of the damper system. VE dampers have been able to increase the overall damping of the structure significantly, therefore, improving the overall performance of dynamically sensitive structures.

In addition, the visco-elastic (VE) dampers are considered to be the most promising and have been installed in several buildings all over the world. It consists of layers of VE material (copolymers or glassy substances) bonded with steel plates. Vibration energy is dissipated through sheared formation of VE materials and wiched between steel plates, (Nishant.K.R.etal,2009).

Fig: Viscoelastic Damper
Pic courtesy: www.google.com

Viscous Damper

viscous dampers are known as one of the effective energy dissipation device, improving structural responses. Using supplemental viscous dampers to dissipate energy and reduce building response to dynamic inputs is gaining worldwide acceptance. This type of dampers has been successfully installed in a number of tall buildings and other structures to reduce the motion of amplitude and the acceleration occurring due earthquake forces& vibrations occurs in a building due to any other reasons. Damper system involves the installation of viscous dampers at various points in structure having relative displacement during excitation.

Viscous dampers, which utilize the principle of fluid flow through orifices, were originally developed as shock absorbers for the defense and aerospace industries. In structures work it acts much like a shock absorber works within a car, but on a much greater scale. Viscous dampers have been used for both new as well as retrofit construction. The viscous nature of the device is obtained through the use of specially configured orifices, and is responsible for generating damper forces that are out of phase with displacement. The damper is usually installed as part of a building's bracing system. Subsequent to installation, the dampers will not require maintenance and have been shown to possess stable and dependable properties for design.

Characteristics of these devices which are of primary interest in structural applications are the linear viscous response achieved over a broad frequency range, insensitivity to temperature, and compactness in comparison to stroke and output force. The viscous nature of the device is obtained through the use of specially configured orifices, and is responsible for generating damper forces that are out of phase with displacement.

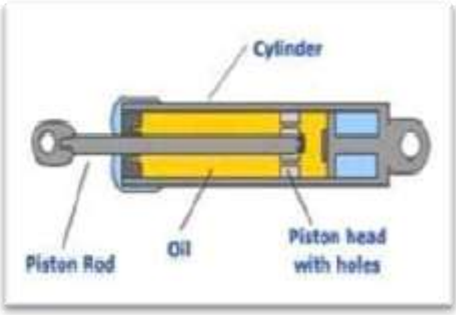

Fig: Viscous Damper

Pic courtesy: www.google.com

2.METHODOLOGY

Among finite element method software's, ETABS is known as "Extended 3D Analysis of Building Structure" software in industry and university researches. It is used for static as well as dynamic analysis of structures. In the present study three dimensional analyses with the help of ETABS (Non-linear version) is used for modeling and analysis of the structure.

Type of structure:	RCC building structure
No of storeys:	G+40
Plan dimensions:	22m x 26m
Floor to floor Height:	4 m
Damping mechanism:	Viscous & viscoelastic damper

Damper location: Installations of viscous fluid & viscoelastic dampers at different locations along the height and width of the building.

2.1.1 SECTION DETAILS

Column: 1250 x 500 mm – base to 11 Storey

Column: 1250 x 500 mm – base to 11 Storey

Column: 1250 x 300 mm – 11 to 21 Storey

Column: 1000 x 300 mm – 21 to 30 Storey

Column: 1250 x 300 mm – 21 to 30 Storey

Column: 1200 x 300 mm – 31 to 40 Storey

Column: 1500 x 500 mm – top to bottom centre 4 column

Slab = 150 mm

Beam = 1200 x 300 mm

Linear Properties

Effective Stiffness: 62750.13 kN / m

Effective Damping: 69676.63 kNS / m

2.1.2 FOR SEISMIC ANALYSIS ACCORDING TO IS 1893-2002

Seismic Zone = 0.36

Soil Type = II

Importance Factor = 1.5

Response Reduction = 5

2.1.3 FOR WIND ANALYSIS ACCORDING TO ACCORDING TO IS 875 (PART3):1987

Windward Coefficient = 0.8

Leeward Coefficient = 0.5

Wind Speed = 44 m/s

Terrain Category = 4

Structure Class = C

Coefficient (K1 Factor) = 1.07

Topography (K3 Factor) =1

Parapet Height =1.5 m

Dead load = 6 kN

Live Load = 4.5 kN

2.1.4 MATERIAL PROPERTIES

Grade of concrete: M40

Grade of steel: Fe500

Unit weight of RCC: 25 KN/m^3

Unit weight of masonry: 20 KN/m^2

2.1.5 LOADING

Gravity loads

Dead loads according to IS 875: Part I

Live loads according to IS 875: Part II

Wind load

Wind loads have been calculated in accordance with IS 875: Part 3.

Basic wind speed is taken as 44 m/s (Mumbai).

Risk coefficient and topography factor are taken as unity.

Code refers following load combinations for wind analysis.

1.5 (DL + LL)

1.2 (DL + LL ± WL)

1.5 (DL ± WL)

0.9 DL ± 1.5 WL

Seismic Loads

Criteria as per IS 1893: 2002

As per this code, Mumbai has been designated to Zone III.

Soil type: Medium

Code refers following load combinations for seismic load analysis.

1.5 (DL + LL)

1.2 (DL + LL ± EQ)

1.5 (DL ± EQ) 0.9 DL ± 1.5 E

2.1.6 DAMPER DETAILS:

Damper type: Viscoelastic Damper

Model: 3MISD110

Dimensions: 30x76x2.5cm.

Design Temp: 30 ^{0} C

Designed Values:

Shear Modulus G'- 0.348Mpa

Loss Modulus G''- 0.417Mpa

Stiffness coefficient (k) - 12695.04 KN/m

Damping coefficient (c) - 10444.48 KN$^{-(s/m)}$

Damper type: Viscous Damper

Model: Single Vane

Dimension: 2.1x2.4m

Width-2.1m

Height-2.4m

Stiffness co-efficient (k) - 32000 KN/m

Damping co-efficient (c) - 1225 KN$^{-(s/m)}$

3. RESULT AND CONCLUSION

The analysis of the high rise building was carried out and the response of the structure with respect to storey displacement of the structure modeled on ETABS has been determined. The difference in the results of these parameters after installing Viscoelastic & Viscous Dampers is represented in the form of graphs.

3.1 RESULT

Following are the results of the model, with and without Viscoelastic & Viscous dampers:

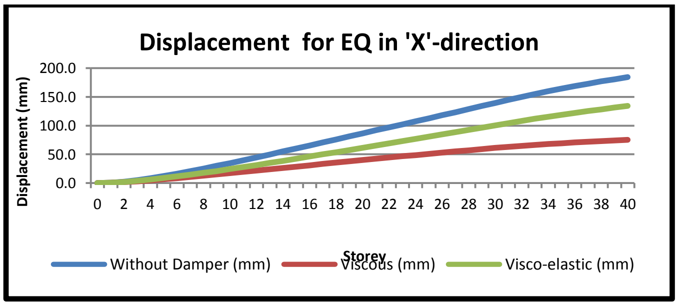

Chart -1: Displacement for Earthquake load applied in 'X'-direction

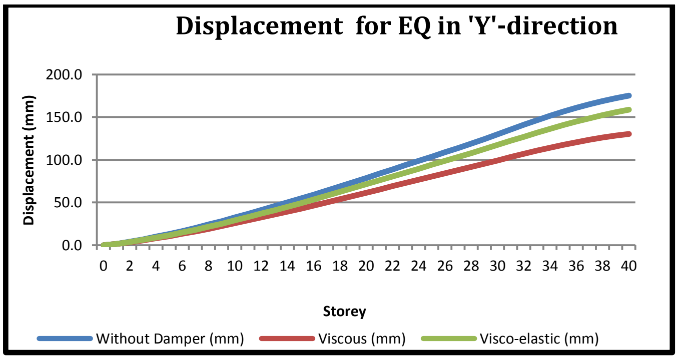

Chart -2: Displacement for Earthquake load applied in 'Y'-direction

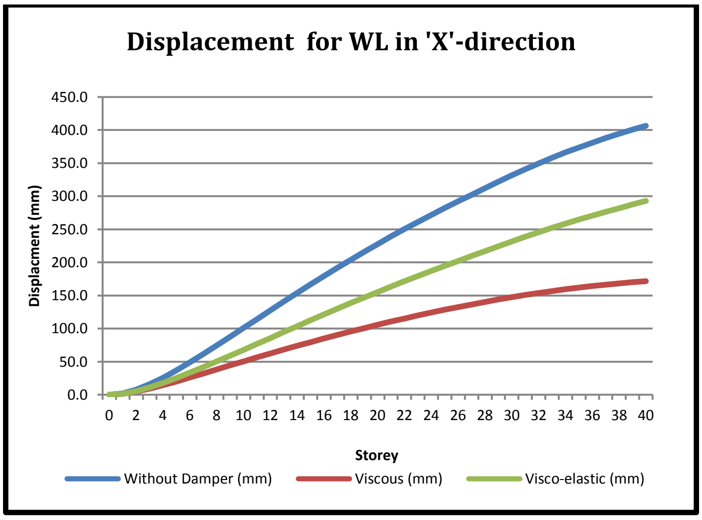

Chart -3: Displacement for Wind load applied in 'X'-direction

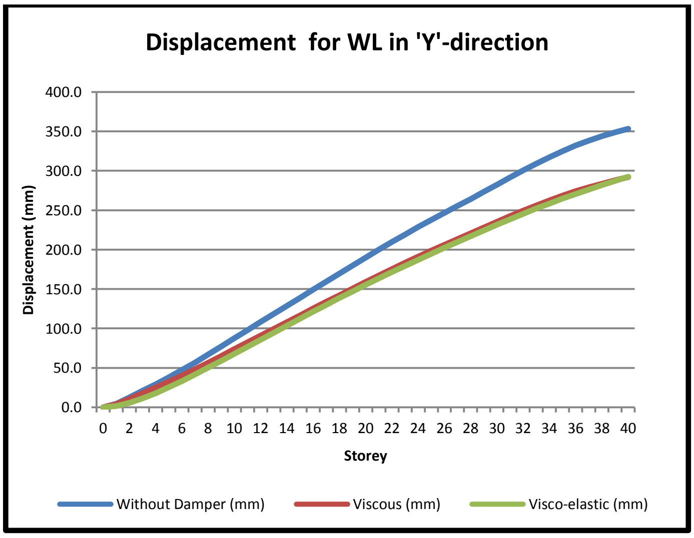

Chart -4: Displacement for Wind load applied in 'Y'-direction

3.2 CONCLUSION

1. The results of this investigation show that, response of structure can be reduced to significant amount by installation of various dampers.

2. From the above result we can see viscous damper is beneficial damper for all the aspects.

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