Comparative Analysis of a Multistorey Building with and without Damper

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ABSTRACT
Viscoelastic dampers are considered to be better than most of the passive energy dissipation devices. Researches done on the improvement of its performance for analyzing structures has always been in vogue. The significant change in the response of the structures to make it resistant to earthquake and wind forces is the main idea behind using such devices. A comparative analysis of a G+44 RCC structure has been carried out in this paper using Viscoelastic dampers. Dynamic behaviour of the structure for wind and earthquake loading with respect to response spectrum analysis is carried out. Changes in the responses of displacement, velocity, acceleration and drift for the damped structure are demonstrated illustrating the efficiency of dampers.

General Terms
Passive dissipation device, damping.

Keywords
Viscoelastic dampers, energy dissipation device.

1. INTRODUCTION
Earthquake in the simplest terms can be defined as Shaking and vibration at the surface of the earth resulting from underground movement along a fault plane. The vibrations produced by the earthquakes are due to seismic waves. Of all the factors accounted for, in any building design, seismic waves are the most disastrous one. Conventional methods of base widening, (as in case of pyramids) or providing heavy massive structure at bottom has been used in the past, for retaining earthquakes and to combat wind effect. However, modern high rise buildings and tall structures cannot conveniently be geared up with these techniques. The safety and serviceability of any structure is thus endangered with the increasing elevation.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 structure. It requires that the elements of the building, be designed to expiate the energy received by earthquakes to minimize the damage caused.The energy induced during the vibrations of any earth quake can be broadly classified under two heads, horizontal forces and gravitational forces. As for the gravitational pull, which increases during an earthquake, an efficient bracing system needs to be provided. This bracing will act as a retrifying system to dissipate extra energy imparted during an earthquake. The horizontal sway of the building can be controlled by providing dampers at optimum and critical locations. This project deals with the study of behavior of the building with viscoelastic dampers, making it earthquake resistant.

2. VISCO ELASTIC DAMPER
Viscoelastic (VE) damper is a passive type of energy dissipation device. 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 devices 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 shear deformation of VE material sandwiched between steel plates.

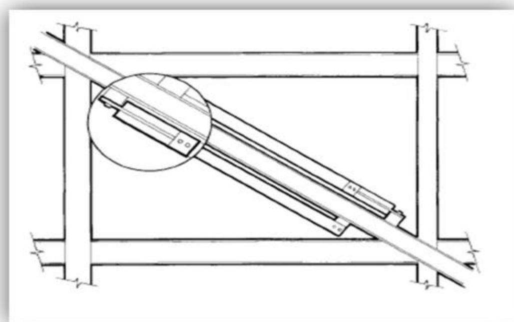

Fig 1: Diagonally installed visco elastic damper

Viscoelastic damper has a highly dissipative polymeric material incorporated into the structure. These materials have an elastic stiffness, which produces a displacement dependent force and viscous component produces a velocity dependent force. Viscoelastic dampers had been in use for the last 20 years as wind vibration absorbers in the terrorist attacked World Trade Center towers in New York City and have more recently been incorporated in a number of other buildings.

3. MODEL SPECIFICATION
The model considered for the study is a 44 storey commercial building, having a typical plan. Following are the specifications of the building:

1. General:

   G+44, floor to floor height 4m.

   Total plan dimension 26*16 sqm

   Elevators/lifts 2*(2.7*3.7).

   Concrete grade M40.

   HYSD FE 500.

2. Structural components:

   Beam: 230*600.

   Column:

   500*600 (30 storey+)

   500*1000(20-30 storey)

   500*1400(10-20 storey)

   500*1800(0-10 storey)

3. Loading:

Table 1. Illustrations of loadings

Type	Live load KN/sqm	Dead load KN/sqm
Slab	2.5	1.5
Stair case	4	2
Terrace	1.5	3

Beam: 11.6 KN/sqm.

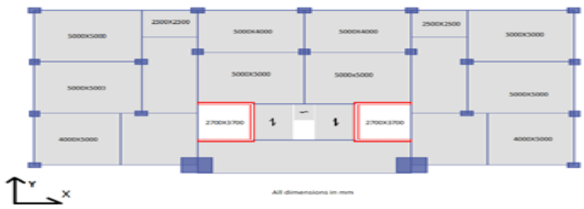

Fig 2: Plan of the model.

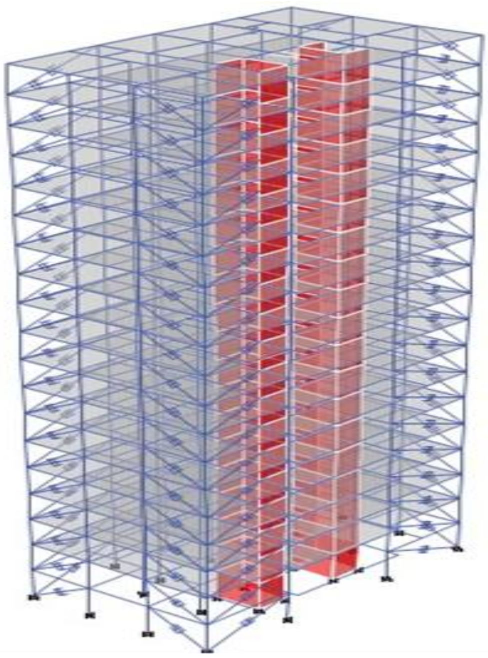

Fig 3: 3D view of the structure along withinstalled visco elastic dampers.

4. SELECTION OF DAMPER PROPERTIES

The prime factor determining the efficiency of any damper is its properties. Visco elastic dampers combines the effect of an elastic spring and viscous damper. The visco elastic material is sandwhiched between the steel plates. The properties of the visco elastic dampers are dependent on various factors, of which temperature is the most significant. The visco elastic dampers used in this project are the holmes consulting product. The stiffness of the damper K is 20000 KN/m while the damping coefficient C is 10000 KNs/m.

5. RESULTS

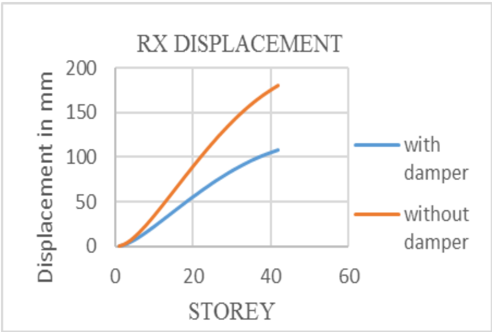

Fig 4: Storey displacement for earthquake in x direction.

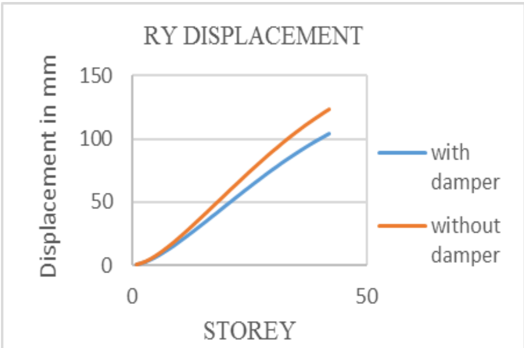

Fig 5: Storey displacement for earthquake in y directionn.

Fig 6: Storey displacement for wind in x direction.

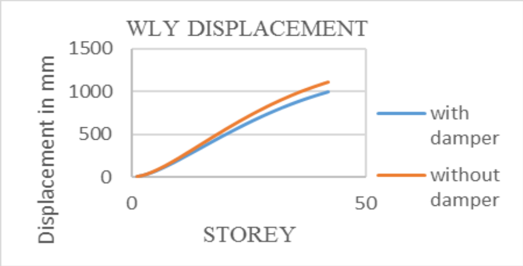

Fig 7: Storey displacement for wind in y direction.

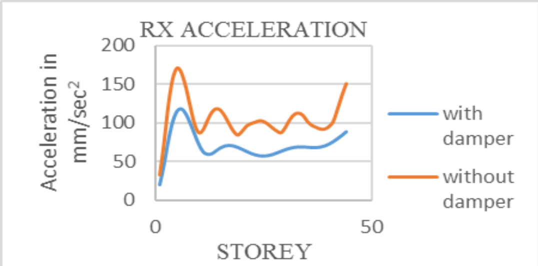

Fig 8: Storey acceleration for earthquake in x direction.

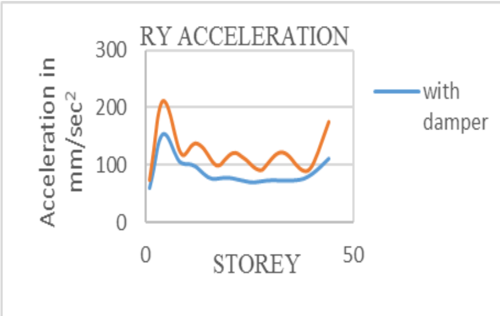

Fig 9: Storey displacement for earthquake in x direction.

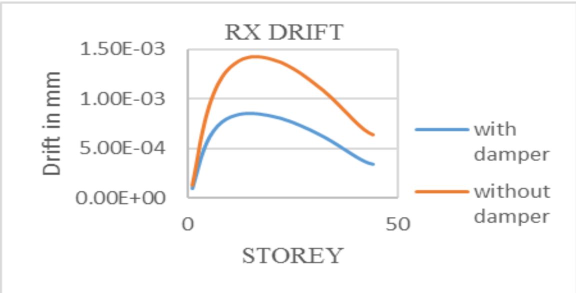

Fig 10: Storey drift for earthquake in x direction.

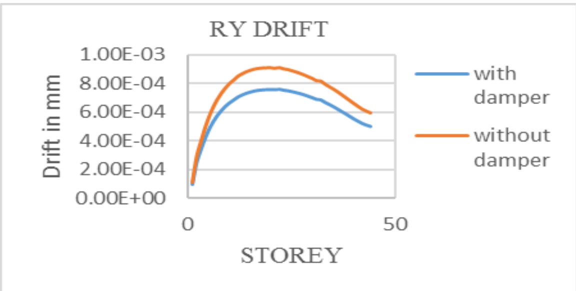

Fig 11: Storey drift for earthquake in y direction.

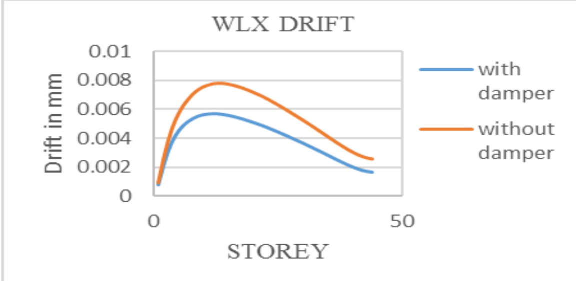

Fig 12: Storey drift for wind in x direction.

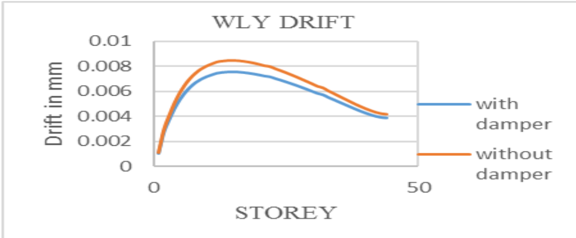

Fig 13: Storey drift for wind in y direction.

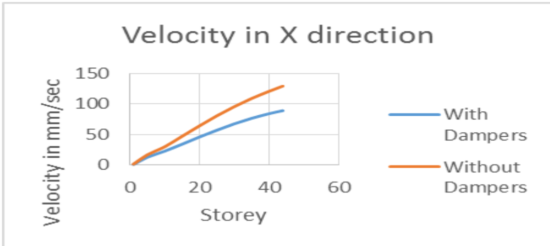

Fig 14: Storey velocity in x direction.

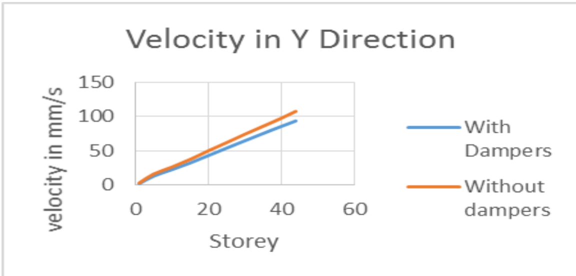

Fig 15: Storey velocity in y direction.

6. METHODOLOGY AND OBSERVATIONS

The model was analyzed using E-TABS 2013. The graph displayed (figure 4 to figure 15) above are for the respective directions of wind and earthquake forces against displacement, drift, velocity and acceleration. When combination of various loading were considered, it was found that displacement and drift were reduced by around 14% while acceleration was reduced by 25% in the damped structure. Prior to the analysis of this model a 20 storey building was worked on. The results for 20 storey, showed that the displacement and acceleration were around 15% and19% respectively. So the efficiency of dampers increases with elevation.

7. CONCLUSIONS

The following conclusions can be drawn from the present study:

1. The results of this investigation shows that, the response of structure can be dramatically reduced by using viscoelastic damper without increasing the stiffness of the structure.

2. It is observed that, the acceleration can be reduced by substantial amount whereas displacement to a considerable amount.

3. Viscoelastic dampers are unique in combating the wind forces, for its visco-elastic material, whereas other dampers are suitable mostly for earthquake forces only.

4. The performance of visco-elastic damper devices is much better for the tall buildings with slender design.

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