

# Application of Fluid Viscous Dampers In Multi-Story Buildings

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**ABSTRACT:** Viscous Damping is one of many different methods for allowing a structure to achieve optimal performance when it is subjected to seismic, wind, blast or other types of transient shock and vibration disturbances. A conventional approach would dictate that the structure must inherently attenuate or dissipate the effects of transient inputs through a combination of strength, flexibility and deformability. By adding fluid viscous dampers, the energy input from a transient is absorbed, not by the structure itself, but rather by the supplemental dampers.

**KEYWORDS:** Fluid viscous damping, resist against seismic, wind, shock and vibration disturbances, energy absorbers..

## I. INTRODUCTION

Fluid viscous damping is a way to add energy dissipation to the lateral system of a building structure. A fluid viscous damper dissipates energy by pushing fluid through an orifice, producing a damping pressure which creates a force. These damping forces are 90 degrees out of phase with the displacement driven forces in the structure. This means that the damping force does not significantly increase the seismic loads for a comparable degree of structural deformation and deflection.

The addition of fluid viscous dampers to a structure can provide damping as high as 30% of critical, and sometimes even more. This provides a significant decrease in earthquake excitation. The addition of fluid dampers to a structure can reduce horizontal floor accelerations and lateral deformations by 50% and sometimes more.

Using supplemental fluid viscous dampers to dissipate energy and reduce building response to dynamic inputs is gaining worldwide acceptance. The concept of supplemental dampers added to a structure is that they absorb much of the energy input to the structure from a transient, not by the structure itself, but rather by supplemental damping elements.

This paper presents an application of fluid viscous dampers in a high-rise structure to suppress the anticipated wind-induced accelerations. The description of the damping system, the design criteria and cost data are discussed.

The viscous damper system proves to be a very cost-effective method to reduce wind motions and resist seismic lateral loads and deflections of structures.

The Fluid Viscous Damper is an equipment protecting structure from damage in earthquake or strong wind.

**II. WORKING PRINCIPLE OF FLUID VISCOUS DAMPERS**

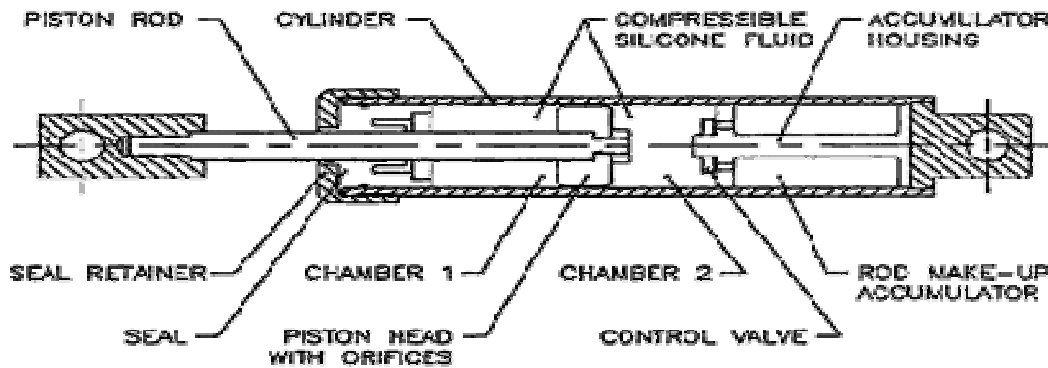


Figure 2.1 fluid viscous damper sketches

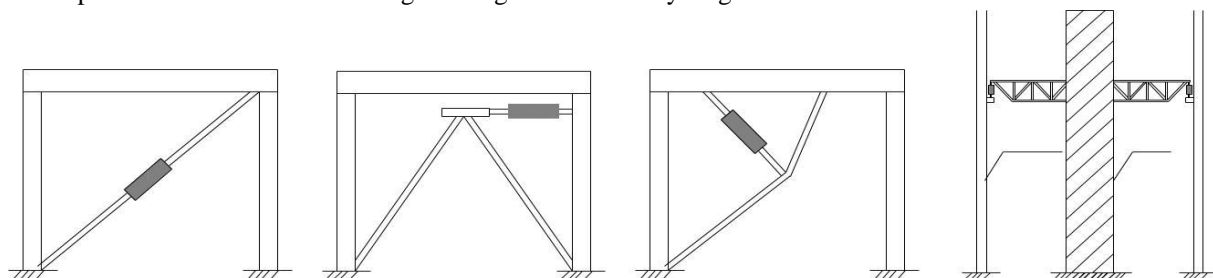
when the damper subjected to external loads to be compressed or stretched, the piston rod with piston will make reciprocating motion in the cylinder to force the damping medium move back and forth between the two cavities separated by the piston.

In the process, the friction force occurred between the molecules of the damping medium, the medium and the shaft and piston, the medium and the cylinder, and throttling damping force produced by the damping medium through the piston, all these action work together composed the damping force. The role of the fluid viscous damper is to transform mechanical energy caused by earthquakes, winds or other structural vibrations into inner energy of the damping medium. The dampers use the increasing temperature of damping medium to temporary store energy. The heat is ultimately consumed by natural cooling. In this way, the dampers protect the structure from damage.

In the course, the damping force should follow the formula:  $F = C v^\alpha$  F: damping force C: damping coefficient v: velocity of piston relative to cylinder  $\alpha$ : damping exponent varies from 0.1 to 1.

The following are the configurations of the dampers are majorly used in buildings

1. Viscous Dampers will work and induce damping only if the two points it connects have significant relative movement. Viscous damper can be installed in structures in different configuration to achieve relative movement .the figure shows some configurations often used in high rise buildings..In Diagonal brace damper and Chevron Brace damper inter story displacement under lateral load will cause the relative movement of the two ends in the devises
2. In the Toggle dampers ,relative movement between the two ends are enlarged by special configuration
3. For Cantilever Dampers, the relative movement id L/H times to inter story displacement, in which L means the length of cantilever truss, H is the height of floor to floor. the relative movement will larger than the interstory displacement if the cantilever length is larger than the story height



(a) Diagonal Brace Damper

(b) Chevron Brace Damper

(c) Toggle Damper

(d) Cantilever Truss Damper

Figure 2.2.Damper configurations

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## III. CASE STUDY

The chaitanya imperial building (Shown in figure) is located at Anna salai, near tnagar, Chennai constructed by M/s. Chaitanya Builders & Leasing Pvt ltd. The Building was 32m high with 10 stories above the ground. The building is mix-used containing retail, office, resident and hotel. The lateral structural consists of mega columns, reinforced concrete beams with framed structure. The closed form of RC core provides a large amount of the overall lateral and torsion stiffness of the building. The mega frame, composed of composite columns and beams, provides additional stiffness, structural integrity, and redundancy for the overall building

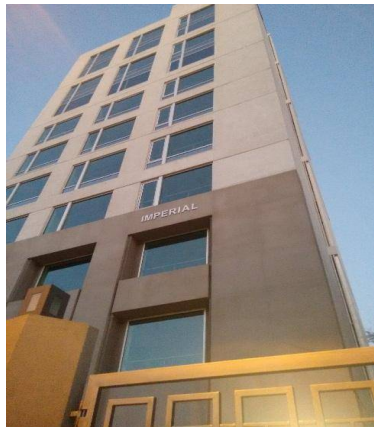


Figure 3.1 Image of chaitanya imperial

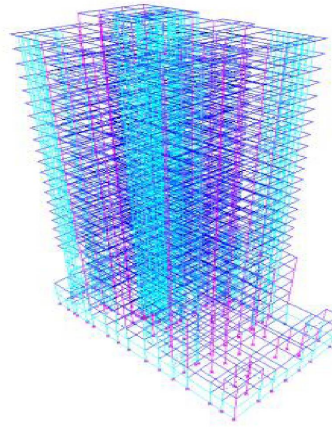


Figure 3.2 structural model in sap2000

Table 3.1 :The design parameters for Chaitanya imperial building

Design wind load		Design earthquake load	
Wind speed	144 km/h	Seismic zone	III
Design category	B	Peak acceleration (Av)	0,12 g
Importance factor	3	Reduction factor (R)	4,5
Aspect ratio of depth to width	1	Soil factor (S3)	1,5
Aspect ratio of depth to width	1	Building period (Ta)	3,65 s

Four dampers are attached in building. two at 15m level and another two at 32m level ,neat column beam joints. The the viscous damper parameters are showed in Table

Table 3.2 General information of Viscous Damper parameters

$\alpha$	C (kN*(s/m) <sup><math>\alpha</math></sup> )	F (kN)	D (mm)	Quantity
0.3	4000	1500	±150	4

### Dynamic Analysis:

The structural dynamic analysis was carried out by SAP2000 computing program, in which viscous damper is modulated by damping element .the intrinsic damping ratio of the structure id 0.02.A of total of three time history records, named TH1, TH2, TH3 respectively are used, the peak acceleration of which is 70 cm/s<sup>2</sup> for the minor. Non-linear time history is performed to evaluate the structural dynamic response with viscous dampers ,Additionally the benefits of viscous dampers are illustrated by the dynamic response comparison of structure with and without viscous dampers

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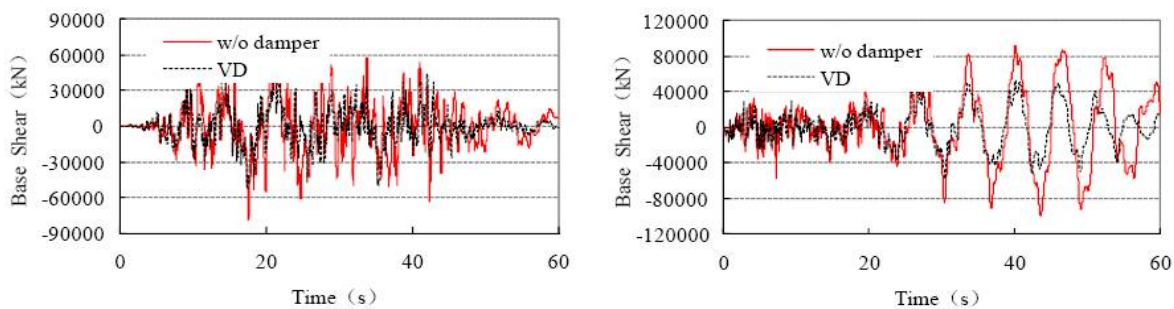
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## IV. EXPERIMENTAL RESULTS

### 4.1 Structural Base Shear and Story Shear

Figure 4.1 shows the time history of structural base shear under minor earthquake with VD and without VD. The peak base shear will decrease up to 28% when VDs are introduced into structure. The maximum story shears of structure are obviously reduced when VDs are used.



a).Base shear at column to column joint b).Base shear at column to beam joint

Figure 4.1. Time history of base shear

### 4.2 Top Displacement and Story Drift

The structural deformation of minor earthquake load, often expressed in top displacement and story drift, is usually strictly controlled to assure overall lateral stiffness and prevent damage of nonstructural partitions and cladding and. After VDs introduced, the structural deformation indexes are much improved, the top displacement and maximum story drift decreases up to 38% and 50% respectively. The variation of top displacement with and without damper is e shown in Figure 4.2

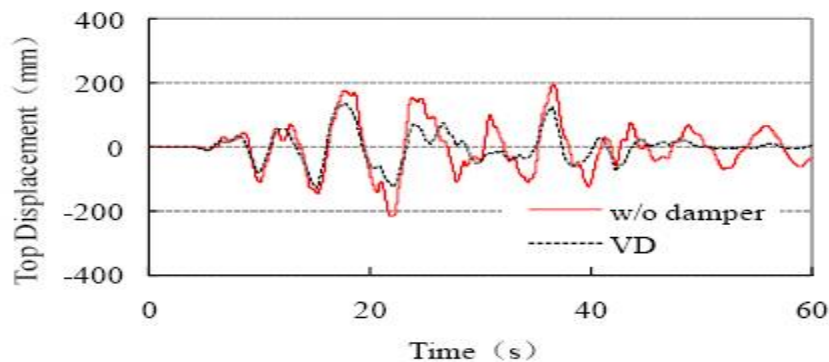


Figure 4.2 Time history of top displacement

### 4.3 Energy Dissipation and Equivalent Additional Damping

During earthquake, the ground motion will arise in the structural vibration. When the structure is elastic, the energy absorbed by structure can be divided into four parts, that is, kinetic energy, potential energy, intrinsic damping energy and VD energy. During elasticity, all of energy induced by earthquake will finally dissipated by damping, including intrinsic damping and viscous damping. And no energy will be dissipated by the kinetic energy and potential energy because they just transfer into each other.

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The energy dissipation in the structure, when suffering minor earthquake are plotted in figure. Nearly 2/3 energy is dissipated by viscous dampers and 1/3 by building intrinsic damping. Therefore the additional damping introduced by viscous damper is twice of the intrinsic damping. According to the energy theory, the equivalent additional damping ratio of the structure will reach to 0.08 since the intrinsic damping is 0.04.

Figures shows the Energy dissipation categories under minor earthquake

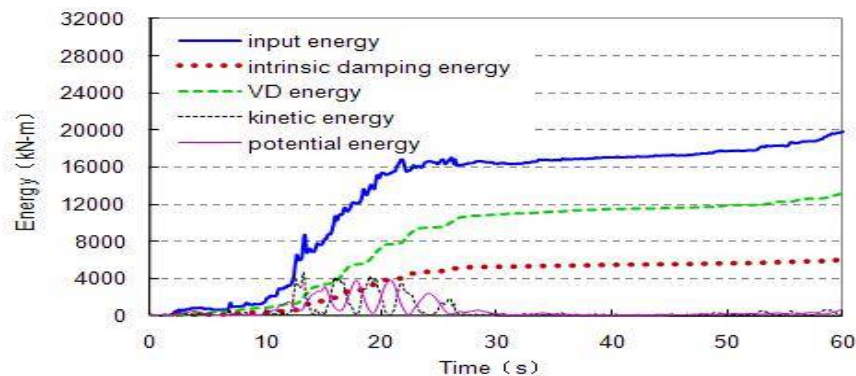


Figure 4.3 Energy dissipation categories under minor earthquake

## V. CONCLUSION

Recently, use of fluid viscous damper systems has increased but choosing best damper and installing it into a building is very important for reducing vibration in structures when subjected to seismic, wind, shock, vibration loading. This paper presents an innovative method for the design of multi-storey building where fluid viscous Dampers are induced. Time history analysis result shows that the structural dynamic responses, such as force and displacement, are virtually eliminated when VDs are applied. VDs dissipate nearly 2/3 energy induced by the minor earthquake. The viscous damping ratio will be twice as structural intrinsic damping according to the energy theory. The investigation illustrates that viscous dampers work effectively to dissipate energy and the benefit can be realized

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