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Analysis Of High Rise Buildings By Using Visco-Elastic Dampers

Rahul Chaudhari
Civil Engineering
Dr.Vithalrao Vikhe Patil College Of Engineering.
Ahmednagar,Maharashra.

Prof.S.N.Daule
Civil Engineering.
Dr.Vithalrao Vikhe Patil College Of Engineering.
Ahmednagar,Maharastra.

Abstract—

An earthquake directly affects a structure by increasing the energy within the structural system. A significant portion of this energy can be dissipated by the introduction of structural control systems. Several structural control systems such as passive, active and semi-active control systems are gaining importance nowadays in the earthquake resistant design of structures. viscous damper (VD) is a type of passive energy dissipation device, which operates on the principle of fluid flow through orifices. This type of damper has found numerous applications in the military and aerospace industry from many years. Recently, in the civil engineering field, high capacity fluid viscous dampers have found commercial applications on buildings and bridges subjected to seismic and/or wind storm inputs. VDs use inertial flows, where oil is forced through small orifices at high speeds, in turn generating high damping force. In the present study, the effectiveness of fluid viscous dampers in reducing the responses of a structure under seismic excitations is evaluated analytically using non-linear time history analysis. A twenty story reinforced concrete structure with square plan is considered in this study. Acceleration time histories of Indian seismic zone III,IV and zone V are used for the analysis. The analysis is carried out using the computer package ETABS 2015. The analysis results confirmed that a significant reduction in the responses such as displacements and other forces is possible with the introduction of fluid viscous dampers and hence it can be used as an alternative to the conventional ductility based design method of earthquake.

Keywords—Viscoelastic dampers,Non-linear analysis,Energy dissipation,story drift,story shear,story deflection,Base reactions.

I. INTRODUCTION

An earthquake is shaking of earth surface by waves emerging from the source of disturbance in the earth by virtue of release of energy in the earth's crest. The earthquake waves induce a large amount of lateral load on the structures. Due to this, the structures may suffer large deformation or complete collapse depending upon the type of structure, magnitude of earthquake and several other factors. The collapse of structures leads to loss of life and property damage, causing a large amount of financial losses and social sufferings. Hence it is necessary to design the structures to resist the earthquakes. Over many decades, the earthquake resistant design of structures was dependent on material ductility to dissipate the seismic energy induced into the structural systems. The ductility based design may provide life safety, as the structure gives enough warning before absolute collapse, but the damage control cannot be achieved to the required level. Because of the drawbacks of ductility based design, many structural control techniques have been developed over the years and are gaining importance now a days. By installing some devices, mechanisms, substructures in the structure, the dynamic performance of the structure is adjusted. The structural control systems dissipate the major portion of the seismic energy and reduce the forces on the primary structure, thereby limiting the structural deformations. Thus, the introduction of structural control systems ensures life safety, as well as damage control to the required level

II. TERMINOLOGY

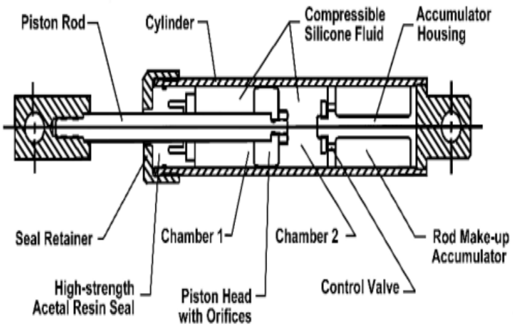
Earthquake loads: Earthquake loads are causes more damage than wind loads. It is occurs frequently in certain regions. It is a sudden lateral movement in ground under a structure that may shift in any direction and the horizontal components of this movement generates a wave action which usually transferred vertically to a structural. The variations in earthquake load are almost consistence than the wind load. The magnitude earthquake load changes with change in the stiffness, mass of the structure, and the motion of the earth surface because of seismic forces. These lateral forces can be resisting by any structure by modifying location of building, importance factor, type of soil, and achieving good construction practices.
Story Displacement: A floor displacement profile is maximum with the maximum story drift ratio depending upon the height, the time period, and the column-to-beam strength ratio. It is measured in terms of mean coefficient of variation. The parameters under which displacement is study are sections and variations in of reinforcement. This term is proportional with the mechanism of formation of plastic hinges in structural members.
Response spectrum analysis: For determine the peak value of ground acceleration in case of seismic analysis of structure. The curve is plotted between ground motion and frequency. For which different damping ratios were considered and the mean peak response of displacement, velocity, acceleration of structure with time period is then calculated from different curves (i.e. .spectrums). Different factors that will affect the response spectrum analysis are energy release mechanism, soil condition, Richter magnitude, damping in the system, time period of the system.

III. VISCOELASTIC DAMPERS

Among the various energy dissipation devices, fluid viscous dampers have been widely used in the vibration control of various structural and mechanical systems. These dampers were widely being used in the military and aerospace industry for many years and recently been adapted for structural applications in civil engineering. VDs have the unique ability of simultaneously reducing both deflection and stresses within a structure subjected to a transient. This is because a Visco damper varies its force only with velocity, which delivers a response that is essentially out of phase with stresses. A modern fluid viscous damper functions at a fluid pressure level of significant magnitude, thus making the damper small, compact and easy to install. This type of damper is generally less expensive to purchase, install and maintain compared to other types of dampers.

Components

FVD consists of a stainless steel piston rod with a bronze orifice head and a self-contained piston displacement accumulator. The damper cylinder is filled with a compressible viscous fluid (silicone oil) which is generally non-toxic, non-flammable, thermally stable and environmentally safe. A typical longitudinal section of fluid viscous damper is shown in figure.



IV. WORKING METHOD

Viscous damper work on the principle of fluid flow through orifices. These devices resemble the common shock absorber such as those found in vehicles. VDs consist of a stainless steel piston that travels through chambers filled with silicone oil. The silicone oil is inert, non-toxic, non-flammable and stable for extremely long periods of time. The silicone oil flows through an orifice in the piston head due to the pressure difference between two chambers and the seismic energy is transformed into heat, which dissipates into the atmosphere. When the VD is subjected to external excitations, the piston rod with piston will make reciprocating motion in the cylinder to force the damping medium move back and forth between the two chambers separated by the piston. In this process, the friction occurred between the molecules of the damping medium, the medium and the shaft and piston, the damping medium and the cylinder, and the throttling damping force produced by the damping medium through the piston, all these action work together constitute the damping force. The role of VD is to transform mechanical energy caused by the winds, earthquakes or other structural vibrations into the inner energy of the damping medium. The dampers use the increasing temperature of damping medium to store energy temporarily. The heat is eventually consumed by natural cooling. In this way, the fluid viscous dampers protect the structure from damage. VDs can operate over temperature fluctuations ranging from minus forty to plus seventy degree celcius.The ideal damping force of a fluid viscous damper is given by,

$$F = C.V^{\alpha}$$

Where, F is the damping force, C is the damping co-efficient, V is the velocity of piston relative to the cylinder and α is the damping exponent.

V. METHODOLOGY

Basement+Podium+20 story reinforced concrete frame of M30 grade concrete and Fe 500 grade steel is considered in this project. A symmetrical plan is considered with width of building 35 m. Story height is taken as 65 m. Hence the total width and height of the frame are 35m and 65m respectively. The support conditions are assume to be fixed and soil structure interaction effects should neglect. A modal damping of 5% of critical is considered in all modes in order to account for the material damping. The beam and column sizes are taken as 200 x 600 mm and 300 x 1500 mm respectively. Slabs thickness is taken as 150mm. Wall thickness is assumed as 150 mm, resting on all floor beams and a live load of 2kN/Sq.m for typical and 5KN/Sq.m for podium. and As per IS 1893:2002 (Part 1), a live load reduction factor of 0.5 for all floors except roof is applied in seismic analysis.

As the plan considered is square shape, the dampers should provide in a similar manner in both directions. Hence the response of the structure will also be the same in both directions. Viscous dampers manufactured by Taylor Devices Inc.,USA are considered in this project. Dampers should providing in the peripheral middle bays and in second and fourth bays in the interior frames throughout the height in single diagonal bracings. However, in practice, the available locations for the placement of dampers have to be identified prior to the analysis.

VI. DETERMINATION OF THE OPTIMAL PROPERTIES OF DAMPERS

The modeling and analysis of the bare frame and structure with fluid viscous dampers are using the ETABS 2015 computer program. The modeling of fluid viscous dampers varies with the type of bracing used to mount the damper to the frame. Link element called Damper – Exponential should use to model fluid viscous dampers. The mass and weight of the damper element along with the bracing connected should be calculate. The fluid viscous dampers should mount in single diagonal bracings are active only in the local axial direction. Therefore, only one active degree of freedom U1 is select in the directional properties and since its behavior is non-linear, the non-linear option is marked. As there will be no provision for rotation, rotational inertia R1, R2 and R3 will be entered zero. After defining the directional properties (U1), the non-linear properties of the damper in that particular direction have to be specifing.The values of stiffness, damping co-efficient and damping exponent should be enter in the non-linear properties window.

It is important to determine the optimal properties of viscous dampers in order to reduce the response of the structure by a considerable amount. The optimal damper properties are nothing but the values of damping coefficient

(C) and damping exponent (α) corresponding to minimum response of the structure and maximum seismic energy dissipation. A simple procedure for the determination of damping co-efficient is used.

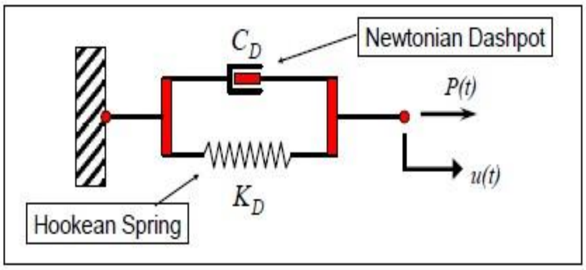
$$C = 2.m.\omega.\xi$$

Where ξ is the damping ratio, m is the seismic weight of the structure and ω is the natural frequency which is given by ω = 2π/T. Here, T is the fundamental time period, which is obtain from modal analysis. Knowing the value of natural frequency ω, the co-efficient of damping is calculate by assuming suitable value of damping ratio ξ and is used in analysis. The value of damping exponent varies in the range of 0.2 to 1.0 for typical viscous dampers used in structural applications. The seismic weight of the structure (m) and fundamental time period (T) obtain from modal analysis are kN and sec.respectively.

Mathematical Model and Behavior-

In VE material energy is dissipated through large shear strain.VE damper caused in a small increased in structural stiffness due to the inherent stiffness .The solid VE device may be model using classical Kelvin model, in which the linear spring is placed in the parallel with the viscous dashpot.

Kelvin Model for Viscoelastic Damper



Most of the mathematical properties of VE material is complex and may vary with the environmental temperature and excitation frequency. Hysteresis loop is obtained when VE damper subjected to periodic displacement. Area of hysteresis represents the actual energy loss. The main VD properties used the designing VE damper as storage modulus .G′ provide with the actual elastic shear stiffness of material The stress strain relation expressed as

τ (t) = G ″C)+G ″Y″(t)/ f

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