TORSIONAL VIBRATION CONTROL OF A STRUCTURE USING FLUID VISCOS DAMPERS

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Abstract. Damping plays a major role in design of structures resistant to earthquakes. The damping reduces the effectiveof the structure when they are assigned to lateral loads by energy dissipation. The number of dampers is available and in use today. Most of the dampers usually isolate the super structure from the substructure, dividinthem in order to hamper the flow of vibrations into the superstructure. This classification is termed as base isolation techniques. While, the rest of the damping techniques, dissipates the oncoming vibrations on the superstructure itself and minimizes the damage to the superstructure. In this present study, Fluid Viscous Dampers (FVD) are used extensively over types of dampers. The structure endures two load types, the vertical loads and the sidewise loads, and conveys to the foundation. In order to have earthquake resistant structures, FVD have been used. In the present study, Dissymmetric Buildings are analyzed with and without Fluid Viscous Dampers. The software ETABS 2016 was used. Using Time history analysis in ETABS software, the RC building is considered and the structure is evaluated and connect with and without FVD.

Keywords – Conventional RC Building, Fluid Viscous Dampers, Time History Analysis, Max Story Displacement, Response Spectrum Curves

1. Introduction

Typical Fluid Viscous Dampers are developed by in the year 1960, Viscous Dampers is a passive energy dissipation device. It dissipates energy by forcing a fluid through an orifice similar to the shock absorber to an automobile. Viscosity of the fluid used in the damper is usually very high e.g.; silicon. This viscous damper consists of a stainless-steel piston with the bronze orifice head. It is filled with high viscous silicon oil. The fluid damper can be designed to behave as a pure passive energy dissipation system or a spring or a combination of two. The movement of the fluid within the damper absorbs kinetic energy and converts it into heat. Other type of viscous fluid that is used in damper is lead and the damper is named as lead extrusion damper. This type of damper resists the force as a bulge on the shaft pushes through lead. Lead recrystallizes after the deformation, therefore, decreasing permanent displacement.

1.1 Roll of Viscous Dampers in Tall Buildings

Unique feature of these viscous dampers is that their damping characteristics and therefore, the amount of energy dissipated, can be made directly equivalent to the velocity. The response of the viscous damper
is considered to be out of phase with those due to the activity of seismic hazards. This is because the damping force provided by the damping device varies inversely with dynamic lateral displacements of a tall building. Consider a building for the better understanding which is shaking laterally back and forth during the seismic hazard. The stress in lateral load resisting elements such as frame column is as its maximum when the deflection of the building is also maximum. The damping force of a fluid viscous damper will be reduced to zero at the point of maximum deflection causes damper stroking velocity goes to zero as the building reverse the direction. Moving back in the opposite direction maximum damper force will occur at maximum velocity which happens when the building goes through its normal upright position. This is the point when the stresses in lateral load resisting elements are at minimum. Hence, the damping provided by the device varies from maximum to minimum as the building moves from at rest to its maximum lateral deflection position.

Viscous dampers are the energy dissipation device. This type of dampers is very robust and they are used in both new and existing structure. In viscous dampers, seismic energy is absorbed by the silicone-based fluid passing between piston-cylinder arrangement. Viscous dampers are used in high rise buildings in seismic areas. It can operate over an ambient temperature ranging from 40 degrees centigrade to 70 degrees centigrade. Viscous damper reduces the vibrations induced by both strong wind and earthquake.

**Figure 1. Torsional Vibration of Building**

**Figure 2. Viscous Damper**

### 2. Methodology

In this structure for slabs and beams we have been used M20 grade of the concrete and Fe 500 grade of the steel. In this structure for columns, we have been used M25 grade of the concrete and Fe 500 grade of the steel. As per IS 456: 2000 we are taken Elastic material properties. In this we considered different types of structural elements are beams, columns and slabs with the variable sections are mentioned below.

#### 2.1 Design of Members:

- **Beam Size:** Rectangular Columns = 230mm * 450mm.
- **Column Size:** Rectangular Columns = 230mm * 650mm.
- **Slab Sizes:**
  1. Area = 16m*35m
  2. Thickness = 125mm.
Table 1. Storey Data

| No of Storey’s | Height m | Elevation m | Master Story | Similar To |
|---------------|----------|-------------|--------------|------------|
| Storey 7      | 3        | 19.2        | Yes          | None       |
| Storey 6      | 3        | 16.2        | No           | Storey 7   |
| Storey 5      | 3        | 13.2        | No           | Storey 7   |
| Storey 4      | 3        | 10.2        | No           | Storey 7   |
| Storey 3      | 3        | 7.2         | No           | Storey 7   |
| Storey 2      | 3        | 4.2         | No           | Storey 7   |
| Storey 1      | 3        | 1.2         | No           | Storey 7   |
| Base          | 1.2      | 0           |              |            |

In the structure when we applying the loads, we consider only external loads which are definitely acting on the members ignoring its self-weight because ETABS 2016 will takes automatically the members’ self-weight. By using Code IS 1893:2002 the Seismic Load patterns are taking EQ-x and EQ-y. By using Code IS 875:2015 the Wind Loads are wind-X and wind-Y.

Table 2. Load Patterns

| Load Type | Self-Weight Multiplier | Auto Lateral Load |
|-----------|------------------------|-------------------|
| Dead      | Dead                   | 1                 |
| Live      | Live                   | 0                 |
| Wind X    | Wind                   | 0                 | Indian IS 875:2015 |
| Wind Y    | Wind                   | 0                 | Indian IS 875:2015 |
| EQX       | Seismic                | 0                 | IS 1893:2002      |
| EQY       | Seismic                | 0                 | IS 1893:2002      |

While applying the loads we consider the dead load, live load in this the load case is linear static and in the external loads wind -x, y is the linear static. Also, EQX and EQY is the linear static load case and the Timehistory-x and Time history-y are nonlinear modal history in load case.
Table 3. Load Case Details

| Load Case Name | Load Case Type                      |
|----------------|-------------------------------------|
| Dead           | Linear static                       |
| Live           | Linear static                       |
| Wind X         | Linear static                       |
| Wind Y         | Linear static                       |
| EQX            | Linear static                       |
| EQY            | Linear static                       |
| THX            | Nonlinear modal history (FNA)       |
| THY            | Nonlinear modal history (FNA)       |

Figure 3. Building Plan (Asymmetric Building)  

Figure 4. Building 3D View

2.2 Modelling of Dampers

In the exterior corner’s elevations XZ and YZ planes we can use any one of them in the structure, since it is simple to fit Fluid Viscous Dampers with base plate is selected here for modelling of the structure. The information of fluid viscous dampers and lock-up devices clevis – base plate configuration is as shown below.
2.3 Model Analysis

The seven-storey structure we analysis that two types of models i.e., without Fluid Viscous Dampers structure and with Fluid Viscous Dampers structure are shown. By the research results are obtained from the analysis are taken into consideration based on aim. We observed that in the rectangular building ETABS 2016 earthquake in the x-direction and y-direction of the maximum story displacement. In this Time History Analysis, the Response Spectrum Curves without Fluid Viscous Dampers time history in x-direction and Response Spectrum Curves with Fluid Viscous Dampers time history in y-direction graphs are shown. We observed that after getting the results these are compared to draw the conclusion from it.
3. Results

3.1 Story Response – Maximum Story Displacement

3.1.1 Without Fluid Viscous Dampers

In the results we observed that we are taken from the ETABS 2016 and in this these are without fluid viscous dampers are using in buildings. In this 7th storey building X-direction earthquake is the 17.663mm.

| Storey | Elevation m | Location | X-Direction mm |
|--------|-------------|----------|----------------|
| Storey7 | 19.2         | Top      | 17.663         |
| Storey6 | 16.2         | Top      | 15.826         |
| Storey5 | 13.2         | Top      | 13.201         |
| Storey4 | 10.2         | Top      | 9.923          |
| Storey3 | 7.2          | Top      | 6.302          |
| Storey2 | 4.2          | Top      | 2.803          |
| Storey1 | 1.2          | Top      | 0.298          |
| Base    | 0            | Top      | 0              |

In the results we observed that we are taken from the ETABS 2016 and in this these are without fluid viscous dampers are using in buildings. In this 7th storey building Y-direction earthquake is the 24.165mm.

| Storey | Elevation m | Location m | Y-Direction mm |
|--------|-------------|------------|----------------|
| Storey7 | 19.2         | Top        | 24.165         |
| Storey6 | 16.2         | Top        | 22.284         |
| Storey5 | 13.2         | Top        | 19.039         |
| Storey4 | 10.2         | Top        | 14.821         |
| Storey3 | 7.2          | Top        | 10.018         |
| Storey2 | 4.2          | Top        | 4.975          |
| Storey1 | 1.2          | Top        | 0.499          |
| Base    | 0            | Top        | 0              |
3.1.2 With Fluid Viscous Dampers

In the results we observed that we are taken from the ETABS 2016 and in this these are with fluid viscous dampers are using in buildings. In this 7th storey building X-direction earthquake is the 7.472mm.

| Storey | Elevation m | Location | X-Direction mm |
|--------|-------------|----------|----------------|
| Storey7 | 19.2        | Top      | 7.472          |
| Storey6 | 16.2        | Top      | 5.847          |
| Storey5 | 13.2        | Top      | 4.233          |
| Storey4 | 10.2        | Top      | 2.72           |
| Storey3 | 7.2         | Top      | 1.431          |
| Storey2 | 4.2         | Top      | 0.52           |
| Storey1 | 1.2         | Top      | 0.153          |
| Base   | 0           | Top      | 0              |

In the results we observed that we are taken from the ETABS 2016 and in this these are with fluid viscous dampers are using in buildings. In this 7th storey building Y-direction earthquake is the 6.254mm.

| Storey | Elevation m | Location | Y-Direction mm |
|--------|-------------|----------|----------------|
| Storey7 | 19.2        | Top      | 6.254          |
| Storey6 | 16.2        | Top      | 4.967          |
| Storey5 | 13.2        | Top      | 3.706          |
| Storey4 | 10.2        | Top      | 2.539          |
| Storey3 | 7.2         | Top      | 1.562          |
| Storey2 | 4.2         | Top      | 0.882          |
| Storey1 | 1.2         | Top      | 0.618          |
| Base   | 0           | Top      | 0              |

3.2 Response Spectrum Curves from the Time History

3.2.1 Without Fluid Viscous Dampers
Response Spectrum when we do not have time history available to us, and then for most of the buildings, the response spectrum, design spectrum whatever is suggested in IS:1893 is available. We can make use of that and find the maximum forces and maximum deformations which might occur in the structure using this response spectrum analysis uses almost same principles as time history analysis, but only
instead of finding time history we will find the maximum values of the response.

It shows the 7 storey without FVD building for point 1. The coordinate system of the structure is spectrum widening and modal is 0% is participated in X-direction and Y-direction.

3.2.2 With Fluid Viscous Dampers

It shows the 7 storey’s with fluid viscous dampers building for point 1. The coordinate system of the structure is spectrum widening and modal is 0% is participated in X-direction and Y-direction.

4. Conclusions

- By comparing both the results we observed that the joint displacements are reduced by using the dampers.
- The stability of the structure is increased, and torsional vibrations are reduced using Fluid Viscous Dampers.
- We observed that buildings with dampers can reduce the displacement about 75% than the buildings without dampers.
- When Fluid Viscous Dampers are used up to 80% decrease in the time period.
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