Comparative Study of Seismic Analysis of Structure with Viscoelastic Damper

Vineet G. Kothari1, C.S.Sanghvi2
1.2Department of Applied Mechanics
1,2L.D. College Of Engineering, Ahmedabad, India – 380015

Abstract—During an earthquake a large amount of energy is imparted into the structure. To reduce the response of structure undergoing vibrations it becomes important for the structure to absorb or dissipate the energy. Basically there are two methods to improve seismic protection of structures primarily traditional methods increasing stiffness of structures (i.e. shear wall, bracings, MR frames dual system) and secondary modern methods (i.e passive control systems, active control systems, semi active control systems and hybrid control system). Our focus is on passive control systems (Viscoelastic Damper). In passive energy dissipation systems the motion of structure is controlled by adding devices which modifies stiffness, damping or both. The present paper presents is the behavior of energy dissipation devices in addition to inherent structural damping of the R.C.C frame building. Damper considered namely Viscoelastic, is undertaken as additional damping members and analyzed by time history analysis under different earthquake excitations. Earthquake events used in this study are Imperial Valley, Northridge (1994), and Kobe (1995) time histories. Five storey is considered to find out effectiveness of viscoelastic damper dampers. Dampers are designed for different damping ratio 5%, 10%, 20%. Response quantities like story displacement, modal frequencies, inter storey drift and damper forces will be extracted for building without damper and building with damper to establish their effectiveness and final conclusion will be made on the bases of study.

Key words: Seismic, MR Frames, Control Systems.

I. INTRODUCTION

A. General

Earthquakes are one of the major natural hazards to life on the earth and have affected countless cities and villages on almost every continent. The damaged caused by earthquakes are mostly manmade structures.

Conventional seismic design attempts to make buildings that do not collapse under strong earthquake shaking, but may sustain damage to non-structural elements and to some structural members in the building. This may cause the building to be non-functional after the earthquake. Basically there are two methods to improve seismic protection of structures primarily traditional methods increasing stiffness of structures (i.e. shear wall, bracings, MR frames dual system) and secondary modern methods (i.e passive control systems, active control systems, semi active control systems and hybrid control system)
Comparative Study of Seismic Analysis of Structure with Viscoelastic Damper
(IJSRD/Vol. 3/Issue 03/2015/116)

All rights reserved by www.ijsrd.com

C. Kazuhiko Kasai\textsuperscript{1} Member ASCE, Yaomin Fu\textsuperscript{2}, and Atsushi Wantanabe\textsuperscript{3}

The analysis methods are also different between the VE (visco-elastic) and EP (Elasto-plastic) systems; these make direct comparison of the two types of passive systems difficult. A 14-story steel MRF having insufficient stiffness and strength at lower stories was retrofitted to achieve the optimized response by using either VE or EP dampers. Both VE and EP systems performed excellently for the major earthquakes considered.

Drifts were very small and uniform; MRF member stresses were well below the yield limit; nonstructural components were protected; and foundation uplift forces were kept below capacity

D. Marko, Julius and Thambiratnam, David P. and Perera, Nimal j(2006)

18-storey and 12-storey frame –shear wall structures with with embedded dampers was considered Three damping mechanisms (i) displacement-dependent friction dampers, (ii) velocity-dependent VE dampers and (iii) hybrid system which is a combination of friction and VE dampers were considered Friction and VE diagonal dampers, friction and VE ehevron brace dampers, hybrid friction-VE dampers and VE lower toggle dampers Study of viscoelastic and friction damper configurations in the seismic mitigation of medium-rise structures Diagonal friction dampers performed better under the earthquakes which produced higher deflections of the structure Diagonal VE dampers was noticeably less sensitive to this aspect chevron brace dampers...were effective in case of overall tip deflection reduction and even significantly more reliable than those of the diagonal dampers Both types of chevron brace dampers were clearly the least effective in terms of tip acceleration reduction The damping systems were embedded in six different locations (one at a time) within cut-outs of the shear wall in the structure In the 18-storey structure reductions of up to 36% in the peak values of tip deflections and 47% in the peak values of the tip accelerations were obtained while in the 12-storey structure the highest tip deflection reduction was 43% and the tip acceleration reduction 50% The friction dampers in the huge majority of cases surpassed the VE dampers in their ability to reduce the intensity of the initial strong strikes In contrast, the VE dampers gradually decreased the deflection and acceleration of the structure The performance of the friction dampers increased with higher interstorey drift, while the best performance of VE dampers was achieved when placed in the lowest storeys.

III. MODEL DEVELOPMENT

This Chapter presents the results obtained through analysis of R.C. frame building with Velocity dependent energy dissipation devices (Viscoelastic damper). The response of R.C frame building in the form of Displacement, Base shear and Drift were obtained. The analysis method used was Time History analysis using PEER data for three earthquakes (Imperial valley, Kobe Earthquake, Northridge Earthquake). Various results such as storey displacement, storey drift, modal frequencies and dampers forces are calculated for different damping ratio (5%, 10%, 20%) and compared for different earthquakes.
Fig. 4: 3D Model with Damper Etabs 2013

<table>
<thead>
<tr>
<th>Time History</th>
<th>Earthquake Magnitude</th>
<th>Distance (km)</th>
<th>PGA</th>
<th>PGV (cm/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kobe, Japan 1995</td>
<td>6.9</td>
<td>17.9</td>
<td>0.4862(g)</td>
<td>35.73</td>
</tr>
<tr>
<td>Loma Perita</td>
<td>6.93</td>
<td>18</td>
<td>0.4442(g)</td>
<td>26.94</td>
</tr>
<tr>
<td>Northridge</td>
<td>6.69</td>
<td>18</td>
<td>0.3928(g)</td>
<td>30.9</td>
</tr>
</tbody>
</table>

Table 2: Time History Data

This section presents the results obtained for five storey R.C. frame building with velocity dependent energy dissipation devices (Viscoelastic damper). Efficiency of these damping systems is investigated for three earthquake excitation of Kobe (1995) and Loma perita and Northridge earthquake. The undamped structural response was found out in order to compare its results with the results of the building embedded with viscoelastic damping system. Various results such as storey displacement, storey drift, modal frequencies and dampers forces are calculated for different damping ratio (5%, 10%, 15% and 20%) and compared for different earthquakes.

<table>
<thead>
<tr>
<th>% Damping</th>
<th>Stiffness (KN/m)</th>
<th>Damping (NS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>2500</td>
<td>400</td>
</tr>
<tr>
<td>10%</td>
<td>5000</td>
<td>500</td>
</tr>
<tr>
<td>15%</td>
<td>8500</td>
<td>550</td>
</tr>
<tr>
<td>20%</td>
<td>12000</td>
<td>750</td>
</tr>
</tbody>
</table>

Table 3: Viscoelastic Damper Properties

A. Comparison of Storey Displacement

B. Comparison of Storey Drift
C. Comparison of Base Shear

IV. RESULTS AND DISCUSSION

- Maximum storey displacement reduction in case of Kobe earthquake, Loma Parita and Northridge are 42.85%, 21.42% and 14.28% respectively for 20% damping ratio as compared to structure without damper.

- Maximum storey drift reduction in case of Kobe earthquake, Loma Parita and Northridge are 37.5%, 26.67% and 18.57% respectively at 3rd storey for 20% damping.

In case of modal frequencies percentage change 28.59% is observed in case of building with 20% damping ratio as compared with building with no dampers.

REFERENCES


