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Performance Evaluation of Shear Wall and Damper in Soft Storey Buildings

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Abstract - The seismic performance of a building can be improved by using energy absorbing devices or shear walls. Passive control systems such as base isolation, dampers, bracing systems etc are found to be easy to install and cost effective as compared to previous one. Also shear walls are found very effective for open ground storey buildings. Use of dampers is now becoming cost effective solution to improve seismic performance of existing as well as new buildings. This paper deals with use of viscous dampers and shear walls in the building. A 10 storey building with a open ground storey is analyzed with and without braced type viscous dampers as well as shear wall Non-linear pushover analysis is carried out using SAP2000 software and comparisons are shown in a tabular and graphical format.

Index terms: Soft storey structure, shear wall, viscous damper, pushover analysis

1. INTRODUCTION

Open ground storey (also known as soft storey) buildings are commonly used in the urban environment nowadays since they provide parking area which is most required. These buildings have no walls provided at its ground floor. There is significant advantage of these category of buildings functionally but from a seismic performance point of view such buildings are considered to have increased vulnerability. Such buildings are to be strengthened by providing various retro fittings such as shear wall, dampers, isolators, bracings, etc. But the effectiveness varies with the type and also positioning of the same. In this paper, we model an RCC frame building with shear walls and dampers and evaluate its response using non-linear pushover analysis.

1.1 *Passive energy devices*

The main reason to use passive energy dissipation devices in a structure is to limit damaging deformations in structural components. The degree to which a certain device is able to accomplish this goal depends on the inherent properties of the basic structure, the properties of the device and its connecting elements, the characteristics of the ground motion. Device that have most commonly been used for seismic protection of structures include viscous fluid dampers, visco elastic solid dampers, friction dampers and metallic dampers. Semi-active dampers have also been used for seismic response control.

1.2 *Shear walls*

Reinforced concrete shear wall structures wide space in many earthquake regions, Such as India, Canada, Turkey and Chile. Shear walls are vertical elements of horizontal force resisting system. They are usually provided in tall buildings to avoid collapse of buildings under seismic forces. Shear wall buildings are usually regular in plan and elevation. Shear walls are usually provided between columns, stairwells, lift wells, toilets, and utility shafts. When walls are situated in advantageous positions in a building, they can be very efficient in restating lateral loads originating from wind or earthquakes. Large portion of the lateral loads on the buildings and horizontal shear force resulting from the load are often assigned to structural elements they have been called shear wall. RC buildings with shear wall also have columns; these columns primarily carry gravity loads. Reinforced concrete shear walls classifications are bar bell type shear wall, coupled shear wall, rigid frame shear wall, and framed shear wall with in filled frames, column supported shear walls and core type shear wall. Out of this shear walls rectangle type shear wall, core type shear wall, and coupled type shear walls are used for analysis. Rectangular type shear wall are formed by columns and walls in between. Core type shear walls have good resistance to torsion.

2. MODELLING OF BUILDING FRAME

A 10 storey reinforced concrete building frame with open ground storey is modeled. Sudden reduction in lateral strength and stiffness of ground storey due to absence of masonry wall at ground storey results in excessive inelastic deformation on the ground story columns leading to the soft-storey collapse of the building under the seismic loading conditions. Here, we shear walls and viscous dampers in different models to check the seismic performance of the structure. In this example, non-linear pushover analysis is carried out using SAP 2000 version 14 software. Modelling procedure is summarized in following steps.

1. Create a 10 storey model using file menu.
2. Define materials to be used, here we will define concrete and steel material using define section properties menu.
3. Assign properties to all the framed sections and shell elements which are used to incorporate the masonry wall effect.
4. Shear walls are provided as membrane elements with adequate thickness.
4. Dampers are added into the model by defining link/support properties in the SAP. Input appropriate value of stiffness, damping coefficient and damping exponent in the data sheet.
5. Assign the joint masses/forces using Assign menu.
6. Define and apply pushover analysis using as displacement control. The maximum displacement allowed is 300mm.
7. Assign the load cases using assign menu. Non-linear pushover cases are considered for analysing the given model.
8. At last analyze menu activates analysis of the frame. SAP is capable of doing different types of analysis. In this problem, nonlinear pushover analysis is carried out to compare the response of building as bare frame, with dampers and shear walls.

3MODEL DETAILING AND SPECIFICATIONS

The model represents a 10 storey building with open ground storey considerations. Fig 3 shows the building model with viscous dampers while Fig 4 shows the building model with shearwall considerations. The supports are provided as fixed at the base. The building specifications are provided as specified in the table 1 given below. After modeling, each of them are analysed to evaluate is seismic response by non-linear pushover analysis. Thus we obtain the base shear and storey drift of the model. These values are then compared to obtain the conclusion that which is more effective for a soft storey building, as we have to note that large inter storey drift occurs at the first storey because of the presence of soft storey.

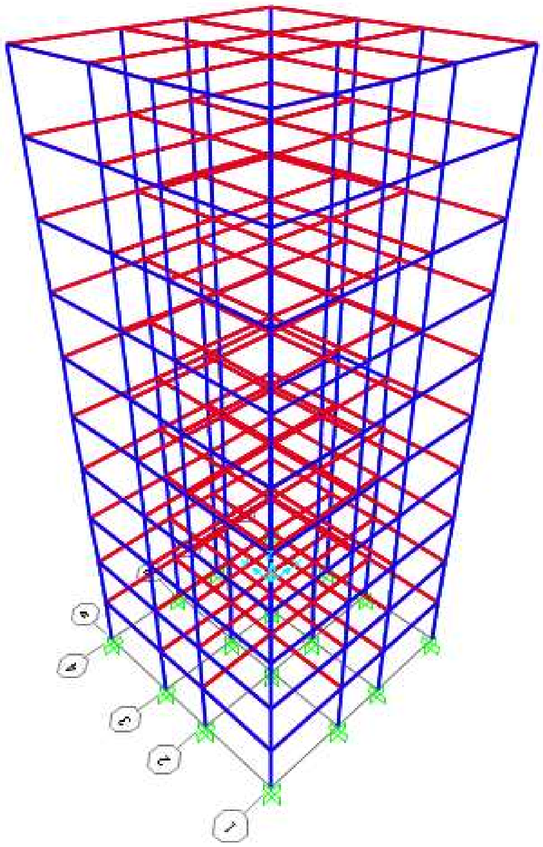

Fig 1. 3D model of the building

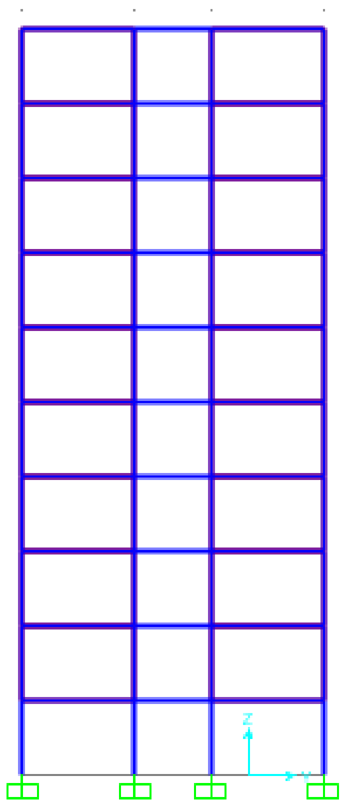

Fig.2 Normal frame model

Table 2a: Specification of the building

	For ten story
No. of stories	TEN (G+9)
Floor to Floor Height	3.0 m
Beam size longitudinal and transverse direction	230x500 mm^2
Column size	300x600 mm^2
Thickness of slab	150 mm
Thickness External Wall	230 mm
Thickness of Internal wall	115 mm
Grade of Concrete and steel	M20 and Fe415

Table 2b: Properties of the damper

Properties of damper	
Stiffness	40000 kN.s/m
Damping coefficient	1500
Damping exponent	1

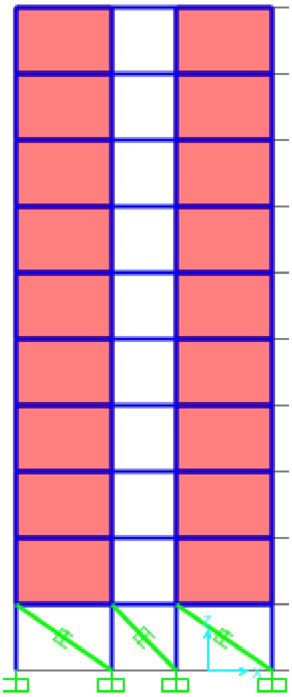

Fig 3. Model with dampers

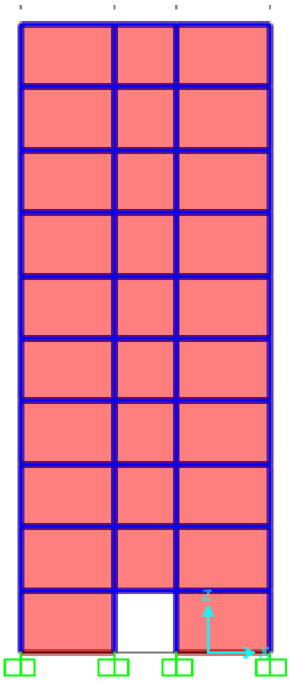

Fig. 4. Model with shear walls

4.ANALYSIS AND RESULTS

A viscous damper provides a damping force of F = C Vu, where C is the damping coefficient, V is the velocity and u is the damping exponent. Damping exponent is generally in the range of 0.4 to 1.0 and in this paper it is taken as 1.0 for all cases. The value of damping coefficient C is taken as 40000(KN.s/m). The response of structure is determined for 10 storey building with open ground storey (without damper) and same soft storey building frame with dampers and then with the shearwall.

In Fig 6, the analysis results show that there is a sudden rise in drift and displacements at storey 1 due to loss of stiffness at the ground storey. Thus, the building can undergo soft storey failure if exposed to seismic conditions. Also, it can be interpreted from the results that the use of Viscous Dampers and shearwalls has improved the performance of the building to great extent.

Table 3. Drift obtained in different models

Storey no.	Normal frame	With damper	With shear wall
0	0	0	0
1	66.8	38.7	37.2
2	21	1.3	11.2
3	22	1.4	14.2
4	23	1.5	14.1
5	23	1.4	14.1
6	23	1.4	13.9
7	22	1.4	13.6
8	20	1.4	13.1
9	20	1.3	12.6
10	19	1.1	12.1

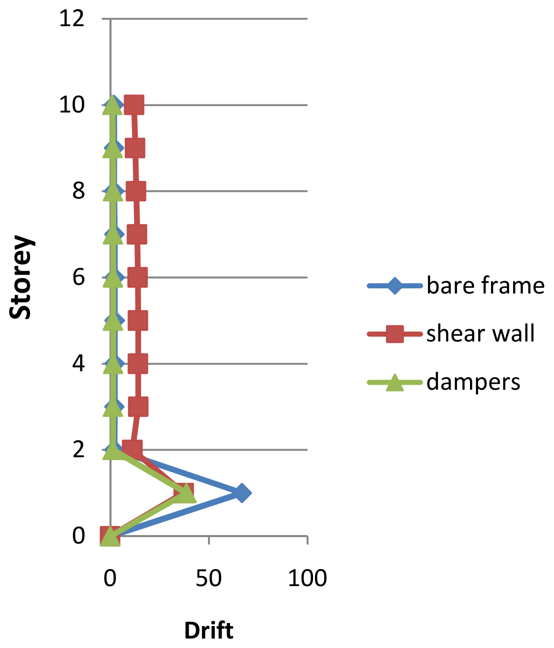

Fig.5 Drift vs Storey

Sudden change in blue plot at storey 1 indicates sharp change in stiffness due to soft storey. Green plot represents the drift behavior of soft storey with viscous Damper and shows considerable reduction in this soft storey problem of excessive drift. The red plot represents the drift behavior of same structure with shearwalls. Also the maximum drift of building is checked within the maximum permissible limits.

Table 4 Base shear of models

Models	Base shear(kN)
Normal frame	364
With dampers	254
With shearwalls	3678

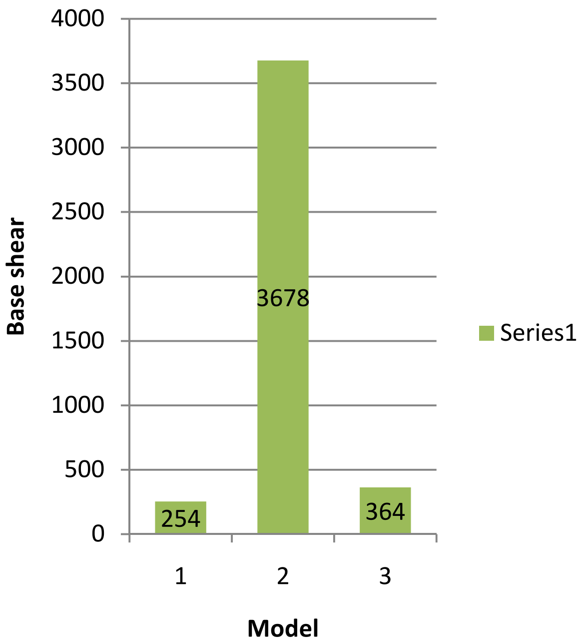

Fig.6 Base shear

5 CONCLUSIONS

- With the deployment of retrofits, that are shearwall and viscous damper in the structure, maximum response and drift gets reduced in structure during seismic loading.
- The performance of building structure in seismic loading is improved to great extent. By the provision of viscous dampers , maximum drift is reduced by 42% and 44% for dampers and shearwall respectively.
- Main factors for reduction of response of the structure are parameters associated with Dampers and the dissipation of energy produced during earthquake by the mean of viscous Dampers.
- The base shear obtained are lesser for model with damper than normal frame and very higher for the shearwall.

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