Analysis and Design of RCC Building Retrofitted By Accordion Metallic Damper

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Abstract*: Metallic damper being used as supplemental damping device is an effective technique to mitigate the seismic risk of the structure. Recent studies on metallic damper shows that it is an efficient way to increase the stiffness of the structure. In this paper, AMD is being incorporated in the structure and the performance of the structure is checked and this performance is the reflection of the effectiveness of damping material. San Fernando and parkfield is used as a distressing ground motion for time history analysis and the entire analysis is done on SAP2000.Push over analysis is also performed and it gives the capacity curve. The structure has been analysed with damper and without damper and after the analysis several response quantities such as maximum inter-storey drift, maximum displacement, Bending moment and shear force has been compared. Results obtained after analysis represents that the response quantities of the structure is reduced significantly and hence it can be further concluded that the installation of these damper is very much effective in dissipation of external seismic energy.*

Key Words: Accordion metallic damper, energy dissipating devices, Time history analysis, Push over analysis.

1 INTRODUCTION

Various natural activities like earthquake, wind etc. induced seismic energy in the structure and the structure behaves in-elastically and shows the non-linear relation under cyclic loads which is being related with the earthquakes. Such an inducement leads to the lateral movement of the structure. And it is further responsible for the collapse of the structure. To prevent these behaviour of structure a supplemental energy dissipating device is incorporated in the structure. These energy dissipating device dissipates the external energy ultimately reducing the response of the structure and hence the structure remains in the elastic range. The amount of energy dissipated by the damper is dependent on the geometry of the damper and the material used. In this paper, the building incorporated with AMD is investigated and the results reflects the effectiveness of the damper material. Performance of the metallic damper can be evaluated by analysing the hysteresis loop which is the relationship between force and displacement of the damper material. From this loop we can be able to know the amount of energy dissipated by the damper.

1.1 Seismic Retrofitting

Seismic retrofitting is the alteration of the existing structures to make them more resistant to seismic activity, ground motion, or soil failure due to earthquakes. The parameter which affects the strength of the building are structural dimensions, materials, shape, and number of structural elements, etc.

And for the ductility it is good detailing, materials used, degree of seismic resistant etc. Earthquake load is generated from the site seismicity, mass of the structures, important of buildings, degree of seismic resistant, etc. Structures vulnerable to earthquakes are retrofitted by means of steel jacketing, concrete jacketing, and Galvanized steel mesh reinforcement, Inclusion of new Supporting walls / concrete shear walls, steel bracings or by any other suitable means.

1.2 Retrofitting strategies for RC building

Following are the two strategies to retrofit the structures:

I. Local /member level
II. Structural Level (or Global) Retrofit Methods

The following are two methods of global level retrofitting.

a. Conventional methods – This based is based on increasing the seismic resistance of existing structure.

b. Non-conventional method –This method is based on reduction of seismic demands of the existing structure.

1.3 Supplemental Damping Systems:

The supplemental damping system is classified into three groups as passive, active and semi-active systems.

These dampers are activated by the movement of the structure and decrease the structural drift by dissipating energy via different mechanisms.

Active Systems.

Active systems monitor the structural behaviour, and after processing the information, in a short time, generate a set of forces to modify the current state of the structure. Generally, an active control system is made of three components: a monitoring system that is able to perceive the state of the structure and record the data using an electronic data acquisition system; a control system that decides the reaction forces to be applied to the structure base on the output data from monitoring system and; an actuating system that applies the physical forces to the structure. To accomplish all this, an active control system needs a continuous external power source. The loss of power that might be experienced during a catastrophic event may render these systems ineffective.

Semi-Active Systems.

Semi-active systems are similar to active systems except that compared to active ones they need less amount of external power. Instead of exerting additional forces to the structural systems, semi-active systems control the vibrations by modifying structural properties (for example damping modified by controlling the geometry of orifices in a fluid damper). The need for external power source has also limited the application of semi-active systems.

Passive Systems:

Passive systems dissipate part of the structural seismic input energy without any need for external power source. Their properties are constant during the seismic motion of the structure and cannot be modified. Passive control devices have been shown to work efficiently. Those are robust and cost-effective. As such, they are widely used in civil engineering structures.

Passive systems can be classified according to the approaches employed to reduce the input earthquake energy as,

(1) Seismic isolation systems.

(2) Passive energy dissipation systems.

As illustrated in the fig.1.3a the seismic isolation system removes the input earthquake energy since it is having a layer between the structure and the foundation with low horizontal stiffness. Such types of schemes are found suitable for a suitable for a large class of structures that are short to medium height. Several building and bridges have now been installed with base isolation systems.

The passive energy dissipation systems act as an energy absorber and it absorb some of the vibration energy and due to this structural response is reduce as less is available to cause deformation of structural elements. As shown in fig. 1.3b it consist of strategically placed dampers or replaceable yielding elements that link various parts of the framing system. The reduction in the structural response is accomplished by transferring some of the structural vibration energy to auxiliary oscillators attached to the main structure. Fig1.3c shows a typical implementation of a tuned mass damper in a building structure.

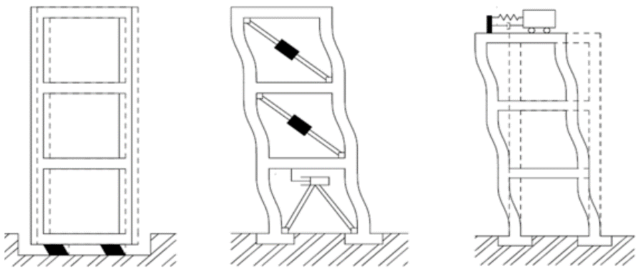

Fig. 1.3a Seismic isolation Systems

Fig. 1.3b Dynamic vibration Absorbers

Fig 1.3c Implementation of Tune mass damper

1.4 Types of Seismic Energy Dissipation Devices

Yielding Metallic Dampers

This type of dissipating device dissipate the input earthquake energy by yielding in elastically and it utilizes the property of metallic element within the damper. This type of damper absorbs a large amount of energy however they must be replaced after an earthquake and may prevent the building from settling back to its original position. The hysteresis behaviour of these device shows the relationship between the force and the displacement of the damping material and hence this devices are also called as displacement dependent.

Viscoelastic damper

In this type a solid viscoelastic material is being sandwiched between steel plates. Here energy is dissipated by the shear strain that occurs in the material.

Viscous damper

The energy is dissipated through the viscous fluid dampers by moving a piston that forces a viscous fluid through orifices in the piston head. The force developed in the damper is proportional to the velocity of the moving piston.

Friction damper

It utilizes the mechanism that the solid bodies when slides against each other within the damper releases the energy.

1.5 Accordion Metallic Damper

AMD is the metal tube folded in the longitudinal axis. It has proven its efficiency to absorb the input energy given to them and due to these property it is used in transportation and automobile system to absorb impact energy. Recently Motamedi and Nateghi has performed experimental and analytical study on this damper to study its effectiveness and the experimental and analytical results shows that the energy absorption capacity of this tube increases with the increase in number of layers in the tube.

Fig 1.4 Accordion Metallic damper

1.6 Necessity and objective of work

a) The buildings have been designed according to a seismic code, but the code has been upgraded in later years.

b) Buildings designed to meet the modern seismic codes, but deficiencies exist in the design or construction.

c) Designers lack understanding of the seismic behavior of the structures.

d) Engineering knowledge makes advances rendering insufficient the previous understanding used in their design.

e) Essential buildings must be strengthened like hospitals historical monuments and architectural buildings.

f) Important buildings whose service is assumed to be essential even just after an earthquake.

g) Buildings the use of which has changed through the years.

h) Buildings those are expanded, renovated or rebuilt. Indian buildings built over the past three decades are deficient because of (b), (c) and (d) above. The last revision of the Indian seismic code in 1987 IS 1893 (1984) is deficient from many points of view, and engineering knowledge has advanced significantly from what was used. Also the seismic design was not practiced in most buildings being built.

1.6.1 Objectives of Work

The objective of the present work is to study the effectiveness of metallic damper.
The following are the objectives:

1) To study linear seismic analysis of building.

2) To study design of a structure for seismic forces.

3) To study the effectiveness of metallic damper.

4) To study Non-linear seismic analysis (push over analysis & time history analysis).

5) Investigate the response of structure with and without AMD.

6) To develop mathematical model of building with and without AMD in SAP2000 and perform non-linear time history analysis of the building to study the seismic response of buildings under real earthquake ground motions.

1.7 Hysteresis Loop

Hysteresis loop is the plot between forces or load acting on a structure and displacement due to this forces as shown in the fig. The area enclosed by this loop is a measure of the energy dissipates over a complete cycle. By considering the force and displacement relationship of damping material, energy dissipated by the metallic damper can be evaluated and such a relationship is called hysteresis loop.

Time History	Magnitude	Source
SAN FERNANDO EARTHQUAKE - 8244 ORION BLVD." "FEBRUARY 9, 1971, 0600 PST	0.13g	NICEE
"PARKFIELD EARTHQUAKE - CHOLAME, SHANDON" "JUN 27, 1966, 20:26 PST"	0.15g	NICEE

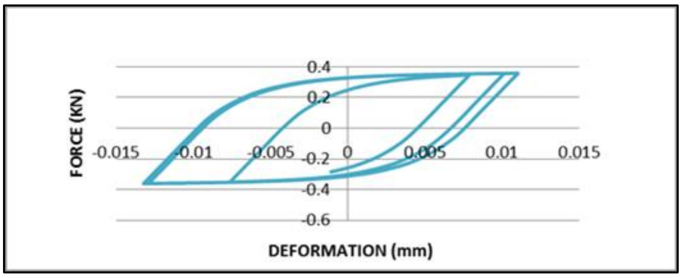

Fig.1.5 Typical hysteresis loop of metallic damper

Initially bilinear model is considered primarily to facilitate the identification of the basic design variables and relationship between them. When performing time history analyses, however, the numerical complications may arise even in simpler bi-linear models due to the sharp transitions from the inelastic to elastic states during the loading, unloading, and reloading cycles. The presence of such abrupt changes in stiffness requires the use of numerical procedures that can locate these transition points in order to avoid erroneous results. As the number of devices installed in a building structure increases and as the different phase or stiffness transition conditions for each device must be taken into account in the numerical calculations, the bilinear representation of the devices can become computationally inefficient.

Columns Designation	Size (mm)	Beams Designation	Size (mm)
C	254 X 457	B	254 X 457

1.8 Analysis and Discussion on result

The data assumed for the problem to be analysing in sap 2000.

Columns and Beams

a. For Rectangular plan & Square plan

1. Building = 7 Storey
2. Slab thickness = 0.12 m
3. Live Load = 3 KN/ m2 (No live load at roof)
4. Software Used = SAP 2000.4.2
5. Method of Analysis = Nonlinear Time History Analysis
6. Real ground motion (Time History) used

1.9 Result and Observation:-

a) Displacements and Inter-Storey Drift Comparison (Graphically)

1. For Square plan

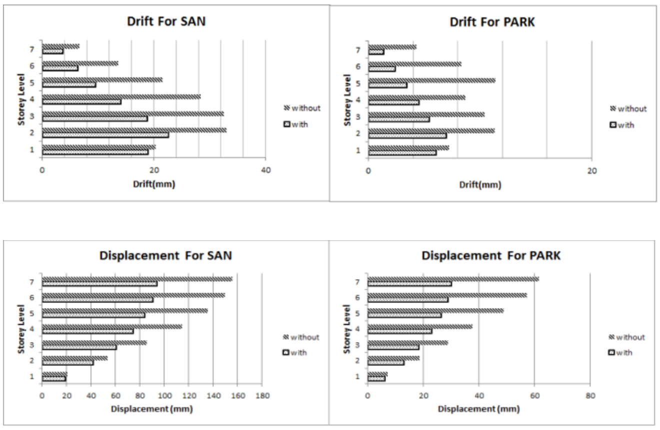

Fig.1.6 Displacements and inter-story drift comparison for San Fernando Earthquake and Parkfield Earthquake

2. For Rectangular plan

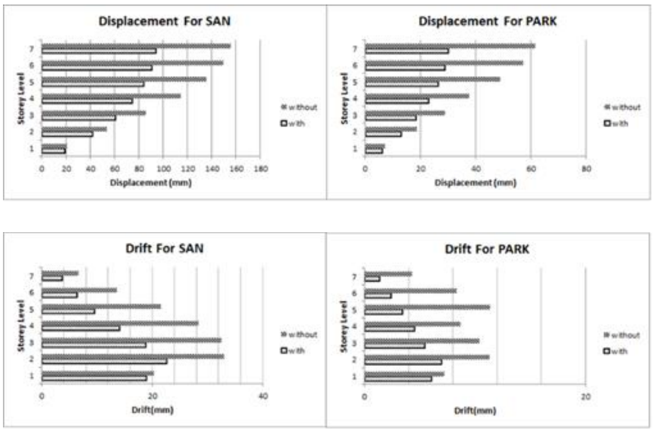

Figure: 1.7 Displacements and inter-story drift comparison for San Fernando Earthquake and Parkfield Earthquake

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b) Hysteresis Loop

1. For Square plan

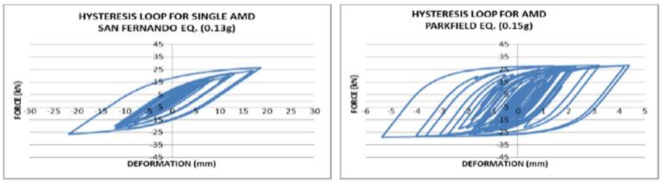


Fig.1.8 Hysteresis loop for San Fernando and Parkfield Earthquake

2. For Rectangular plan

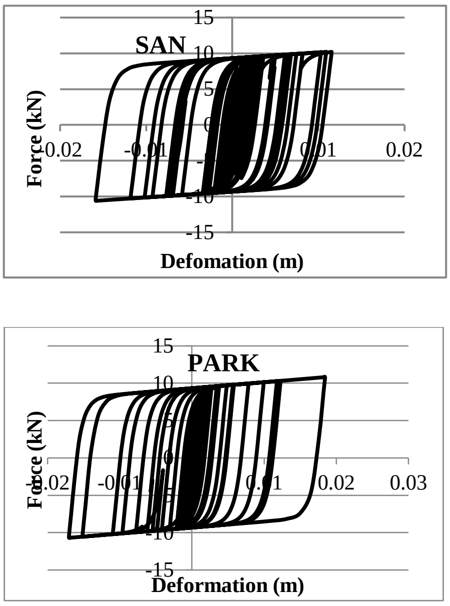
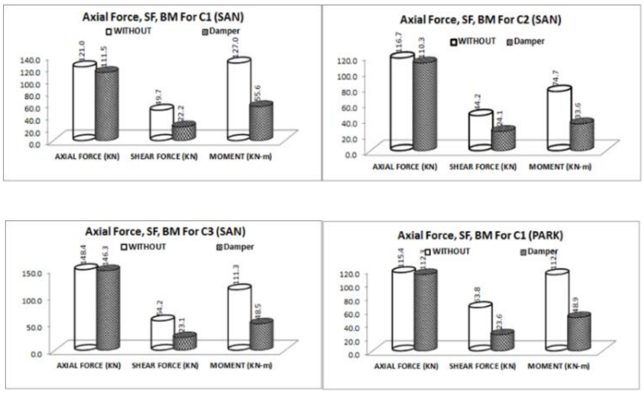


Fig. 1.9 Hysteresis loop for San Fernando and Parkfield Earthquake

c) Comparison of Axial Force, Shear Force and Bending Moment. (Graphically)



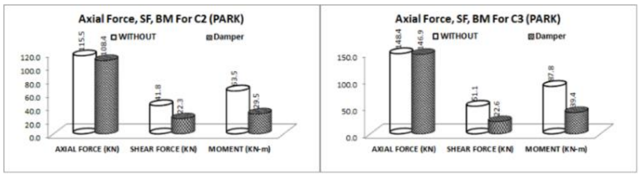


Figure 1.10: Axial Force, SF and BM comparison with and without damper for two earthquakes

d) Top storey displacement

1. For Square plan

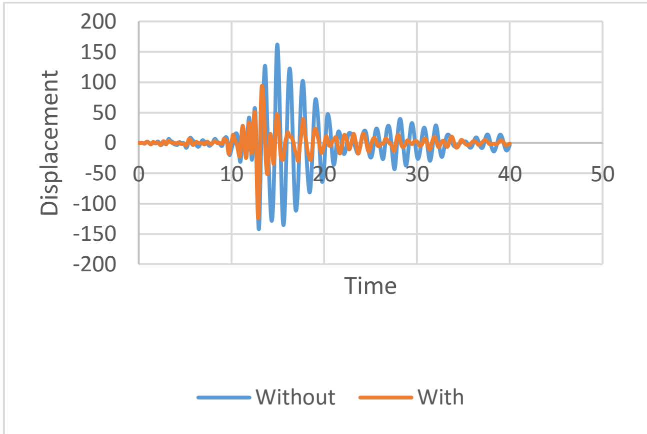


Fig 2.1. Top storey displacement comparison with and without damper

2. For Rectangular plan

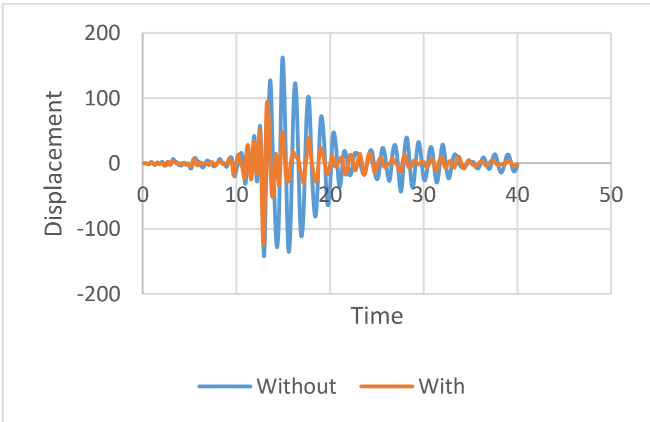
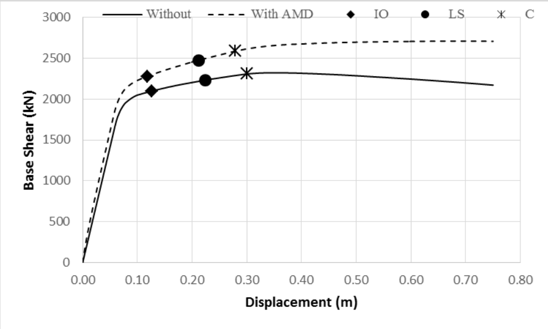


Fig 2.2: Top storey displacement comparison with and without damper

e) Push over curves

1. Push over curves for Square plan



2. Push over curves for Rectangular plan

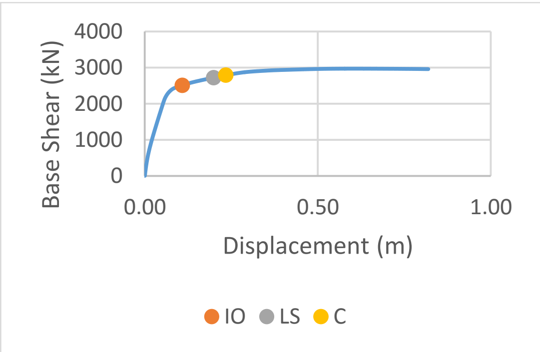


Fig 2.3: Push over curves

f) Discussion on Result:

Due to damper displacement and inter-story drift at various floors shows significant reduction. With damper, shear force and bending moment of all columns can reduce up to (55) %. Reduction in axial force is very small as compared to reduction in shear force and bending moment in all columns at top storey. From hysteresis loops dissipation of energy can be observed. But it is not possible to provide damper at each storey thus, it is necessary to optimize the damper location which gives more reduction for given numbers of damper.

2 CONCLUSION

On the basis of study carried out in this project following conclusion are made.

i. The existence of damper in the structure reduces the seismic response of the structure.

ii. Wen's model is a perfect model to study and understand the behavior of the metallic damper.

iii. It is important to find out the optimal damper location format in the building to improve its efficiency and reduce total cost of dampers to accomplish the max reduction in the response of the building.

iv. Structural behavior of building with dampers is different than the behavior of building without dampers.

v. There is a significant reduction in max lateral displacement and max drift in the building due to presence of dampers in the building.

vi. There is a significant reduction in max bending moment and max shear force in the building due to presence of dampers in the building.

vii. There is a significant reduction in base shear in the building due to presence of dampers in the building.

viii. The reduction in response quantities of the building is dependent on many factors such as properties of damper such as geometry and material and real input ground motion data selected for the analysis.

ix. The reduction in response quantities of the building is dependent on stiffness of the dampers.

x. Response quantitates of the building reduces with increase in the initial stiffness (yield stiffness) of damper.

xi. The energy dissipates by the damper is dependent on the external seismic energy imparts to the structure i.e. input ground motion data.

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