Seismic Performance Evaluation of RC Building Connected with and without X Braced Friction Damper using Etabs

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***Abstract*—All the tall buildings are get affected by the seismic actions. So the buildings constructed in the earthquake zones are mainly designed considering seismic forces. The structures present in the higher earthquake zones are more liable to get more damages or collapse. To increase the safety of these structures few retrofitting techniques are used to stabilize against the earthquake force are done. Now a days damping devices are used to reduce the seismic energy and able to control the structural response of the building to the vibration. The advantages of using friction dampers over other types of energy dissipation devices are due to materials are less likely to be affected by degradation due to aging, materials are insensitive to changes in ambient temperature, there are no material yielding problems after a large earthquake and there are no fluid leaking. Previous studies have shown that tension-only braced frames provide more structural stability and hence offer better resistance when the frame is subjected to lateral loads. In comparison between braced frames, additional efficiency offered by the bracing depends on the selection of bracing system.**

Key Words: Storey Building, Friction Damper, Storey Drift, Storey shear, Storey Stiffness, Friction Braced System, Overturning moment, Conventional Bracing System.

1. INTRODUCTION

In recent years, an efforts is being made to develop and improve the structural control devices to reduce seismic impact in the buildings. To achieve the concept of structural control the modification in the structural elements is carried out. To improve seismic response friction dampers is provided as X braces. They may be adjusted to decrease effects of loads under considerable level. To achieve the structural system in control many techniques have been adopted.

1) Active Damping System 2) Passive Damping System

1.1 Active Damping System

The active damping system is considered with large external power source that may vary from ten kilowatt to several mega watt . The structure can be adopted to add or dissipate seismic energy. The energy required by the active system is very large. It is difficult as it is expensive and less reliable. Full scale implementation of Active structural control is used in Japan, USA, Taiwan, China.

Active damping system – 1) Active brace system 2) Active mass damper system 3) Active tendon system.

1.2 Passive Damping System

It is a device that is attached to the structure which may by designed to modify in damping or stiffness in a structure without requiring an external power in an appropriate manner to operate. Passive damping system includes – 1) Tuned Mass Dampers 2) Magnetic Dampers 3) Viscous Dampers 4) Yielding Dampers 5) Friction Dampers

1.2.1 Tuned Mass Damper, also known as vibration absorbers or vibration dampers , is a passive control device mounted on a specific location in a structure so as to reduce the amplitude of vibration to an acceptable level whenever a strong lateral force such as an earthquake or high winds hits. The application of tuned mass damper can prevent discomfort, damage or outright structural failure. They are frequently used in power transmission, automobile, and tall buildings.

Fig 1.1 Tuned Mass Damper

1.2.2 Magnetic damper consists of two racks , two pinions , a copper disk and rare earth magnet. This type of damper is neither expensive nor dependent on temperature . Magnetic damping is not strengthen that is why it is effective in dynamic vibration absorbers which requires less damping.

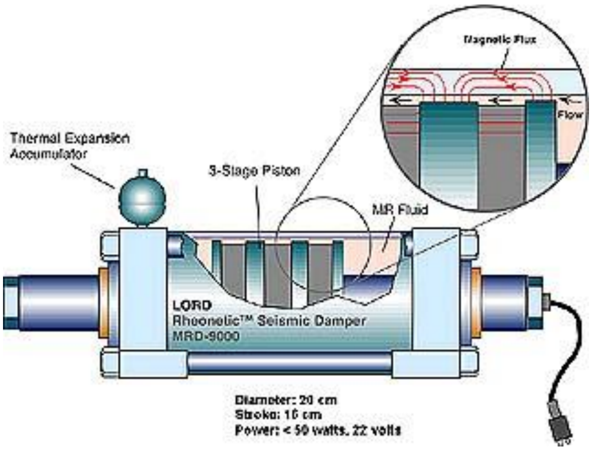

Fig 1.2 Magnetic damper

1.2.3 In Viscous dampers seismic energy is absorbed by silicone based fluid passing between piston cylinder arrangement. They are used in high rise buildings in seismic areas. It can operate over an ambient temperature ranging from 40°C to 70°C. Viscous damper reduce the vibration induced by both strong wind and earthquake.


Fig 1.3 Viscous damper

1.2.4 Yielding dampers or metallic yielding energy dissipation device is manufactured from easily yielded metal alloy materials. It dissipates energy through its plastic deformation which converts vibratory energy and consequently declines the damage to the primary structural elements. Yielding dampers are economical, effective and proved to be a good energy dissipater.

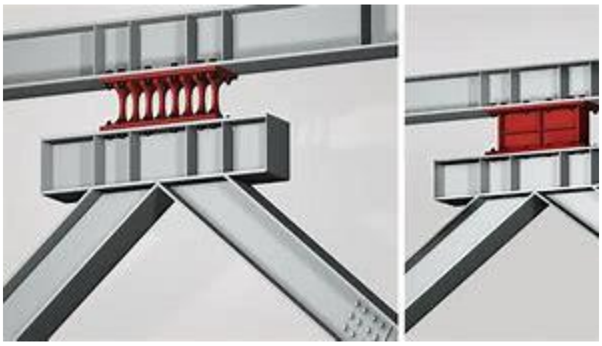
Fig 1.4 Yielding damper

1.2.5 Friction damper device consist of several steel plates sliding against each other in opposite directions. The steel plates are separated by shims of friction pad materials. The damper dissipates energy by means of friction between the surfaces which are rubbing against each other. It is also possible to manufacture surfaces from materials other than steel.

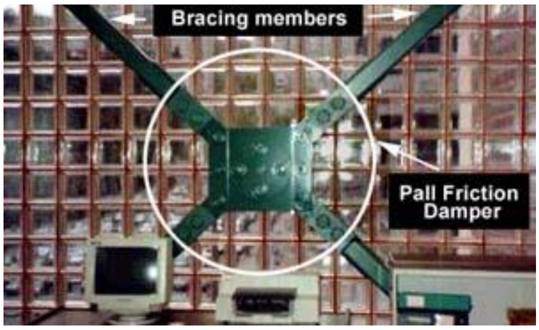

Fig 1.5 Friction damper

2 METHODOLOGY

This research involves the various analysis techniques to determine the lateral forces ranging from purely linear to non-linear inelastic analysis. In India the Standardized method of analysis is followed by using a code – IS1893 (Part 1):2002 – "Criteria for Earthquake resistant design of structures". The seismic performance of building connected with and without friction dampers is carried out.

Table 2.1: The loading combinations are

Sl.No	Load Combination Details
1	1.5DL
2	1.5DL+1.5LL
3	1.2DL+1.2LL+1.2EQX
4	1.2DL+1.2LL+1.2EQY
5	1.2DL+1.2LL-1.2EQY
6	1.5DL+1.5EQX
7	1.5DL-1.5EQX
8	1.5DL+1.5EQY
9	1.5DL-1.5EQY
10	0.9DL+1.5EQX
11	0.9DL-1.5EQX
12	0.9DL+1.5EQY
13	0.9DL-1.5EQY

3 MODELLING AND ANALYSIS

The primary purpose of structural analysis of building structures is to establish the distribution of internal forces and moments over the whole or part of a structure and to identify the critical design conditions at all sections. The geometry is commonly idealized by considering the structure to be made up of linear elements and plane two-dimensional elements. The program ETABS is employed herein to perform nonlinear dynamic time history analysis to obtain the modal characteristics

3.1 Modelling of conventional bracing

The conventional bracings are modelled using steel tubes . Both linear properties are provided for the bracer. The linear properties are used for the linear modal load case.

Table 3.1.1 Braces section details for 12 story building

PROPERTY NAME	TUBE450X250X20
MATERIAL	Fe250
SHAPE	STEEL TUBE
DEPTH	450mm
WIDTH	250mm
FLANGE THICKNESS	25mm
WEB THICKNESS	25mm
WEIGHT	26.973kN

3.2 Modelling of friction damper

Friction brake is widely used to extract kinetic energy from a moving body as it is the most effective, reliable and economical mean to dissipate energy. For centuries, mechanical engineers have successfully used this concept to control motion of machinery and automobiles. This principle of friction brake inspired the development of friction dampers.

The friction dampers are modelled using two-joint link elements (Plastic Wen). Both linear and nonlinear properties are provided for the dampers. The linear properties are used for the linear modal load case and the nonlinear properties are used for the nonlinear time history load cases.

Table 3.2.1 FD details for 12 story building

PROPERTY NAME	FD
MASS kg	2200
WEIGHT kN	0.225
EFFECTIVE STIFFNESS kN/m	20000
EFFECTIVE DAMPING kN-s/m	4000
TYPE	EXPONENTIAL
DIRECTION	U1
NON-LINEAR	NO

3.3Modelling of RC structure

In the finite element analysis software ETABS, building is idealized as an assemblage of area, line and point objects. Those objects are used to represent members like wall, floor, column, beam, and brace and link/spring.

A 12 storey RCC special moment resistant framed structure is considered as the case study model. The building plan and elevation as shown in figures 3.1 and 3.2 respectively. The plan is symmetrical in shape and having an area measurement of 37.5x37.5 m2. The total height of the building is 36 m. each story has a height of 3m including ground floor. The base is fixed to restrain in all 6 DOFs.

Table 3.3.1 Beam and Column details of 12 story building

PROPERTY NAME	MATERIAL	SECTION SHAPE	DEPTH	WIDTH
B250*450 M25	M25 Fe415	RECTANG ULAR	250	450
C 600*600 M25	M25 Fe415	SQUARE	600	600

Table 3.3.2 Slab details of 12 story building

PROPERTY NAME	MATERIAL	THICKNESS
S150 , M25	M25, Fe415	150mm

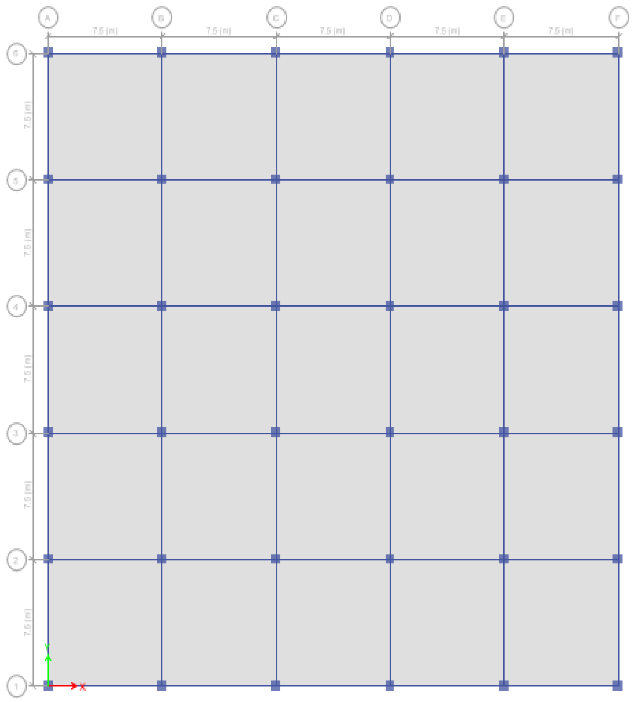

Fig 3.1 Plan of the building

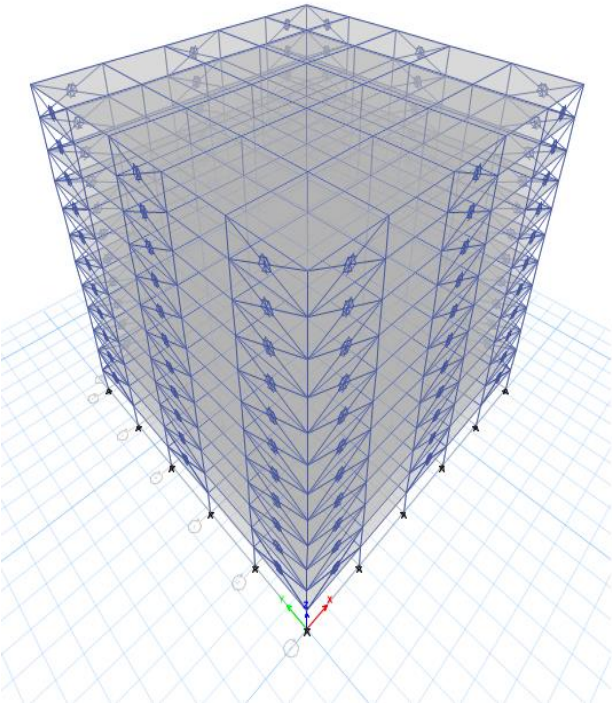

Fig 3.2 3D view of a 12 storey building with friction damper

4 RESULTS

This section defines about detail discussions of software results of different building models with and without BRBs. Comparative study of all types of building models are discussed with respect to storey shear, storey deflection, storey drift and time period etc

4.1 Maximum Storey displacement (mm)

Model	Displacement, EQX	Displacement EQY
Conventional Bracing System	22.51	22.51
FrictionDamper System	28.5	28.5

4.2 Storey Drift

Model	Storey Drift, EQX	Storey Drift EQY
Conventional Bracing System	0.000747	0.000747
FrictionDamper System	0.00189	0.00187

4.3 Storey Shear (kN)

Model	Storey Shear, EQX	Storey Shear EQY
Conventional Bracing System	2521.78	2521.78
FrictionDamper System	2408.32	2424.60

4.4 Overturning Moment (kN-m)

Model	Overturning Moment, EQX	Overturning Moment EQY
Conventional Bracing System	72229	72228.68
FrictionDamper System	67168	67594.49

4.5 Storey Stiffness(kN/m)

Model	Storey Stiffness, EQX	Storey Stiffness, EQY
Conventional Bracing System	2720330	2720330
FrictionDamper System	848152	859763

5 CONCLUSION

The seismic performance of a reinforced concrete (RC) building structure was evaluated and concluded that the structure can be strengthened by incorporating friction dampers.

The response parameters such as maximum storey displacement, storey drift, storey shear, overturning moment and storey stiffness are compared for both structures with and without friction dampers. The storey displacement is increased due to introduction of friction dampers as the energy dissipation . The storey drift of the building including the friction damper system is increased slightly. The storey shear ,overturning moment and storey stiffness of the building including the friction damper system is reduced.

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