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Performance Evaluation of Friction Damper for Steel Structure

Vinay Mandare[1], Pratik Patil[2], Tousif Nadaf[3], Parashram Patil[4], V.G. Khurd[5]

[1,2,3,4]Student *Sou. Sushila Danchand Ghodawat, Kolhapur, Maharashtra, India*
[5]*Assistant Professor,* Sou. Sushila Danchand Ghodawat, Kolhapur, Maharashtra, India

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Abstract - *Tall steel building is increasing day by day, thus need for such building is in demand due to rapid growth in population and increase in competition to construct tall buildings. The building in earthquake prone area are frequently subjected to serious ground motion, the result of this is collapse of structure. The various effects of earthquake are landslide, tsunami, rock fall, etc. such that in this area tall building is not allowed to construct unless properly analyzed for seismic behavior. But however tall building is constructed necessarily due to increase in demand. The design of building in earthquake zone should be such that they must resist moderate earthquake. The main the objective is to control the major part of energy that is getting into the structure and to avoid the collapse of structure, thus analysis of building is done in nonlinear domain. To take care of response friction damper is used in the building. The analysis and design friction damper is discussed in this paper. The analysis is carried out using ETABs software.*

Key Words: Steel Structure, linear static analysis, Friction damper, ETABS

1. INTRODUCTION

Increase in population has lead in growth of tall structure for the propose of accommodation. Also, a competition around the world to construct tall buildings is going on as the symbol of power and technology. Tall structures are subjected to vibration due to wind effect, earthquake, and other source of vibrations. These vibrations can cause serious harm to the structure and can lead to collapse of structure. Earthquake is the most serious phenomenon that engineers are extremely concerned about. The place and time of occurrence of an earthquake are unpredictable and therefore, this categorizes them as a disaster phenomenon. During an earthquake, a large amount of energy is absorbed by the structure. The damage of the structure is determined by the amount of energy consumed. The most dangerous effects of earthquake are collapse of structure, especially in case of tall buildings due to high displacement of stories. The main problem is to reduce the structural response by decreasing the dissipation of input energy due to earthquake. The objective is to control a portion of energy that is getting into the structure, so that the seismic response of the structure and damage control potential could be improved. The main goal is to study and analyse the seismic behavior of tall steel structure using viscous dampers. Different nonlinear computer programs are now capable of modeling viscous dampers. Some of these programs are SAP2000, ETABS, ANSYS, etc. Use of EATBs in analyzing is user friendly and we can model and analyze the building quickly.

1.1 Proposed work

This work is focused on the analysis of steel building and to find the performance of the steel building with friction damper. The linear static analysis is to be done to check the performance for different earthquake. The use of friction damper in the building and to check the performance for different damping and different position of damper is to be done. The building performance in terms of displacement, drift and base shear is to be find out.

2. DAMPING

Damping is event in which mechanical energy is dissipated in dynamic systems and it is converted into thermal energy. Damping reduces the system response, especially for near resonance conditions, where damping controls the response. Damping values depends on various factors such as, vibration amplitude, material of construction, fundamental periods of vibration, mode shapes and structural configurations.

2.1 Types of damping

Three primary damping are

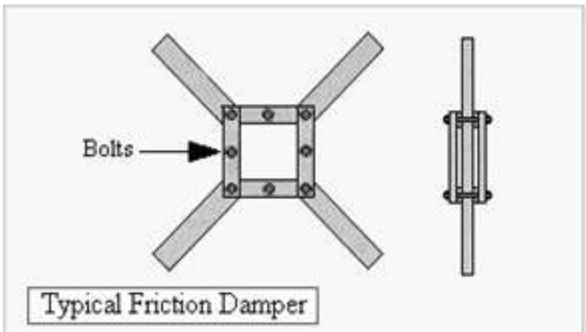
- Internal Damping – due to material
- Structural Damping - at joints and interface
- Fluid Damping – through fluid-structure interaction.
  Two types of external dampers can be added to enhance its energy dissipation characteristics:
- Active Dampers: require external source of power.
- Passive Dampers: does not require external source of power.

2.2 Passive Energy Dissipation Devices

Passive energy dissipations have been under development for a number of years. The main function of passive energy dissipation devices in a building is to absorb a portion of the earthquake input energy. The result is to reduce damage to the structure system. A high number of passive energy dissipation devices are available and others are under development. The various passive devices that have most commonly been used for seismic protection of structures include viscous fluid dampers, viscoelastic solid dampers, friction dampers, and metallic dampers.

2.3 Friction Damper

This device depends on the resistance created between two solid interfaces sliding relative to one another, during severe seismic excitations, the device slips at a predetermined load, providing the desired energy dissipation by friction while at the same time shifting the structural fundamental mode away from the earthquake resonant frequency. One of these devices is slotted bolted connection (SBC).



For this study a 5, 10, 15-story steel frame building is considered. The steel building consists of 5 bays in X-direction and 5 bays in Y-direction. Each bay is of dimension of 4mx4m, having total plan area of 20m X 20m. The building is considered to be located in zone V and designed according to Indian standard code. The structures are considered to be fixed at the base. The structures are modeled using software ETABS2016. Models are studied for comparing maximum story displacement, maximum story drift and base shear.

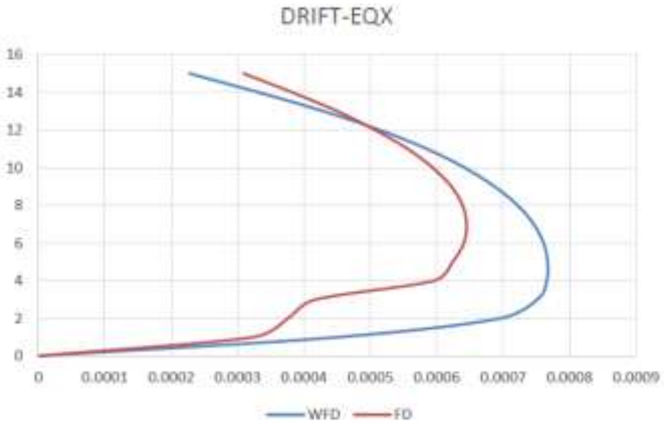


Chart -1: 15 storey drift

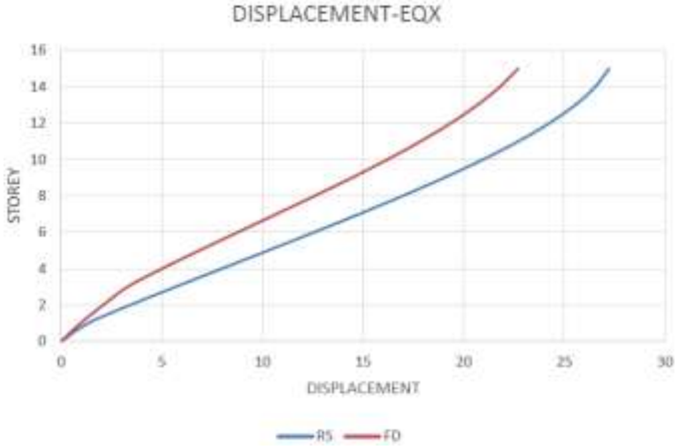


Chart -2:15 storey displacement

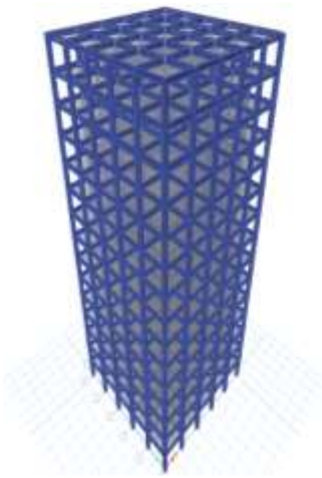


Fig-1: 3-D view of Building.**Fig-2:** with damper of Building

No. of Storey	05	10	15
Storey height	3000 mm	3000 mm	3000 mm
Total height of building	20 m	40 m	60 m
Thickness of Slab	150 mm	150 mm	150 mm
Concrete grade	M25	M25	M25
Grade of steel	Fe500	Fe500	Fe500
Number of bays	5 (X and Y direction)	5 (X and Y direction)	5 (X and Y direction)
Column Size	Outer=PISHB450-2-400/40	Outer=PISHB450-2-400/40	Outer=PISHB 450-2-400/40
	Inner=PISWB 600-2 400/40	Inner=PISWB602-400/40	Inner= PISWB600-2-400/40
Beam Size	ISMB400-200-32	ISMB400-200-32	ISMB400-200-32
Zone	V	V	V

Response reduction factor	5	5	5
Soil Type	Medium (Type II)	Medium (Type II)	Medium (Type II)
live load	3 kN/m^2	3 kN/m^2	3 kN/m^2
floor finish load	1 kN/m^2	1 kN/m^2	1 kN/m^2

3. RESULT AND DISCUSSION

In this chapter, the results are plotted after the analysis. Initial the building is statically analyzed and response spectrum analysis is done. Then application if friction damper is done to reduce the response of the structure, and results are plotted in terms of displacement, drift and base shear.

		5th Story		10th Story		15th Story	
		WFD	FD	WFD	FD	WFD	FD
DISPLACEMENT	EQX	8.114	5.815	17.323	15.043	27.216	22.709
	EQY	8.256	5.941	17.727	15.352	27.914	22.22
	RSX	61.481	40.919	122.738	103.122	189.455	153.106
	RSY	62.161	41.535	125.206	105.096	193.941	156.134
DRIFT	EQX	0.000353	0.000327	0.000244	0.000321	0.000227	0.000309
	EQY	0.00038	0.000346	0.000267	0.00034	0.000249	0.000327
	RSX	0.002323	0.002107	0.001709	0.002131	0.001679	0.002187
	RSY	0.002519	0.002239	0.001884	0.002271	0.001848	0.002323
BASE SHEAR	EQX	1797.35	2314.88	2227.94	1765.88	1720.341	2290.78
	EQY	1788.26	2314.88	1296.79	1739.95	1697.99	2254.96
	RSX	15766	18553.28	18303.42	15336.99	15341.05	20133.13
	RSY	15571	18459.51	18082.57	15098.96	15057.92	19950.42

4. CONCLUSIONS

The modeling of building is done in ETABS for analysis. The first static analysis shows that there is more deflection in building than required. Thus to reduce the response of the building there is need of energy dissipating device like damper. The design of friction damper is done and it is applied in building to check the performance in terms of deflection, inter storey drift and base shear. The linear dynamic response spectrum analysis is also done to check the response of the building. The results are plotted in terms of graphs.

The response spectrum plot shows considerable reduction of acceleration over the time scale of the event by use of dampers against the building without damper. The analysis results show that there is more deflection of building for response spectrum. After application of friction damper in the building, it shows great results in terms of reduced response of the structure. The use of friction damper shows about 25% to 30% reduction in the response of the structure.

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