Seismic Analysis of Unsymmetrical Building using Supplemented Device

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Abstract— Dampers are the supplemented device which are used in the structure to dissipate the energy against the ground movement. Of which, Friction damper consists of steel plates which dissipate energy by sliding against each other in opposite direction. The aim of this research program is to analyse the building with and without friction damper subjected seismic loading with unsymmetrical plan. The first step of this project is to study the design parameters of the friction dampers. The modelling is carried out using software SAP2000. In addition, different parameters such as base shear, axial force, shear force, torsional moment, bending moment, fundamental time period, energy dissipation of bare frame and friction-damped frame has been studied.

Key words: Supplemented Device, Unsymmetrical Building

I. Introduction

Today it is very to design the structure with the consideration of seismic forces to safeguard the lives of the occupant during the earthquake. In order to achieve this different studies had been carried out in the past with the outcome that the codal provision are insufficient in the seismic design of the structure. To reduce the response of the structure seismic analysis of structure is done. The design should be such the it should resist the forces with some deformation. The displacement should be in limit so that the structure remains in the workable position with some retrofitting work.

In order to achieve this, there are various method to tune the response of the structure. The various methods are Base isolation of the structure and other by using supplemented devices. The supplemented devices consists of friction damper, viscous damper and yielding damper.

As per the literature review studied friction damper proved to be more efficient in reducing the response of the structure. The friction damper have very high energy dissipating capacity. It is very easy to construct and maintain.

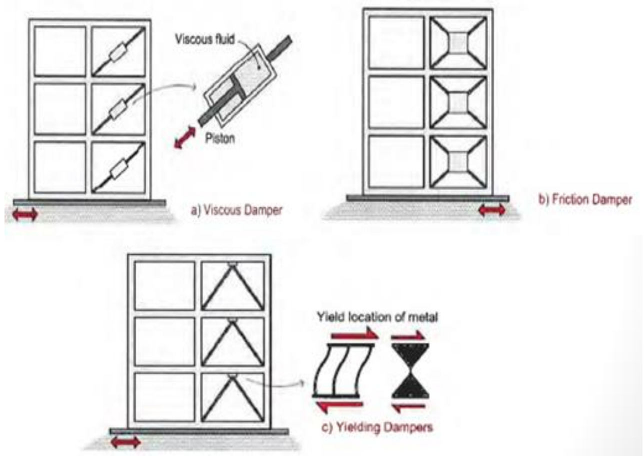

Fig. 1:

The mechanism of friction damper is very simple which consist of two steel plates having some stiffness which slides over each other. The sliding friction itself is used to dissipate the energy and hence reducing the response of the structure. No replacement is required after the earthquake have been occurred.

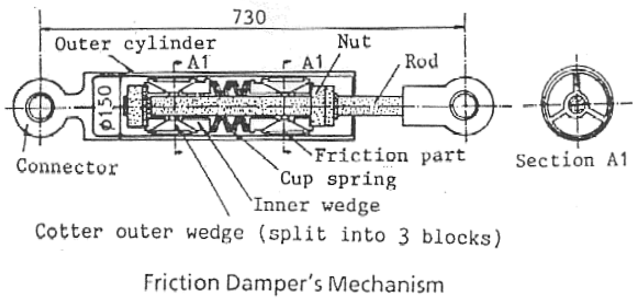

Fig. 2: Friction Dampar's Mechanism

II. Methodology

Software SAP 2000 will be used to analyze the effect of friction damper on seismic response of building. The study will be carried out for 3D building models having mass irregularities in plan. Each building model will be analyzed for four conditions which are as follows:

- 3D bare frame building model without friction damper having no eccentricity.
- 3D bare frame building model without friction damper having eccentricity.
- 3D friction damped building model with no eccentricity.
- 3D friction damped building model with eccentricity.

The seismic response of the structure will be studied on the basis of comparisons of base shear, axial force, shear force, torsional moment, bending moment, fundamental time period, energy dissipation of bare frame and friction-damped frame.

A. *Design Data*

For the study purpose, a six storey building plan has been considered having plan irregularity. The type of irregularity considered is the horizontal irregularity with having mass eccentricity of five per cent. The plan is as shown below-

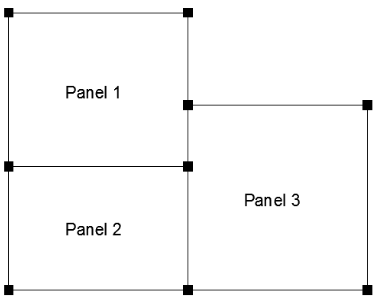

Fig. 3: Plan

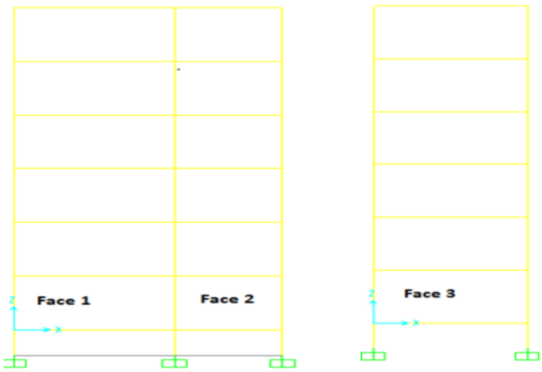

Fig. 4: ELEVATION

The other design data are as follows:
Slab thickness – 150mm
Column Size – (300*300) mm
Beam Size – (300*400) mm
E - $5000\sqrt{25}$ = 25000 N/mm^2
Poisson Ratio – 0.15
Centre of mass – 4.75m

1) Load Calculation

Internal wall- 0.115*3.1*20 = 7.13 KN/m
External wall – 0.230*3.1*20 = 14.26 KN /m
Parapet wall- 0.230*1*20 = 4.6 KN/m
Dead FF = 1 KN/m^2 (assume)
Dead slab = 0.15 * 25 * 1 = 3.75 KN /m^2
Roof live = 1.5 KN /m^2
For 5% eccentricity-
Live load- Panel 1- 3KN/m^2
Panel 2- 3.67KN/m^2
Panel 3- 4KN/m^2
Centre of mass calculated as 4.75m

Talking about the seismic analysis of the structure, to have a detailed study of the response of the structure a non linear time history analysis method is used. Because study of non linearity is well done by performing time history analysis. To have this study an earthquake ground motion having a detailed record of the different types of shaking is to be used. El Centro type earthquake data record is used as it is recorded at imperial valley which was very close to a fault rupture. It has time step of 0.01sec with peak ground acceleration as 0.313g.

B. Optimum Slip Load

During the design of friction damper it is very important to know the load at which the damper slips. The amount of energy dissipated is directly depends upon the load at which the two friction plates slips. The slip load is the important factor with the proper selection of which it is possible to reduce the response of structure.

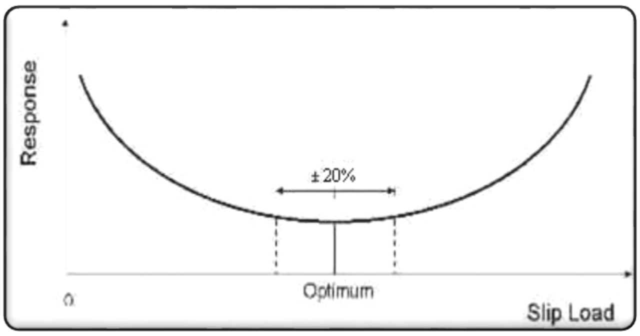

Fig. 5: Optimum Slip Load

The optimum slip load is selected on the basis of three parameters such as peak displacement, peak acceleration and peak base shear. For this purpose different ranges of slip load ranging from 0 to 400KN of 50 KN interval. The dampers are placed at every floor from lower to upper storey as shown in figure below-

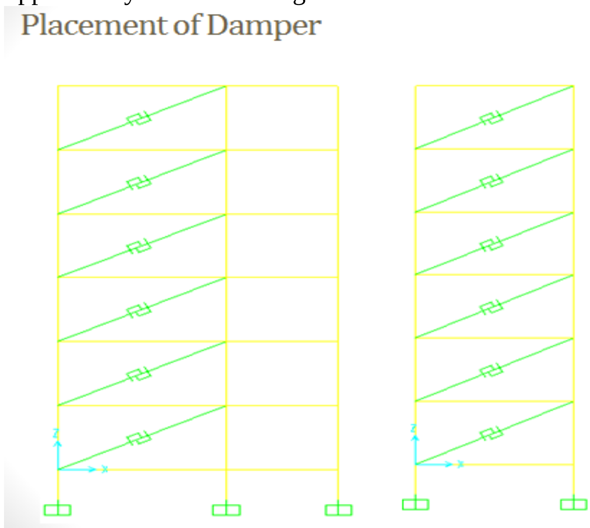

Fig. 6: Placement of Damper

For to find the optimal damper location using optimization technique different placement matrix of one, three and five damper has formed. The response of such damper location matrix are plotted.

III. RESULTS

Slip Load KN	Displacement m	Slip Load KN	Acceleration m/sec^2	Slip Load KN	Base shear KN
50	0.07	50	5.02	50	631.67
100	0.12	100	4.49	100	429.61
150	0.08	150	4.27	150	332.41
200	0.07	200	5.62	200	300.98
250	0.05	250	7.4	250	252.77
300	0.025	300	7.07	300	209.9
350	0.02	350	8.69	350	155.72
400	0.018	400	9.47	400	123.43

Fig. 7: Results

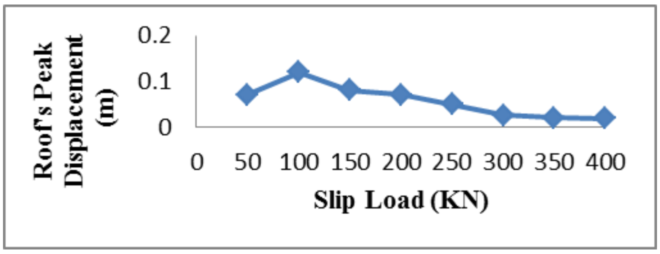

Fig. 8: Roofs Peak Displacement

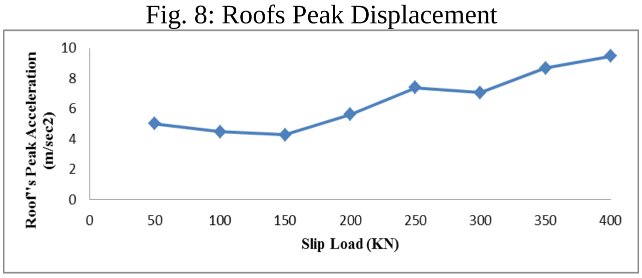

Fig. 9: Roofs Peak Acceleration

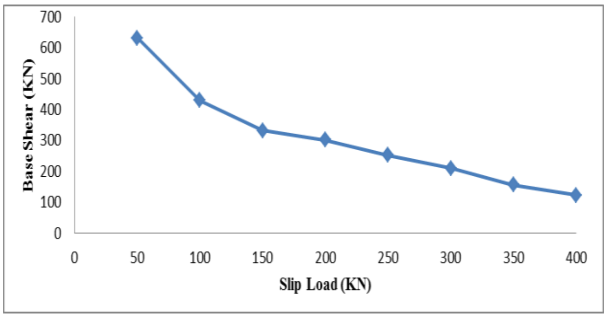

Fig. 10: Base Shear (KN)

Peak displacements/accelerations and peak base shear obtained for different slip load values subjected to El Centro earthquakes.

IV. Design Data For Friction Damper

The optimum slip load calculated from the three parameter considered of peak displacement, acceleration and base shear found to be 225.5KN. Friction damper is designed as a link element in the modelling having plastic wen property.

Parameters	Properties
Link / support type	Plastic (Wen)
Mass	0.225 KN/m
Weight	2.22 KN /m
Yielding exponents	10
Post yield strength ratio	0.0001
Yield strength (Optimal slip load) KN	225.5

Table 1:

To select the optimum placement of the damper of one, three and five damper placement drift ratio per storey is calculated and the graphs are plotted as shown below.

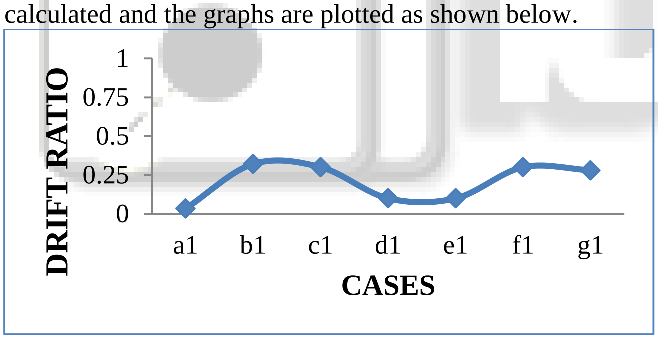

Fig. 11: Effect of one damper placement

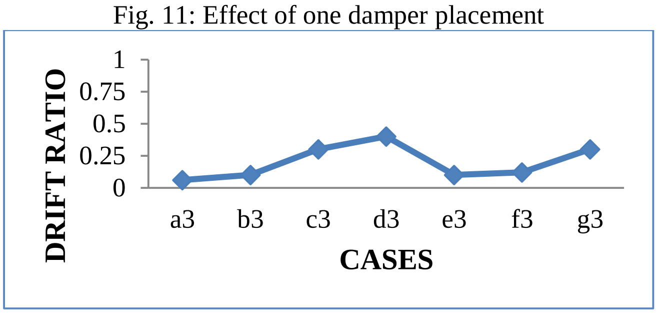

Fig. 12: Effect of three damper placement

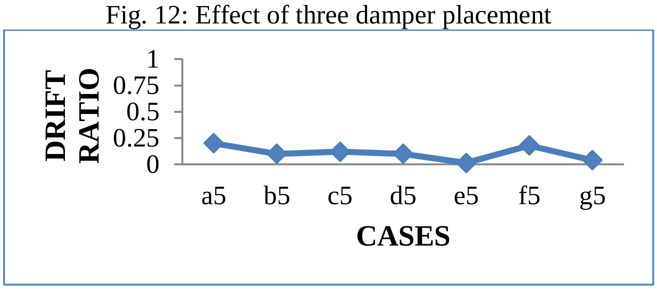

Fig. 13: Effect of five damper placement

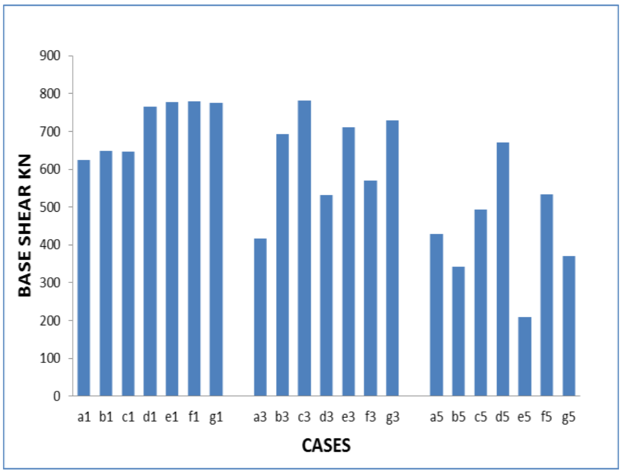

Fig. 14: Graph of various cases of damper placement versus peak base shear

Optimal damper's location matrix for one, three, five number of damper respectively

FACE	STOREY LEVEL				
	1	2	3	4	5
1	1	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0

FACE	STOREY LEVEL				
	1	2	3	4	5
1	1	0	0	0	0
2	1	0	0	0	0
3	1	0	0	0	0

FACE	STOREY LEVEL				
	1	2	3	4	5
1	1	0	1	0	0
2	1	0	0	0	0
3	1	0	1	0	0

Fig. 15:

PARAMETERS	BARE FRAME	FRICTION DAMPED FRAME
Base shear	835.60 KN	208.39 KN
Axial force	581.11 KN	292.88 KN
Shear force	157.40 KN	76.13 KN
Bending moment	229.44 KN-m	118.99 KN-m
Torsional moment	6.03 KN-m	3.61 KN-m

Table 2: Comparison of bare frame and friction damped frame with different parameters

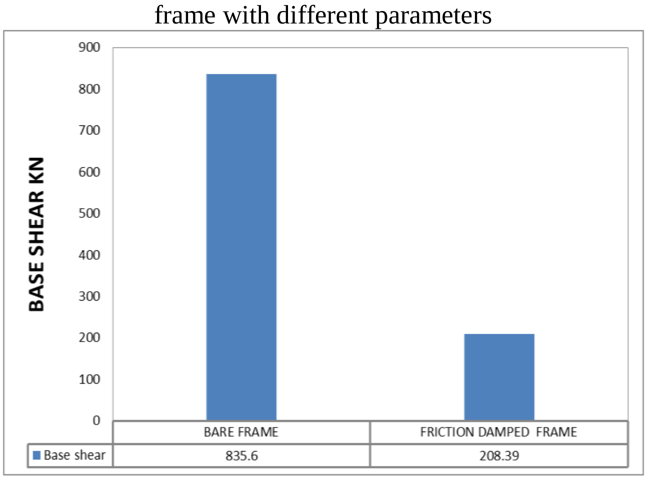

Fig. 16: Graph showing the comparison between bare frame and friction damped frame for Base shear

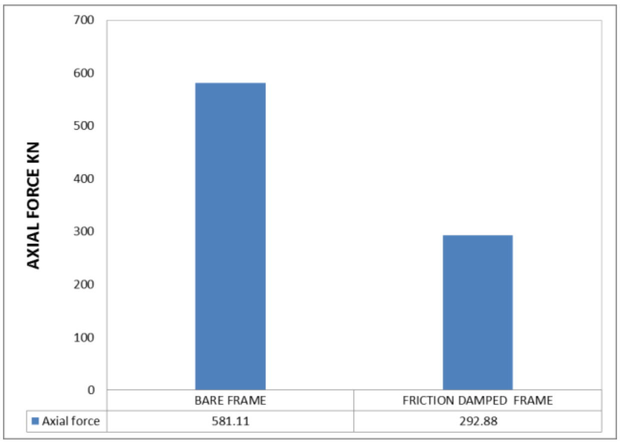

Fig. 17: Graph showing comparison between bare frame and friction damped frame for Axial force

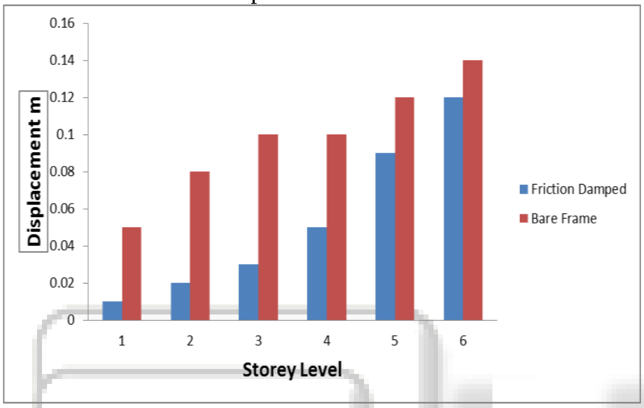

Fig. 18: Graph showing the displacement of various storey level of bare frame and friction damped frame

V. Conclusion

- In this study the effect of the number and placement of friction damper in a five storey frame structure with irregularity has been investigated.
- The study of different parameters has been done for the design of the friction damper.
- It has been observed that the slip load of the friction damper is the principle parameter with the proper optimum selection of which it is possible to reduce the response of the structure.
- As per the results, friction damped frame proved to be more effective in reducing the Base shear, axial force, bending moment of the structure in comparison with bare frame.
- Friction damper is simple in construction and inexpensive in cost with high energy dissipating capacity. No replacement needed after an earthquake with optimum selection of the slip load.
- In case of the number and placement of damper, five numbers of damper proved to be more effective in reducing the response of the structure. Assigning more dampers to the structure only increases the design cost.
- It has been also found out that the dampers are more effective at the lower storey of the structure.

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