SEISMIC EVALUATION OF REINFORCED CONCRETE BUILDING WITH FRICTION DAMPERS

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Abstract

Dynamic action is caused on building by both wind and earthquake. But design of structure for these forces are different. With increase in infrastructure growth the need of structural response control is increased around the world. The paper mainly emphasized use of one such device friction damper for response control of structures. In this paper the comparison of reinforced concrete building connected with and without damper for G+5,G+10,G+15 storied building for seismic zone IV is considered. Analysis is done using equivalent static method, response spectrum method and time history method in finite element software package, ETABS version 16.2.For seismic load combination IS 1893:2016 is used. The model analysis is carried out by all four methods of analysis and results are discussed in terms of storey displacement, storey drift, base shear, bending moment and axial forces. From result obtained it is concluded that storey drift and displacement in friction damper building is reduced where as base shear is less in building without damper.

1.Introduction

Earthquakes are most unpredictable and devastating of all-natural disasters. Earthquakes have the potential for causing the greatest damages among all the natural hazards. They not only cause great destruction in human casualties, but also have a tremendous economic impact on the affected area. With increase in infrastructure growth the need of structural response control is increased around the world. When a structure is subjected to ground motions in an earthquake, it responds by vibrating. Those ground motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. By looking after the destruction, it has become necessary to design building considering seismic codes. With the advancement of technology, it is observed that as mechanical engineers are busy with are providing shock absolver to vehicle similarly it can be done for building. Thus, the use of one such shock absolver friction damper is discussed in this paper. During an earthquake, seismic energy is input into the structure which results in increased vibration response. Mechanical devices e.g. dampers are provided throughout the height of structure to increase the damping hence reduce the response either by absorbing or dissipating energy. Friction dampers dissipate specifically kinetic energy through sliding of plate /surfaces.

2. METHODOLOGIES FOR SEISMIC EVALUATION

The various method used in seismic analysis of reinforced concrete building connected with and without damper are

a) Equivalent static analysis
b) Response spectrum analysis
c) Time history analysis

Table: 1 Load combinations as per IS: 1893-2016

Load Combination	Load Factors
Equivalent static analysis	1.2[DL+IL±(EQ_X±0.3EQ_Y±0.3EQ_Z)]
	1.2[DL+IL±(EQ_Y±0.3EQ_X±0.3EQ_Z)]
	1.5[DL±(EQ_X±0.3EQ_Y±0.3EQ_Z)]
	1.5[DL±(EQ_Y±0.3EQ_X±0.3EQ_Z)]
	0.9DL±1.5(EQ_X±0.3EQ_Y±0.3EQ_Z)
	0.9DL±1.5(EQ_Y±0.3EQ_X±0.3EQ_Z)]
Response spectrum analysis	1.2[DL+IL±(RS_X±0.3RS_Y±0.3RS_Z)]
	1.2[DL+IL±(RS_Y±0.3RS_X±0.3RS_Z)]
	1.5[DL±(RS_X±0.3RS_Y±0.3RS_Z)]
	1.5[DL±(RS_Y±0.3RS_X±0.3RS_Z)]
	0.9DL±1.5(RS_X±0.3RS_Y±0.3RS_Z)
	0.9DL±1.5(RS_Y±0.3RS_X±0.3RS_Z)]

3.Plan details

Modelling means the formation of structural body in the structure software and assigning the loads to the members as per loading consideration. Here we considered a 3-D RC frame with the dimensions of 4 bays @ 4m in x-axis and 4 bays @ 5m in y-axis. The z axis consisted of G+5, G+10, G+15 floors. The plinth height is 2.5m and rest of the floors had a height of 3.5m.

DESIGN DATA FOR ALL THE BUILDINGS

1	**Details of building**		
i)	Structure		OMRF
ii)	Number of storey		G+5,G+10,G+15
iii)	Type of Building		Regular in plane
iv)	Storey height	Ground storey	2.50 m
		Upper storey	3.50 m
v)	Type of building		Residential Building
vi)	Seismic zone		IV
2.	**Material properties**		
i)	Grade of concrete		M25 & M30
ii)	Grade of steel		Fe415
iii)	Density of reinforced concrete		25 kN/m^3
iv)	Density of steel		78.50 kN/m^3
3.	**Member properties**		
a	**Slab**		
i)	Grade		M25
ii)	thickness		0.125m
b	**Beam**		
i)	Grade		M25
ii)	Size (for all storey)		0.23x0.4m
c	**Column**		
i)	Grade		M30
ii)	Size (for all storey)		0.3x0.5m
4	**Type of loads & their intensities**		
i)	Floor finish		1 kN/m^2
ii)	Dead load		4.125 kN/m^2
iii)	Live load on floors		2.5 kN/m^2
iv)	Live load on roof		1.5 kN/m^2
5	Seismic properties		
i)	Zone factor (Z)		0.24
ii)	Importance factor (I)		1
iii)	response reduction factor (R)		3
iv)	Soil Type		Medium (II)
6	Link (Friction damper) properties		
i)	Effective stiffness, K		$2.925x10^{10}$ kN/m
ii)	For storey G+5	Weight of one damper	5585.14kg
		Effective damping	$25.65x10^6$kN-s/m
iii)	For storey G+10	Weight of one damper	10409.088kg
		Effective damping	$34.89x10^6$kN-s/m
iv)	For storey G+15	Weight of one damper	14923.39kg
		Effective damping	$41.78x10^6$kN-s/m

4.Loading Details

The structures are acted upon by different loads such as dead load (DL), Live load and Earthquake load (EL).

A. Self-weight of the structure comprises of the weight of the beams, columns and slab of the structure.

B. Dead load of the structure consists of self weight of slab and floor finish according to IS 875 (Part1).

Dead load on slab: density of concrete x depth of slab x one square meter area+ floor finish

= 25x0.125x1 +1= 4.125 kN/m^2

C. Live load: It consists of Floor load which is taken as 2.5KN/m^2 and Roof load as 1.5 KN/m2 , according to IS 875 (Part 2).

D. Seismic Load: Earthquake loads have been defined and assigned on the building as per IS 1893:2002 (Part-I).

- Seismic zone (Zone Factor): IV (z = 0.24),
- Soil type: Medium soil
- Importance factor: 1
- Response reduction factor: 3 (OMRF)

5.Result and Discussions

The result obtained after the analysis of G+5,G+10,G+15 reinforced concrete building by Equivalent Static Method(**ESM**), Response Spectrum Method**(RSM)** and Time History Method**(THM)** are in terms of base shear, bending moment, axial force and displacement. An efforts are being made to study the reinforced building by pushover analysis method and compare the results of all four method.

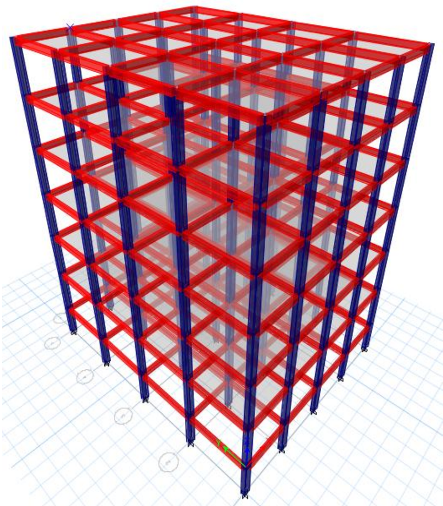

Fig.1-G+5 storey building without damper

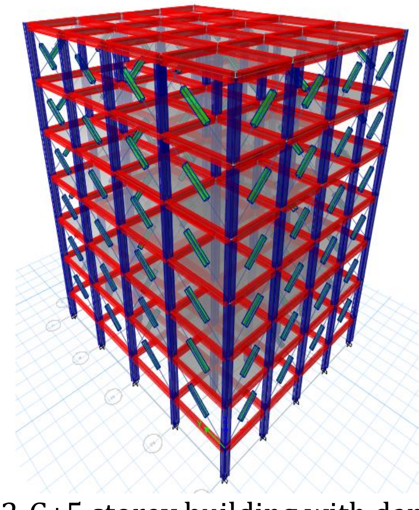

Fig.2-G+5 storey building with damper

A. Base Shear

The base shear of each building frame using equivalent static method(EQM), response spectrum method (RSM) and Time History method (THM) are given in tabular form. Story shear is a force that acts on any story in a direction perpendicular to its extension and is measured in 'KN'. Table-2 and table -3 shows the Base Shear in X-direction and Y-direction respectively for different storey building bye different method. It has been concluded that the story shear tends to decrease with the increase in height of the story. For all the structures it is highest at bottom and it decreases linearly towards top. G+5 storey building has less story shear compare to G+10 and G+15 storey building.

Fig.3 and Fig 4 shows the graphical representation of base shear in X and Y direction with different storey and different method.

Table 2- Base Shear in X-direction

	without damper by ESM	with damper by ESM	without damper by RSM	with damper by RSM	without damper by THM	with damper by THM
G+5	729.094	2269.3181	730.6887	2264.1767	731.0118	2267.0393
G+10	420.1103	1497.5922	756.2287	2688.7931	755.8776	2690.469
G+15	313.5778	927.5578	814.3105	2414.1157	818.7686	2402.8942

Table 3- Base Shear in Y-direction

	without damper by ESM	with damper by ESM	without damper by RSM	with damper by RSM	without damper by THM	with damper by THM
G+5	558.9262	1707.5699	560.6132	1696.7125	560.6206	1703.1081
G+10	328.3099	1200.031	594.4747	2155.51	588.848	2154.3881
G+15	313.5778	877.5069	814.198	2282.3303	816.3084	2280.4958

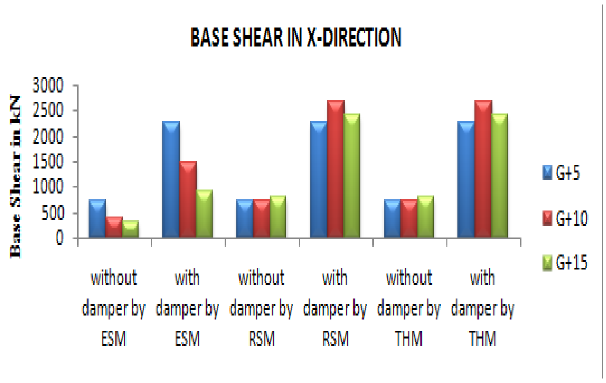

Fig.3.showing Base shear (kN) in X-direction

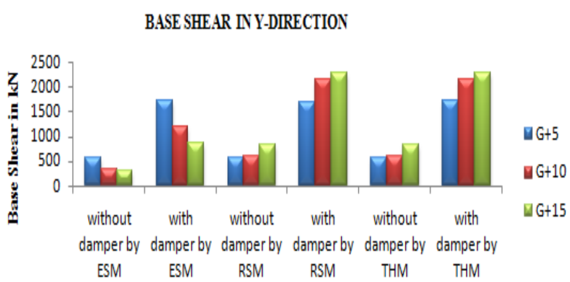

Fig.4. Showing Base shear (kN) in Y-direction

B. DISPLACEMENT

Story displacement is the displacement of one level of a multi-story building relative to the base of the building. Table that story displacement is linearly increasing from bottom to top for all the structures. According to Codal provision, maximum or permissible story displacement should be equal to or less than 0.4% of total building height. Hence here the maximum permissible story displacement = ((0.4 / 100) x 56000) = 224 mm. Table 4 & 5 shows the tabular format of maximum story displacement for different stories using EQM, RSM and THM and Fig.5 shows the graphical format of maximum story displacement for different storey building.

Table 4 - Displacement in X-direction

	without damper by ESM	with damper by ESM	without damper by RSM	with damper by RSM	without damper by THM	with damper by THM
G+5	26.26	13.52	95.457	18.803	79.775	21.458
G+10	59.696	14.161	165.092	45.962	163.287	48.344
G+15	154.821	36.436	695.36	138.413	228.198	121.696

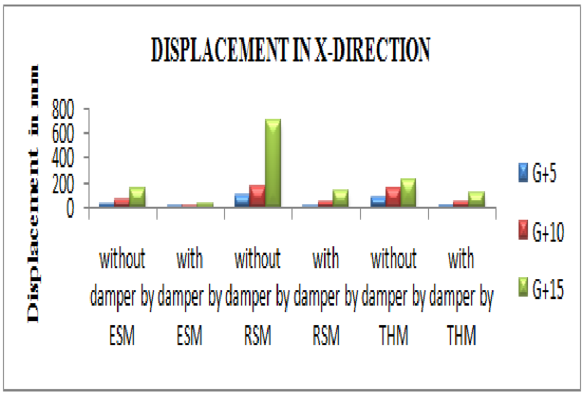

Fig.5.Showing Displacement(mm) in X-direction

Table 5 - Displacement in Y-direction

	without damper by ESM	with damper by ESM	without damper by RSM	with damper by RSM	without damper by THM	with damper by THM
G+5	57.476	15.628	140.264	25.305	103.698	33.17
G+10	94.014	18.678	237.271	44.829	165.423	52.965
G+15	241.258	20.632	1092.358	127.88	591.016	103.767

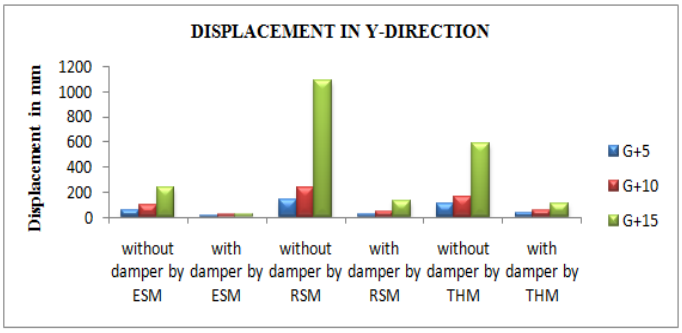

Fig.6.Showing Displacement(mm) in Y-direction

C.AXIAL FORCE

The base reactions in terms of axial force for each building frame using 3 methods are given in tabular form. As can be seen the base shear for building with damper against the building without damper has higher values for large fraction of time indicating that on the time scale of the event the building experiences high amount of force over the run of the event. This increased force is evidently resisted by the friction damper system. The increased force in case of the building with damper can be attributed to increased mass due to addition of damper brace system to the building.

Table 6 - Axial force

	without damper by ESM	with damper by ESM	without damper by RSM	with damper by RSM	without damper by THM	with damper by THM
G+5	252.656	553.5562	458.216	553.5562	221.0251	664.9758
G+10	769.5312	722.5561	721.9377	128.338	366.9529	1250.741
G+15	1542.132	1447.153	4741.285	3085.073	708.9121	2403.808

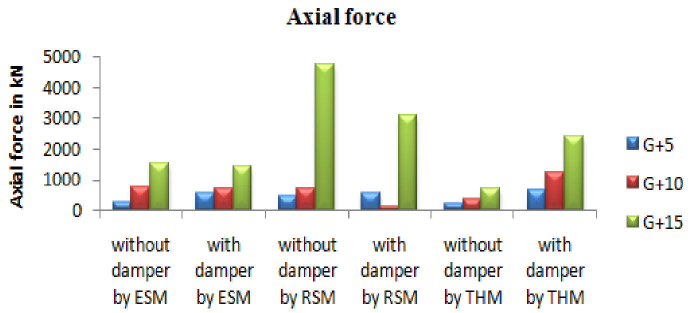

Fig.7. Showing Axial Force (kN) .

D.BENDING MOMENT

A bending moment is the reaction induced in a structural element when an external force or moment is applied to the element causing the element to bend. As bending moment in column is more due to more displacement due to which secondary forces get generated .Table 7 shows the bending moment for all storey building , it increases with addition of friction damper to building.

Table 7 - Bending Moment

	without damper by ESM	with damper by ESM	without damper by RSM	with damper by RSM	without damper by THM	with damper by THM
G+5	113.4884	183.4859	211.9583	327.9527	131.2114	443.6253
G+10	208.6534	227.1132	198.9249	400.2146	110.8775	427.707
G+15	303.7106	370.3257	950.34	796.6828	316.2505	643.5946

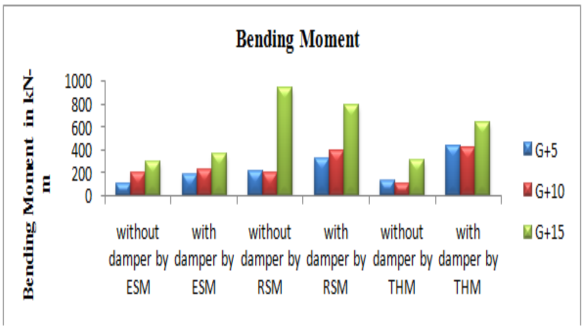

Fig.8. Showing Bending Moment (kN-m) .

6.CONCLUSION

In the present paper the study of G+5,G+10,G+15 storey building are studied in with friction damper .Based on this work following conclusion can be drawn.

- It is observed that Base shear increases in building with friction damper and it decreases for the buildings without friction dampers, it happens due to increase of mass and stiffness of friction dampers in buildings.
- when building connected with friction dampers are compared the storey displacement is decreases with increase in stiffness of the buildings.
- The result shows that, the buildings without friction dampers are more defenceless compared to buildings with friction dampers.
- Friction dampers have been very attractive due to their simplicity and low cost of construction and are found to be very effective in reducing the earthquake responses of the adjacent connected structures.
- High seismic performance of damper has been a great motivation to extend its application out of its origin to other countries.
- As bending moment in column is more due to more displacement due to which secondary forces get generated .
- when dampers are added to building lateral strength and rigidity are enhanced and axial force are increased
- Thus after static analysis and dynamic analysis we find that displacement in column is more than permissible limit thus so resists this we will need to put the dampers.

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