COMPARATIVE STUDY ON SEISMIC EFFECTS OF FLUID VISCOUS AND VISCOELASTIC DAMPERS IN RC BUILDING

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Abstract - *Among all the natural disasters such as flood, earthquake, drought, tornadoes, hurricanes the least understood and the most destructive one is earthquake. Since, they cause plenty of injuries and economic losses leaving behind a series of signs of panic. There is necessity to implement seismic codes in building design, the earthquakes is like wake up call. For this a better method of analysis such as static analysis, dynamic analysis, push over method and time history analysis has to be adopted for performing the structures seismic risk assessment. This dissertation work is concerned with the comparative study on effects of Fluid viscous and Viscoelastic dampers in RC building. According to IS 1893 (part 1): 2002, codal provisions the structures are analyzed by Equivalent static analysis and Response spectrum method. The modeling and analysis is done with SAP 2000 software and the results that is, seismic parameters such as Time period, Base shear, Lateral displacement and Inter storey drift are tabulated and then comparative study of structures with and without dampers has done.*

Key Words*: *Fluid viscous damper, Viscoelastic damper, Displacement, storey, seismic.

1. INTRODUCTION

Seismic design of building relies on the conception of increasing the resistance of the building against earthquake excitation by employing shear walls, braced frames. Buildings in the city are often built without having earthquake resistant design due to limited land availability. To improve the seismic resistance of these buildings, the concept of using control devices has been presented and numerous such passive control strategies have been considered for low to high rise buildings.

Retrofitting methods like base isolation, providing bracings and energy dissipating devices are used to protect buildings from earthquake effects. In the past several decades, so many type of passive energy dissipating devices have been developed, such as oil damper, fluid viscous damper, Viscoelastic damper, metallic damper, tuned mass damper and friction damper etc.

1.1 Fluid Viscous Damper

Most used dampers are fluid dampers, just like the shock absorbers in vehicles. Fluid viscous damper is composed of a piston head, a piston rod and a cylinder full of a viscous fluid. Fluid viscous damper that operates according to the principle of flow of fluid through orifices. When in the damper, piston connecting rod and piston head strokes, forcefully fluid flows through orifices by creating differential pressure across the piston head, will produce very forces that resist the relative motion of the damper (Lee and Taylor 2001).

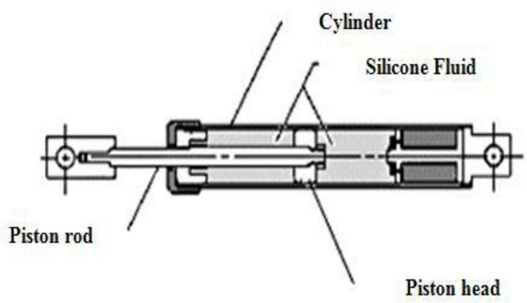

Fig.1: Fluid viscous damper

In this type of dampers, dissipation happens by converting mechanical energy to heat as piston deforms thick, extremely viscous substances. To maximize the capacity of energy dissipation, viscous fluid density should be increased.

1.2 Viscoelastic Damper

Viscoelastic damper are made of Viscoelastic layers connected with steel plates. Energy dissipation is achieved in these layers, by shear deformation which occurs as different component move relatively to each other. Viscoelastic materials employed in structural applications were glassy or copolymer substances that dissipates energy thorough shear deformation. These materials have associate elastic stiffness, with a displacement dependent force and viscous element that produces velocity dependent force. Bitumen, rubber compound can also be used, as the Viscoelastic material, in the energy absorbing device.

Viscoelastic solid dampers typically incorporate solid elastomeric pads together bonded to steel plates. The steel plates were attached inside diagonal or chevron bracing in the building. As any one damper end displaces respect to other, the elastic material is sheared results as bracing.

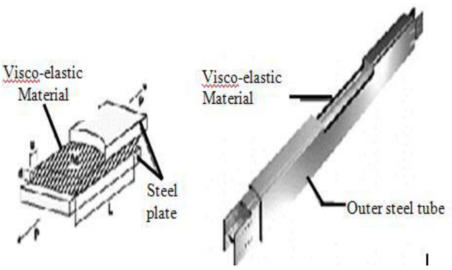

Fig.2: Viscoelastic damper

2. METHODOLOGY

To determine the seismic parameters like lateral displacement, storey drifts of G+ 9 storeys RC Building, Equivalent static and Response spectrum method of analysis were carried out using the software SAP 2000.

2.1 BUILDING MODEL DETAILS

In the present dissertation work G+9 storey Reinforced concrete building with and without dampers is considered.

Total Number of storey =10
Number of bays in X- direction =5
Bay width in X –direction =6m
Number of bays in Y- direction =4
Bay width in Y- direction =5 m

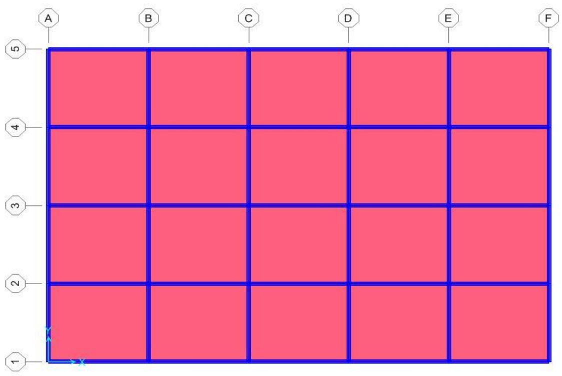

Fig.3: 2D plan view of G+9 storey building

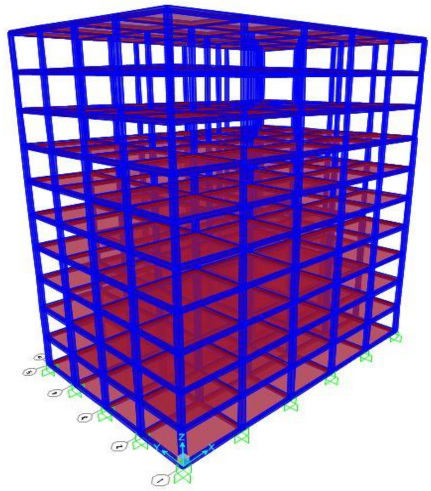

Fig.4:3D view of the G+9 storey building without dampers

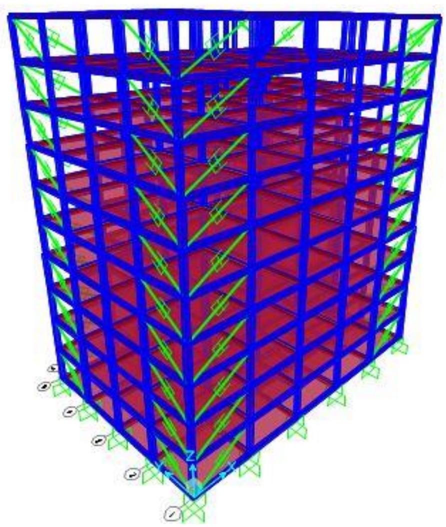

Fig.5: 3D view of the G+9 storey building with dampers

2.2 MATERIAL PROPERTIES

1. Grade of concrete used……………………..M20 and M30
2. Grade of Steel used…………………………..Fe500
3. Density of concrete…………………………..25 k N/m^3
4. Density of steel………………………………...78.50 k N/m^3
5. M20 concrete Young's modulus……………22360680 k N/m^2
6. M30 concrete Young's modulus…………...27386128 k N/m^2
7. Young's modulus of steel……………………2x10^8 k N/m^2
8. Concrete Poisson ratio ………………….……0.2
9. Steel Poisson ratio ………………………..….0.3

2.3 SECTION PROPERTIES

1. Slab

   1. Grade……………………………………M20
   2. Thickness……………………………0.15m

2. Beam

   1. Grade……………………………………M20
   2. Size………………………………………0.23x0.4 m

3. Column

   1. Grade……………………………………M30
   2. Size up to 4th floor…………………0.4x0.4 m
   3. Size 4th to 7th floor…………………0.35x0.35 m
   4. Size 7th to 10th floor………………0.3x0.3 m

2.4 Types of loads and their intensities:

a. Assumed super dead load:

1. Floor finishes……………………………1.5 k N/m^2
2. Roof finishes………………………………2 k N/m^2

b. Live load intensity…………………………………3 k N/m^2

2.5 Seismic properties from code IS1893 (part 1): 2002

1. Importance factor (I)……………………1.0
2. Zone factor (Z)…………………………… 0.36
3. Response factor(R)………………………3.0
4. Soil type……………………………………II
5. Damping ratio………………………………5%

2.6 Link properties:

1. For Fluid viscous damper

   a) Effective stiffness (K_e)………………11000.0 k N/m

   b) Effective damping (D_e)………………800.0 k N-s/m

2. For Viscoelastic damper

   a) Effective stiffness (K_e)………………5000.0 k N/m

   b) Effective damping (D_e)………………500.0 k N-s/m

Table 1: Load combination considered as per IS: 1893(part 1)-2002 and IS: 875(part 3)-1987.

Analysis methods	Load combinations
Equivalent static analysis	1.2(DL+IL+ELX)
	1.2(DL+IL+ELY)
	1.5(DL+ELX)
	1.5(DL+ELY)
	0.9(DL)+1.5(ELX)
	0.9(DL)+1.5(ELY)
Response spectrum analysis	1.2(DL+IL+RSX)
	1.2(DL+IL+RSY)
	1.5(DL+RSX)
	1.5(DL+RSY)
	0.9(DL)+1.5(RSX)
	0.9(DL)+1.5(RSY)

Where,
DL =dead load
IL = imposed load
EQX and EQY =earthquake load in X and Y direction
RSX and RSY = earthquake load in X and Y direction

3. RESULTS AND DISCUSSION

Lateral displacement profile for building models obtained from the equivalent static method and response spectrum method are given in table 2.

- Model 1: Building without damper
- Model 2: Building with Viscoelastic damper
- Model 3: Building with fluid viscous damper

Table 2: Lateral displacement of G+9 storey building model in longitudinal direction

	1.2(DL+IL+ELX)		
Storey	Equivalent static method		
	Displacement (mm)		
	Model 1	Model 2	Model 3
10	280.50	112.2	97.6
9	261.80	107.5	89.3
8	235.10	98.74	78.8
7	202.10	84.8	69.2
6	165.20	71.0	58.5
5	137.50	61.3	48.1
4	108.50	47.75	39.0
3	78.60	34.6	30.8
2	48.70	21.43	17.3
1	20.60	9.3	7.25
Ground	0.0	0.0	0.0

	1.2(DL+IL+RSX)		
Storey	Response spectrum method		
	Displacement (mm)		
	Model 1	Model 2	Model 3
10	252.80	101.12	90.2
9	226.00	92.66	80.6
8	196.90	82.7	70.5
7	174.50	75.03	62.6
6	148.90	64.01	53.2
5	128.70	56.7	45.0
4	98.50	43.34	32.2
3	72.10	32.74	25.0
2	46.10	20.75	15.9
1	19.90	9.4	7.0
Ground	0.0	0.0	0.0

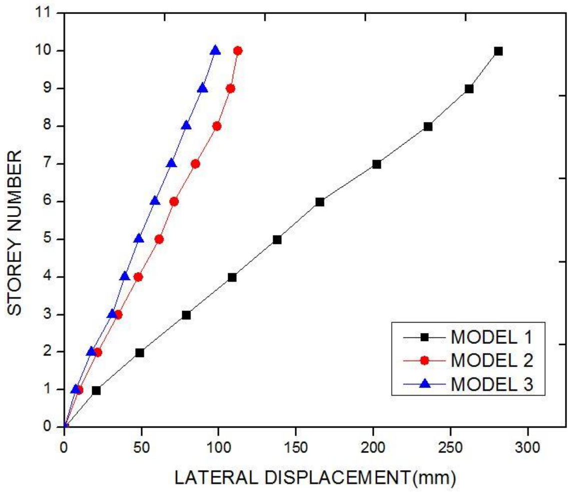

Fig.6: Lateral displacements Profile for G+ 9 storeys building in longitudinal direction

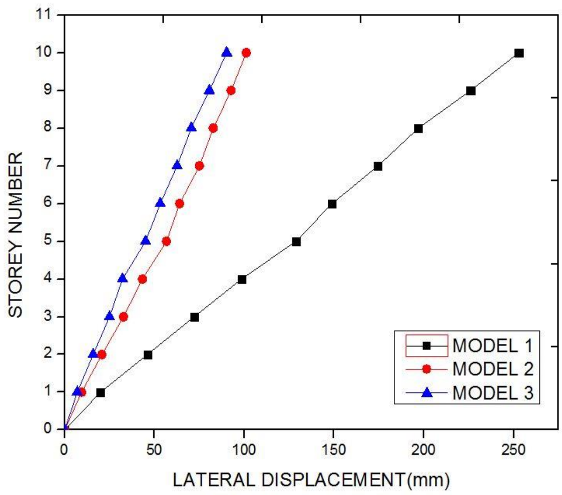

Fig.7: Lateral displacement Profile for G+ 9 storeys building in longitudinal direction

Table 3: Inter storey drift of G+9 storey building models in longitudinal direction

	1.2(DL+IL+ELX)		
STOREY	Equivalent static method		
	Inter storey drift (mm)		
	Model 1	Model 2	Model 3
10	5.34	2.37	1.35
9	7.63	2.5	2.1
8	9.43	3.96	2.74
7	10.54	4.1	3.06
6	7.91	3.36	2.97
5	8.29	3.46	2.65
4	8.54	3.75	2.34
3	8.54	3.86	3.52
2	8.03	3.46	2.87
1	5.89	2.66	2.06
Ground	0.0	0.0	0.0

	1.2(DL+IL+RSX)		
STOREY	Response spectrum method		
	Inter storey drift (mm)		
	Model 1	Model 2	Model 3
10	7.66	2.74	2.42
9	8.31	2.89	2.83
8	6.40	2.26	2.21
7	7.31	3.15	2.69
6	5.77	2.34	2.09
5	8.63	3.82	3.66
4	7.54	3.03	2.04
3	7.43	3.42	2.6
2	7.49	3.24	2.54
1	5.68	2.69	2.0
Ground	0.0	0.0	0.0

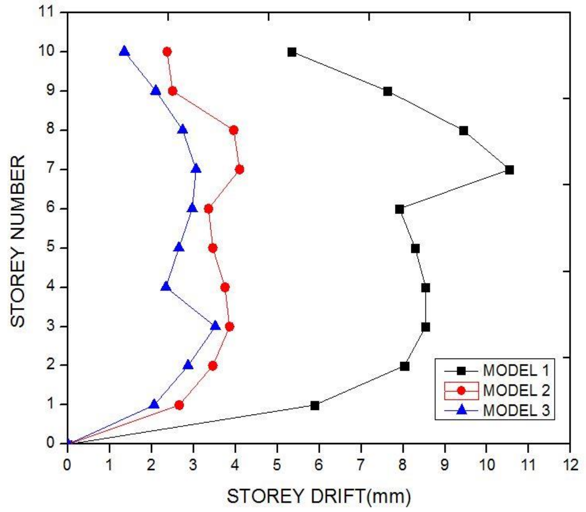

Fig.8: Storey drift Profile for G+ 9 storeys building in longitudinal direction

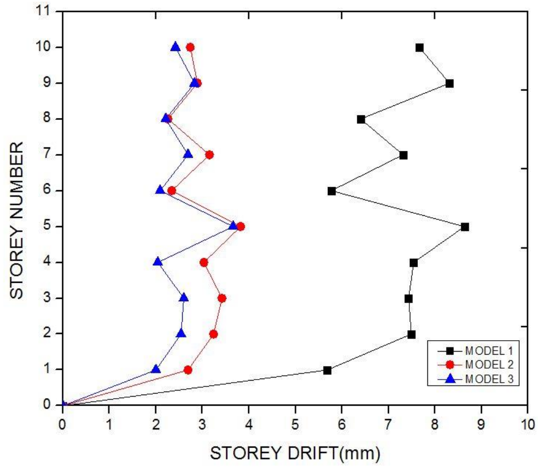

Fig.9: Storey drift Profile for G+ 9 storeys building in longitudinal direction

Table 4: Codal and analytical natural time periods for building as per seismic code IS 1893(part 1) -2002

BUILDING	MODELS	NATURAL TIME PERIOD	
		CODAL VALUES (sec)	ANALYSIS VALUES(sec)
G+9	Model 1	0.725	3.240
	Model 2	0.725	1.523
	Model 3	0.725	1.432

Table 5: Base shear and scale factor of models for 1.2(DL+IL+EL/RSL) combination

MODELS	ELX(KN)	RSX (KN)	Scale factor
Model 1	4183.15	2207.76	1.89
Model 2	4621.91	2970.44	1.56
Model 3	4812.85	3208.11	1.50

Table 6: Base shear and scale factor of models for 1.2(DL+IL+EL/RSL) combination

MODELS	ELY (KN)	RSY (KN)	Scale factor
Model 1	4162.25	2178.43	1.91
Model 2	4603.61	2949.32	1.56
Model 3	4782.56	3163.45	1.51

4. CONCLUSIONS

The following are the conclusions presented based on the obtained seismic response of the buildings;

- The fundamental natural time period of the building without damper is reduced to 53% by using Viscoelastic dampers and 56% by using Fluid viscous dampers in the structure.
- The Base shear of the building is increased by providing Fluid viscous and Viscoelastic dampers in the structure compared to building without dampers.
- Fluid Viscous dampers effectively reduce Lateral displacement of the RC building without dampers from 65% to70% where as Viscoelastic dampers reduce by 55% to 60%.
- Fluid Viscous dampers effectively reduce Inter storey drift RC building without dampers up to 70%-75% where as Viscoelastic dampers reduce up to 65% - 70%.

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