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Comparison of Seismic Performance of RCC Normal Structure, Structure with Shear Wall and Structure with Friction Damper

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Abstract: There are several natural calamities, including flooding. worst natural disaster – quake, drought, tornado, hurricanes, and earthquake are the most devastating. Since it leaves a trail of injuries and financial losses fear-inducing behaviors. Implementation is necessary When it comes to earthquake codes in building design, earthquakes are like a wake a wake-up call is made. Urban areas in India are seeing a growth in the popularity of medium-rise as well as high rise R.C.-framed apartment complexes with storey counts ranging from 8 to 10 and even greater than 20. R.C. framed buildings of these heights are equipped with shear walls to resist lateral loads. Thus, it's important to understand how they affect storey drift and stiffness, as well as shear and moments, as well as stress within the shear walls. In order to determine the strength of the building's shear wall, a three-dimensional analysis is performed by Response spectrum. In this study we will be using a shear wall on one structure and friction dampers on another, we will create and analyses a 30-story high-rise structure and compare the results based on the parameters listed above, by using E-tabs software.
Keywords: E-tabs, Response spectrum, Friction damper, Shear wall, Earthquake

I. INTRODUCTION

High-rise buildings have become a trend and have also paved the way for global competition in the competition of construction of building with large number of floors to demonstrate the symbol of power and technology of their people. The competition for the construction of high-rise buildings is also taking place in all countries point to the symbol of the power and technology of their people. However, high-rise buildings are subjected to vibrations. Vibrations can be caused by wind loads, earthquakes, machine vibrations, and other sources of vibration. These vibrations can cause structural damage or even breakdown of the structure. In recent years in particular, earthquakes have been the main cause of structural collapse Seismic energy is the most destructive phenomena that causes significant structural damage. It's been suggested that neglecting how an earthquake impacts buildings and bad construction procedures are two sources of mistakes that could put structures in grave danger. Conventionally constructed buildings in India follow old logic. The stronger and stiffer the building the most structural masses it has. But the past examples prove these common reinforced concrete or RC buildings fall apart during heavy earthquake shaking. Modern science presenting a solution, where the buildings are reinforced with modern energy dissipation devices.

A. Shear Wall

In structural engineering, a shear wall could be a vertical part of an unstable force resistance system that's designed to face up to lateral forces within the plane, usually wind and seismic loads. Shear walls additionally offer lateral stiffness to prevent the roof or floor higher than from excessive side-sway. When shear walls are stiff enough, they will prevent floor and roof framing members from moving of their supports. Also, buildings that are sufficiently stiff enough can typically suffer less non-structural damage. A shear wall's efficiency is solely determined by its rigidity or stiffness. A shear wall with no openings is much more efficient than one with openings. However, it is occasionally impossible to construct a wall without apertures, such as those for doors and windows. Connect the piers of shear walls with spandrels in the case of openings to increase the strength of the shear wall. Pier refers to the section of shear wall between two openings, whereas spandrel refers to the section of shear wall above the opening. A connected shear wall is defined as a wall formed by interconnecting spandrels of piers of 2 shear walls. The shear wall can also be built by providing openings in a balanced design efficient.

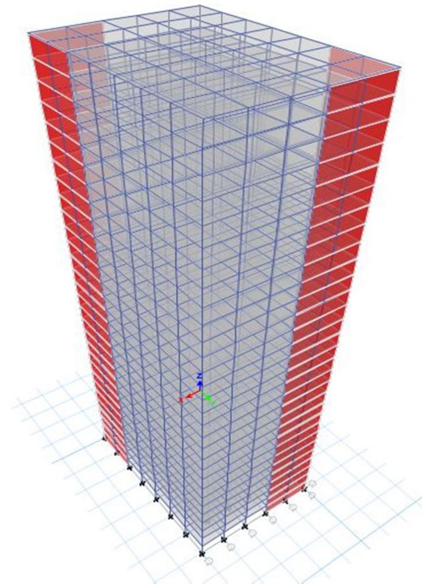

Fig.1 Shear Wall System

B. Dampers

Damper systems absorb seismic energy and reduce deformations inside the structure in order to protect structural integrity, manage structural damages, and prevent harm to residents. Seismic dampers enable the structure to withstand high input energy while reducing detrimental deflections, stresses, and accelerations to structures and people. Dampers are terribly effective at absorbing energy, and that they are straight forward to install or replace. They additionally work well in tandem with alternative seismic protection technology like base isolation. Engineers usually design a building so there are dampers at every story level.

C. Passive Energy Dissipation Devices

Passive energy dissipation systems are under improvement for some of years with a rapid increase in implementation starting in the midd-1990s. The primary function of a passive energy dissipation system is to reduce the inelastic energy dissipation demand on the framing system of a structure. The results to reduce damage to the structure system. A large number of passive energy dissipation devices are available and others are under development. Devices that have most typically been used for seismic protection of structures include viscous fluid dampers, viscoelastic solid dampers, friction dampers, and metallic dampers. Other devices that might be classified as passive energy dissipation devices (or, more generally, passive control devices) include tuned mass and tuned liquid dampers, both of which are primarily applicable to re-centering dampers, wind vibration control, and phase transformation dampers. Additionally, there's a category of dampers, referred to as semi active dampers, which can be 9 considered controllable passive devices in the sense that they passively resist the relative motion between extreme points but have controlled mechanical properties. Semi active dampers are used for seismic response control in many countries, notably Japan (Soong and Spencer 2002). The expansion in application and development of passive energy dissipation devices has led to variety of publications that present detailed discussions on the principles of operation and mathematical modelling of such devices, analysis of structures incorporating such devices, and applications of the devices to numerous structural systems.

D. Friction Dampers

The friction dampers translate the kinetic energy into heat by friction. The dampers allow the building to move elastically. The friction plates consist of steel plates sliding against each other in opposite directions. The friction plates or steel plates are separated by friction pad material (Rubber). Mostly used at HAVC (Heating, ventilation and air conditioning) system or seismic zones. Whenever there is a horizontal force, the building starts swing and the friction dampers will start slipping; when it starts slipping it dissipate the energy. Now what earthquake do is, the earthquake pumps the energy into the building and building starts absorbing the earthquake energy. So, the building needs an external device which will dissipate the energy, so we provide the steel braced friction dampers. Plates within the friction dampers that slips against one another to reduce the huge energy produced by an earthquake.

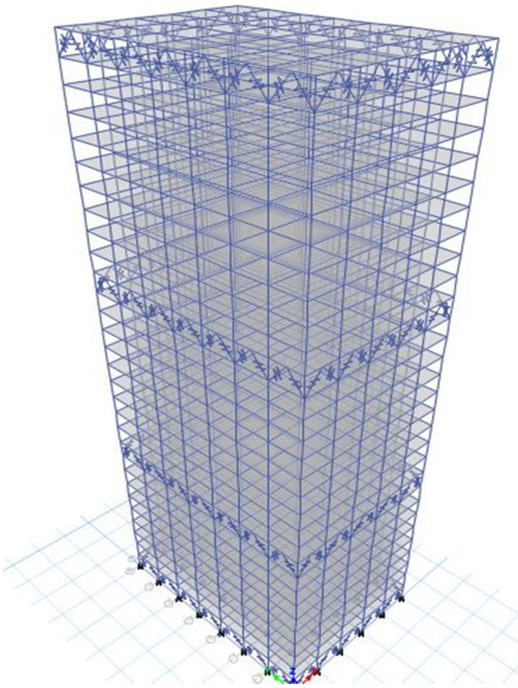

Fig. 1 Friction damper System

E. About E-Tab Software

"ETABS-Extended 3D analysis of Building Systems", is a made from Computers and Structures Inc. It is an engineering software program this is utilized in construction. It has surprisingly efficient structure analysis and layout programs developed for catering to multi story building systems. In addition to modelling tools and templates, it also includes codebased load prescriptions, analysis methods as well as solutions. It can manage the largest and most complicated building models and related configurations. The E-TABS software tool includes a CAD-like drawing tool with an object-based interface and grid display. For the construction and design industries, the ETABS software has the following implications:

1) It's a construction software, building seismic performance is assessed, and the load bearing capacity of structures is checked
2) It is possible to view and manipulate the analytical model with great precision using this software program. Every grid line generates a plan and elevation view.
3) On the other hand, ETABS is used to analyze shear walls and moment frames made of concrete. Static and dynamic analysis of multi-storey frame and shear wall buildings is a specialty of this software.
4) It is one of the most widely used civil design tools in the construction industry, and it helps structural engineers work more efficiently. It also prevents the waste of time and money on general-purpose software applications.
5) The ETABS input, output, and numerical solution methodologies are specifically developed to take use of the unique physical and numerical properties of building type structures. As a result, data preparation, output interpretation, and overall execution are all sped up with this analysis and design tool.

F. Merits of Friction Damper

1) Device and installation are both inexpensive.
2) Allows for structural section size reduction.
3) It's simple to construct with, as it's not affected by velocity or temperature.
4) Highest (largest) energy dissipation per cycle in a rectangular hysteretic loop.
5) There is no need for maintenance.
6) To grow massive loads, they might be installed in parallel.
7) It serves as a load control system (slip load limits buckling, column and foundation loads).

II. OBJECTIVES

A. To study the performance of reinforced concrete conventional structure, reinforced concrete structure with shear wall ad reinforced concrete structure with friction damper.
B. To analyse the three different structural systems using E-TABS software.
C. To obtain response of the different structural systems in terms of different parameters such as Base shear, Time period, joint displacement & Story drift.
D. To compare the behaviour of shear wall structure system and friction damper structure system by performing "Response spectrum analysis".

III. METHODOLOGY

A. A 30-story reinforced concrete conventional frame is taken with the shear wall and friction damper structural system with each story height of 3m with a total height of 90 m is considered and analysed for gravity as well as lateral loads.
B. The material properties as well as the sectional properties of conventional structure, structure with shear wall and structure with friction damper are kept same with similar story height in the three models.
C. A structure is modelled with shear wall of 254mm(10inch) is provided on the two opposite side of the structure through out the length of the structure from base to 30th storey. And the friction damper parameters such as mass, weight, length and slip load is calculated and a model is modelled with friction dampers. Dampers are defined at every 10 storeys.
D. A dynamic (Response spectrum) analysis is done on all the models and a comparison is made in between them.
E. The structure's behavior has been analyzed, and it has been determined that the drift and displacements are within the limits set by Indian standards.
F. The results obtained from analysis of three different models and the parameters associated with every model are compared.

IV. MODEL DATA

A. Building Plan And Its Geometry

Plan Dimensions	: 25m×35m
Number of storeys	: 30
Typical storey height	: 3m
Bottom story height	: 3m
Total height	: 90m
No of bays in x direction	: 5
No of bays in y direction	: 7
Bay width in x and y direction	: 5m

B. Material Properties

1) Shear wall & column – M40
2) Slab & beam – M40
3) Reinforcement – Fe-550

C. Section Properties

1) Beam - 533.4mm x 609.6mm (21" x 24")
2) Column- 762mm x 762mm (2.5' x 2.5')
3) Shear wall- 254mm
4) Slab -150mm

D. Gravity Loading

1) Floor Finish – 1.2 kN/m2
2) Live Load – 3 kN/m^2,
3) Wall load – 6 KN/m

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E. *Seismic Loading*
1) Zone factor – 0.16, for zone III
2) Response reduction factor – 5
3) Soil Type – II
4) Importance factor – 1.5
5) No. of modes to be considered – 12
6) Modal Analysis – Ritz
7) Scale factor – Ig/2R
8) Minimum eccentricity – 0.05
9) Damping – 5 percent
10) Mass source – 1DL + 0.5 LL
11) Diaphragm type – Rigid

F. *Response Spectrum Analysis*
1) Response-spectrum analysis determines the statistically-possibly response of a structure to seismic loading. This linear form of analysis uses response-spectrum ground- 48 acceleration records based at the seismic load and placement conditions, rather than timehistory ground motion records. This technique is extraordinarily efficient and takes into consideration the dynamical behavior of the structure.
2) Response spectrum analysis is a technique for calculating the structural response to nondeterministic, transient dynamic disturbances. Examples of such activities are earthquakes and shocks. Since the exact time records of the load is not known, it is hard to perform a time-based analysis. Due to the short period of the event, it cannot be taken into consideration as an ergodic ("stationary") process, so a random response approach isn't always applicable either.
3) The response spectrum technique is based on a special type of mode superposition. The concept is to offer an input that gives a limit to how much an Eigen mode having a sure natural frequency and damping may be excited by an event of this type.

G. *Design Response Spectra*
1) The response spectrum of a single time sign is rarely of interest for analysis, as it may be preferable to perform a direct time domain analysis of the structure using the unique signal as input. A specific earthquake may also generate a response spectrum with notable peaks at specific frequencies. The peaks for another comparable earthquake may also, however, be located at different frequencies
2) To be capable of use a response spectrum for analysis of an event that has now no longer but occurred, a design response spectrum is created. The design response spectrum may be idea of as an envelope that covers all acknowledged and predicted earthquakes in a given area. Such spectra are, for example, furnished in building codes like IS 1893. The acceleration levels in a design response spectrum will normally rely upon the geographical region and the kind of soil. The response spectrum analysis uses the design response spectrum as its actual input. Design response spectra are frequently provided in terms of the period, instead of the frequency. Since one is the inverse of the other, the two graphs are simply reflected when plotting on a logarithmic scale.

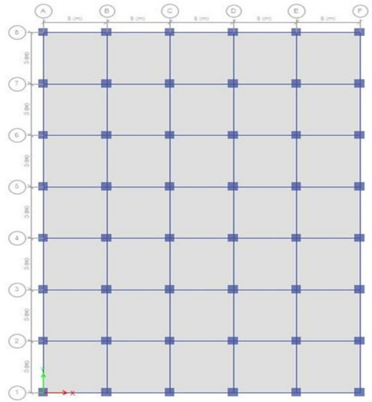

Fig. 3: Plan view of modelled reinforced concrete conventional structure

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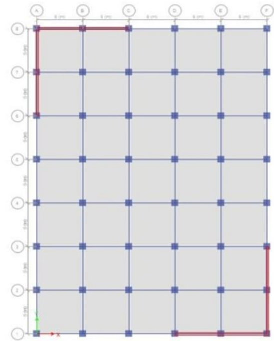

Fig. 4: Plan view of modelled reinforced concrete structure system with shear wall

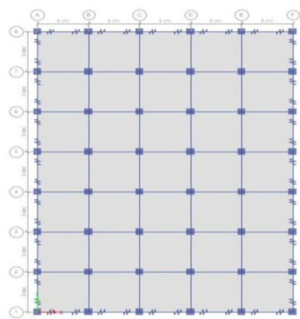

Fig. 5: Plan view of modelled reinforced concrete structure system with friction damper

V. RESULTS AND DISCUSSIONS

The results are obtained from the Response spectrum analysis, for all the models. Different parameters such as joint displacement, story drift, time period and base shear associated with every model are compared as shown in figure and discussed as follows

A. Maximum Story Displacement

The results of story displacements which are obtained by conducting time history analysis are compared between structure with framed tube system and structure with outrigger system in x and y direction as mentioned below in table 1 and shown in figure 6 and 7.

Table 1: Values of storey displacement

Storey	Conventional building		Building with shear wall		Building with friction damper	
	X	Y	X	Y	X	Y
30	35.443	33.392	21.242	19.673	24.28	22.392
28	34.37	32.589	20.036	18.529	23.552	21.903
26	32.987	31.469	18.753	17.311	22.446	21.031
24	31.317	30.05	17.39	16.023	21.091	19.899
22	29.408	28.376	15.948	14.669	19.564	18.578
20	27.298	26.482	14.434	13.255	18.182	17.384
18	25.011	24.39	12.857	11.79	17.225	16.628
16	22.562	22.112	11.226	10.285	15.303	14.856
14	19.965	19.662	9.555	8.751	13.189	12.866
12	17.24	17.059	7.864	7.205	11.009	10.786
10	14.407	14.32	6.18	5.671	9.222	9.078
8	11.475	11.455	4.543	4.182	8.271	8.237
6	8.438	8.462	3.009	2.788	5.879	5.888
4	5.313	5.356	1.659	1.558	3.293	3.318
2	2.197	2.231	0.605	0.584	0.825	0.839
Base	0	0	0	0	0	0

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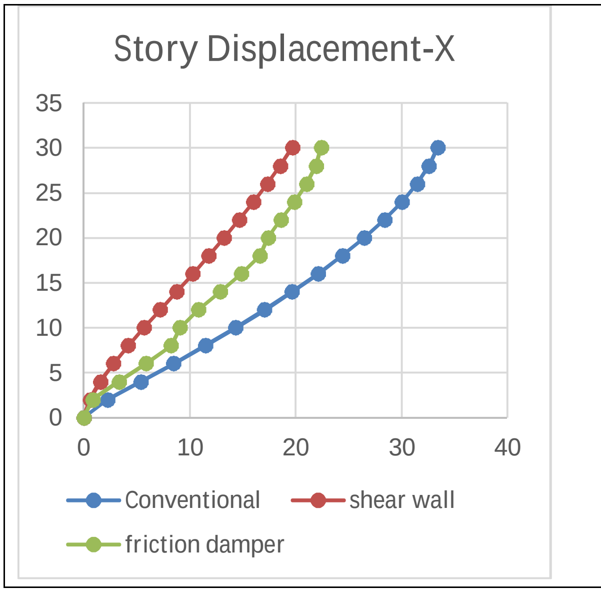


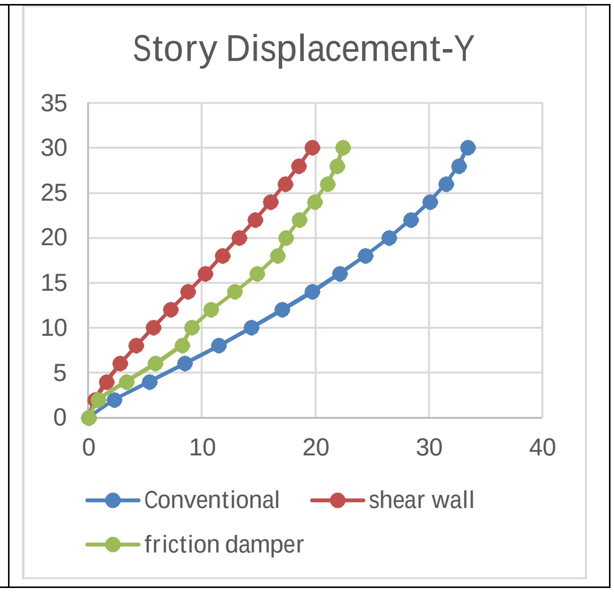


Figure 6: Story displacement comparison, X and Y-direction

Table compares the value of story displacement. Maximum storey displacement obtained in the X-direction for RC normal frame is 35.443mm and in RC frame with shear wall, maximum displacement obtained is 21.242mm and in RC frame with friction damper, maximum displacement obtained is 24.28mm. Comparing to conventional building with shear wall the displacement is reduced in shear wall by 40.06%. And comparing to RC frame with friction damper with RC frame with shear wall the maximum storey displacement is reduced in shear wall by 12.22%. compares the value of story displacement. Maximum storey displacement obtained in the Y-direction for RC normal frame is 33.392mm and in RC frame with shear wall, maximum displacement obtained is 19.673mm and in RC frame with friction damper, maximum displacement obtained is 22.392mm. Comparing to conventional building with shear wall the displacement is reduced in shear wall by 41.08%. And comparing to RC frame with friction damper with RC frame with shear wall the maximum storey displacement is reduced in shear wall by 12.14%.

B. Time Period

The values of time period (sec) and mass participation factor in x and y directions are obtained and comparison of reinforced concrete normal frame with reinforced concrete frame with shear wall and RC frame with friction damper are shown in below table.

Table 2: Values of time period (sec) and mass participation factor

Modes	Normal frame			Building with shear wall			Building with friction damper		
	Time period (sec)	Mass Participation X (%)	Mass Participation Y (%)	Time period (sec)	Mass Participation X (%)	Mass Participation Y (%)	Time period (sec	Mass Participation X (%)	Mass Participation Y (%)
1	3.01	0.7759	0	2.283	0.4897	0.2306	2.036	0.7943	0
2	2.85	0	0.7859	2.019	0.213	0.4804	1.909	0	0.8074
3	2.544	0	0	1.361	0	0	1.665	0	0
4	0.973	0.117	0	0.654	0.0758	0.056	0.662	0.1204	0
5	0.931	0	0.1084	0.527	0.0796	0.0922	0.63	0	0.1088
6	0.841	0	0	0.357	0	0	0.558	0	0
7	0.539	0.0398	0	0.32	0.0296	0.0271	0.383	0.0245	0
8	0.525	0	0.0392	0.249	0.0297	0.0317	0.372	0	0.0237
9	0.487	0	0	0.168	0	0	0.345	0	0
10	0.285	0.0437	0	0.16	0.0319	0.029	0.193	0.0439	0
11	0.278	0	0.0433	0.13	0.0262	0.0288	0.188	0	0.0436
12	0.258	0	0	0.087	0	0	0.174	0	0

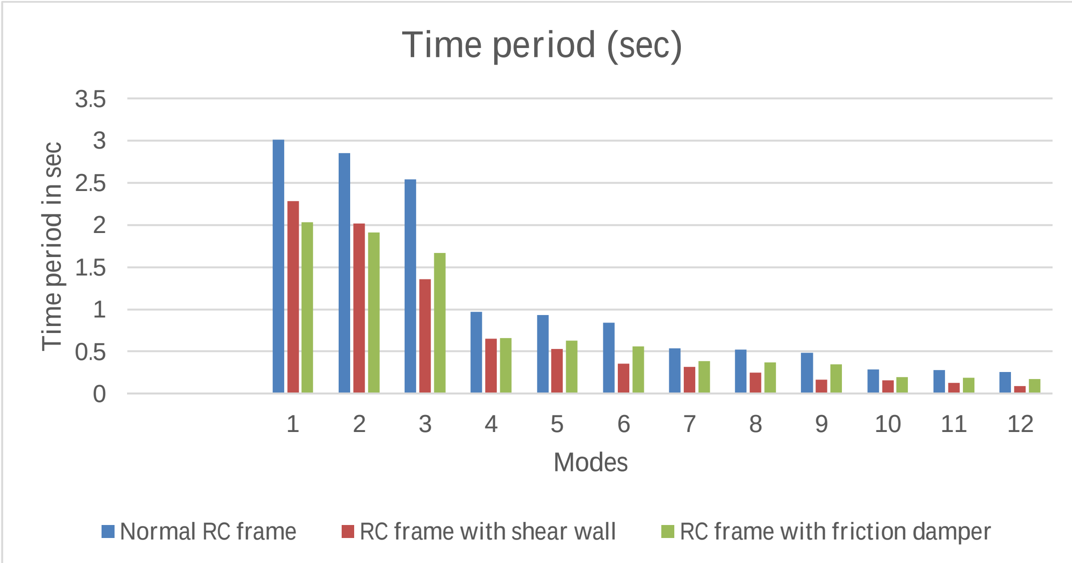


Figure 7: Comparison of time period

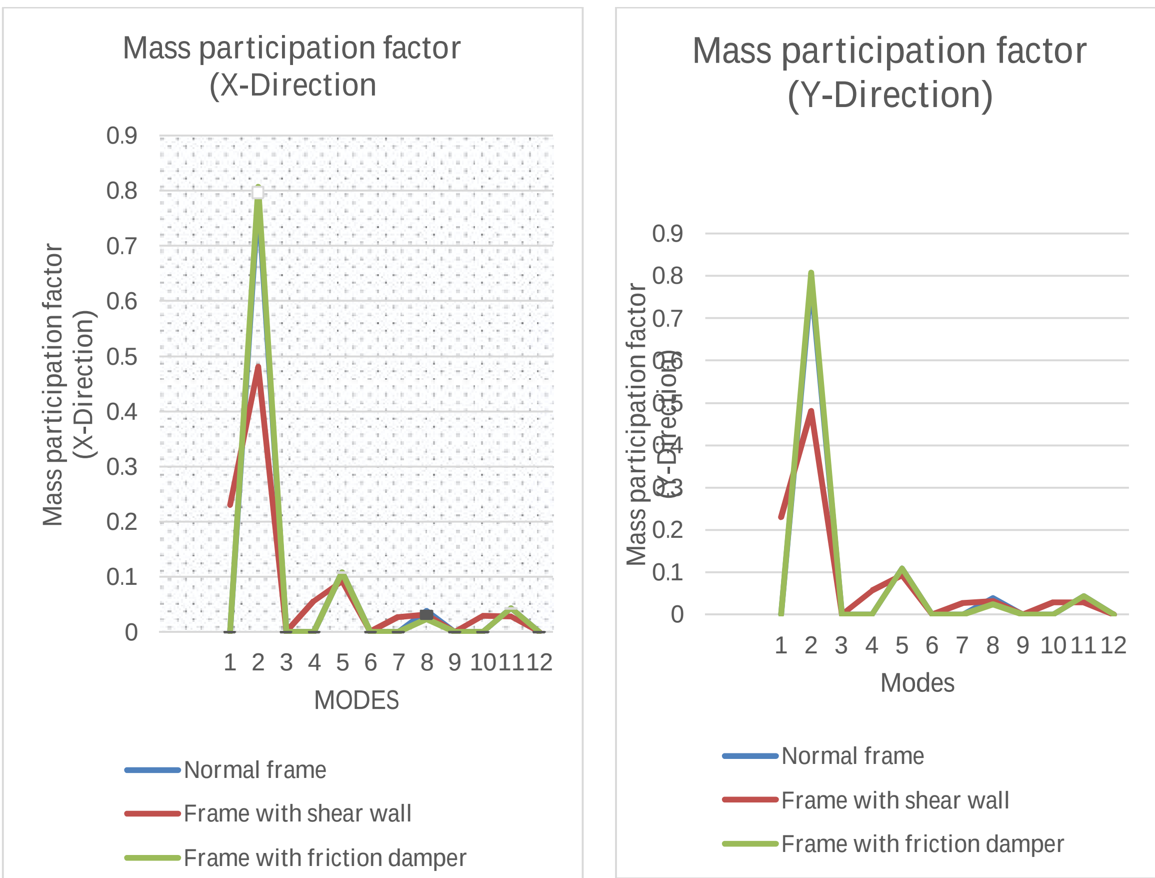


Figure 8: Mass participation comparison in X and Y direction

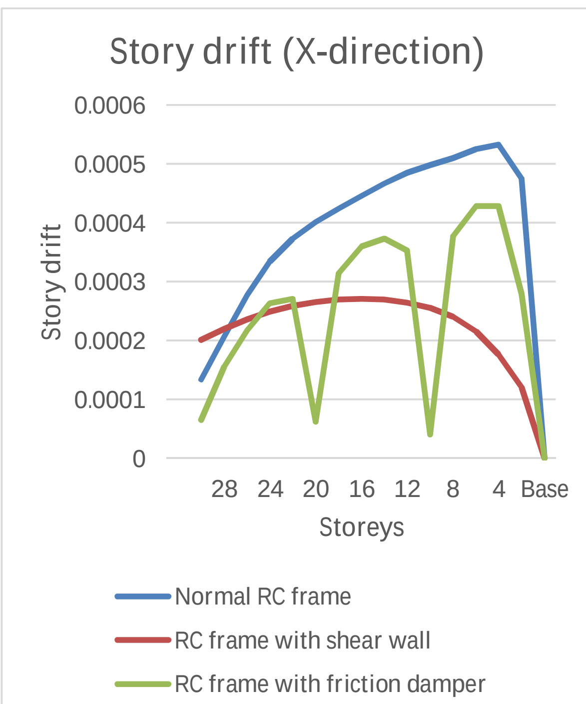
When compared to the reinforced concrete normal frame and frame with friction damper used for analysis, the frame with shear wall shows the least amount of time period. Mode 1 and 2 show stronger mass participation factors in the X and Y directions after modal analysis.

C. Story Drift

The storey drift results obtained for comparing a reinforced concrete normal reinforced frame to a reinforced concrete frame with shear wall and RC frame with friction damper.

Table 3: Values of Story drift

Storey	Normal RC frame		RC frame with shear wall		RC wall with friction damper	
	X	Y	X	Y	X	Y
30	0.000181	0.000134	0.000214	0.000201	0.000106	6.60E-05
28	0.000252	0.000207	0.000233	0.00022	0.000196	0.000156
26	0.000322	0.000278	0.00025	0.000236	0.000258	0.000218
24	0.000376	0.000334	0.000266	0.000249	0.000301	0.000263
22	0.000413	0.000373	0.000277	0.000259	0.000306	0.000271
20	0.000437	0.000401	0.000286	0.000266	0.0001	6.20E-05
18	0.000456	0.000424	0.000291	0.00027	0.000343	0.000314
16	0.000475	0.000446	0.000294	0.000271	0.000384	0.00036
14	0.000492	0.000467	0.000294	0.00027	0.000394	0.000373
12	0.000505	0.000485	0.00029	0.000265	0.000368	0.000352
10	0.000513	0.000498	0.000281	0.000256	6.60E-05	4.10E-05
8	0.00052	0.00051	0.000265	0.000241	0.000386	0.000377
6	0.000531	0.000525	0.000237	0.000216	0.000434	0.000429
4	0.000533	0.000533	0.000192	0.000177	0.000429	0.000429
2	0.000469	0.000475	0.000127	0.000121	0.000275	0.00028
Base	0	0	0	0	0	0



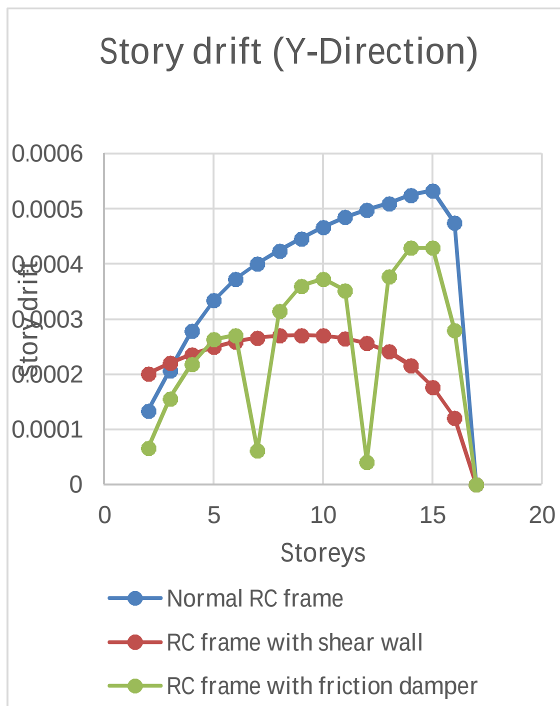


Figure 9: comparison of story drift in X and Y direction

1) From the results obtained, the maximum drift in the X-direction is found in normal RC frame as 0.000533 comparing to RC frame with shear wall as 0.000294 and RC frame with friction damper 0.000434.
2) From the results obtained, the maximum drift in the Y-direction is found in normal RC frame as 0.000533 comparing to RC frame with shear wall as 0.000271 and RC frame with friction damper 4.29E-04

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D. Base Shear

In the x and y directions, the maximum base shear for reinforced concrete normal frame and reinforced concrete frame with shear wall and normal RC frame with friction damper.

Table 4: Values of Base shear

Normal frame		Frame with shear wall		Frame with friction damper	
Fx (kN)	Fy (kN)	Fx (kN)	Fy (kN)	Fx (kN)	Fy (kN)
4431.80	4681.03	6164.25	6969.96	3781.41	3933.06

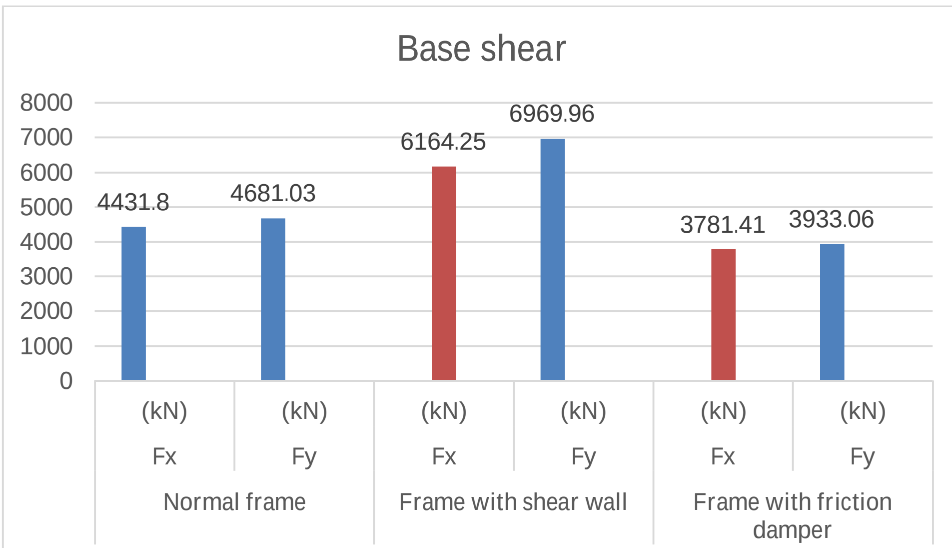

Figure 10: comparison of base shear

By observing both the models, the maximum base shear is 6969.96KN considerably more in reinforced concrete structure with shear wall than the normal reinforced concrete frame and reinforced concrete frame with friction damper.

VI. CONCLUSION

As per the study, the reinforced concrete frame with shear wall concept has substantial advantages over conventional building and building with friction damper. Certain results are obtained by studying a G+29 structure with a shear wall as well as structure with friction damper and analyzing it using the response spectrum approach. Based on the analysis and extraction of data, the following conclusion can be made.

A. By observing both the models, the maximum base shear is considerably more in reinforced concrete structure with shear wall than the normal reinforced concrete frame and reinforced concrete frame with friction damper.
B. The reinforced concrete frame with shear wall shows the lesser displacement comparing to other two models.
C. From the results obtained, the maximum drift in the X-direction is found in normal RC frame as 0.000533 comparing to RC frame with shear wall as 0.000294 and RC frame with friction damper 0.000434 and the maximum drift in the Y-direction is found in normal RC frame as 0.000533 comparing to RC frame with shear wall as 0.000271 and RC frame with friction damper 4.29E-04
D. When compared to the reinforced concrete normal frame and frame with friction damper used for analysis, the frame with shear wall shows the least amount of time period. Mode 1 and 2 show stronger mass participation factors in the X and Y directions after modal analysis.

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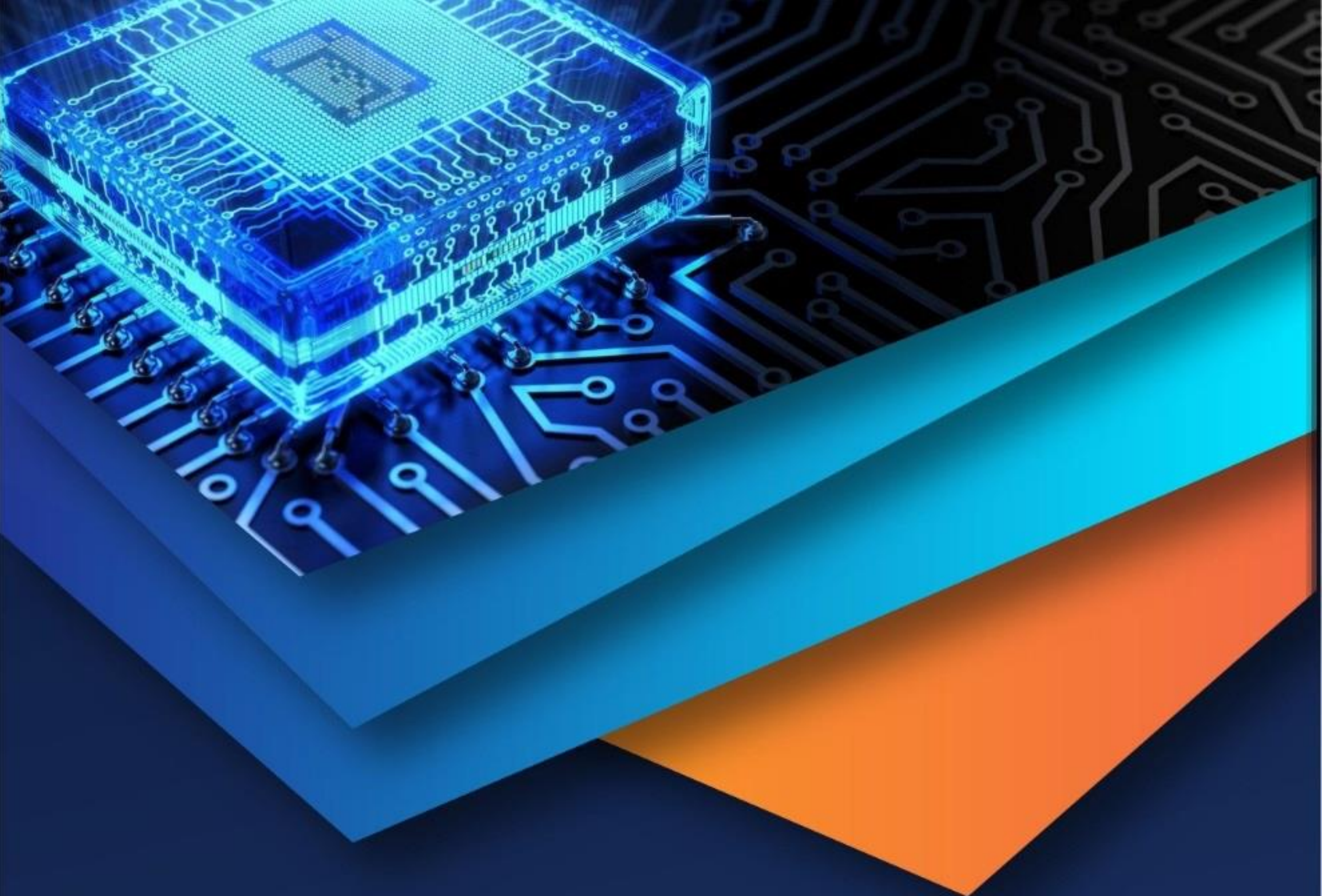

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