International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Effect of Shear Wall and Friction Dampers in High-Rise Irregular Structure Subjected to Dynamic Loading in Various Seismic Zones

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Abstract

An earthquake is known as a devastating and feared calamity on Earth due to the sudden release of energy from beneath the surface, causing movement in the crust. This movement subject structures in contact with the ground to seismic forces. To resist the lateral forces produced by earthquake and wind we are providing shear walls and friction dampers.This paper aims to study the behavior of high-rise irregular structures with shear walls and frictional dampers when subjected to horizontal forces caused by earthquake. In this study, a series of G+40 buildings are compared with similar structures after adding shear walls and frictional dampers for various seismic zones using the response spectrum method. All structures will be compared to regular structures under the same conditions. Dynamic analysis is carried out on different soil types in various seismic zones. The response spectrum method is a seismic analysis technique that provides the response of structures subjected to seismic loads. The complete modeling and analysis are performed using the well-known FEM integrated software "ETABS," considering relevant data for specific seismic zones according to IS 1893(Part 1): 2016. All reinforcement criteria for RCC structure components will be considered according to IS 456:2000 and IS 13920:2016. By the results we can conclude that the structure with shear walls is more susceptible compared to the other two structures. Mostly shear walls should be provided in zone V. In zone IV and V the structure with shear walls, displacement is reduced by 34% & 30% and base shear is increased by 61% and 40%.

Keywords: High-rise irregular structures, Shear walls, Friction Dampers, Response spectrum method

1. Introduction

EARTHQUAKE

An earthquake is a sudden release of energy from the Earth's crust, which is mostly caused by tectonic plate movements. This energy release causes seismic waves, which cause ground shaking that can range from mild to severe. The hypocenter is the origin point, while the epicenter is the point on the surface directly above it. Earthquakes can cause extensive damage, such as structural collapse, landslides, and tsunamis. Their magnitude is measured using the Richter or moment magnitude scale. To limit their impact, durable building design and disaster planning are crucial.

HIGH-RISE IRREGULAR STRUCTURES

High-rise irregular structures are a common sight in urban areas, particularly in rapidly developing nations like India. These buildings, with their unique shapes and varied floor plans, are designed to optimize space in crowded cities and create distinctive architectural designs. According to Indian Standards, specifically IS 1893 (Part 1): 2016 and IS 13920: 2016, the design and construction of high-rise structures must consider several factors to ensure safety and stability, especially in earthquake-prone areas.IS 1893 (Part 1): 2016 outlines guidelines for earthquake-resistant design, highlighting the need for sufficient lateral stiffness and strength. These standards mandate comprehensive seismic analysis, including response spectrum methods, to assess a building's behavior during an earthquake. Irregular high-rise buildings present additional challenges due to their unconventional geometry, which can lead to uneven seismic force distribution. Therefore, structural engineers must use shear walls, bracings, and friction dampers to enhance stability and mitigate structural failure risks. IS 13920: 2016 focuses on the ductile detailing of reinforced concrete structures to improve their performance under seismic loads. This involves specific reinforcement practices that enable buildings to absorb and dissipate energy during earthquakes, reducing the chances of catastrophic collapse. In everyday life, these standards ensure that high-rise buildings can withstand natural forces, providing safety and reassurance to residents. Adhering to these codes is essential for sustainable urban development, minimizing risks, and improving the resilience of India's expanding cities.A structural frame subjected to dynamic loading experiences forces that vary with time, such as those caused by earthquakes, wind, and moving vehicles. Dynamic loads can induce vibrations and oscillations in the structure, requiring careful design to ensure stability and safety. Structural frames, composed of beams, columns, and joints, must be designed to absorb and dissipate energy efficiently. This involves using materials and design techniques that enhance flexibility and strength, such as reinforced concrete and steel. Engineers are applying various analysis methods, including time history and response spectrum analysis, to predict the behavior of structures under dynamic loads. Adequate damping mechanisms, like friction dampers and tuned mass dampers, are often incorporated to reduce vibrations and enhance resilience. Ensuring that a structure can withstand dynamic loading is crucial for the safety and longevity of buildings, bridges, and other infrastructure, protecting them from potential damage or failure during dynamic events.

SHEARWALLS

A shear wall is a crucial structural element used to resist lateral forces from wind or earthquakes in buildings. These walls enhance the rigidity and stability of structures, helping to prevent swaying and potential collapse. Typically constructed from reinforced concrete or masonry, shear walls extend vertically throughout the building, acting like vertical cantilevers.

In high-rise buildings, shear walls are essential for maintaining structural integrity, particularly in seismic regions. They distribute lateral forces more evenly across the structure, reducing stress on beams and columns. Strategically placed in areas like stairwells, elevator shafts, or at the building's perimeter, shear walls maximize effectiveness without compromising usable space.

Shear walls also improve a building's torsional stability. In irregular structures, they help counteract asymmetrical force distributions that can cause twisting during dynamic events. According to Indian Standard IS 13920:2016, shear walls must be designed with sufficient ductility to absorb and dissipate energy during seismic events, minimizing damage. Incorporating shear walls into building designs ensures greater safety and resilience, making them vital in modern construction practices to withstand natural forces.

FRICTION DAMPERS

Frictional dampers are essential devices used in buildings to mitigate the effects of dynamic loads from sources such as wind and earthquakes. They operate by dissipating kinetic energy through friction, converting it into heat, which reduces vibrations and stabilizes the structure. These dampers feature materials or surfaces that slide against each other when the building moves. The friction between these surfaces absorbs some of the dynamic energy, curbing excessive movement and potential damage. This makes them especially useful in high-rise and irregularly shaped structures, where dynamic forces can be significant. Friction dampers are designed and implemented according to guidelines like those in Indian Standard IS 1893 (Part 1): 2016, which specifies earthquake-resistant design criteria. They can be installed in various parts of a building, such as bracing systems, shear walls, and floor connections. Integrating frictional dampers into building designs increases resilience and dur1.ability. By effectively managing dynamic forces, these dampers help maintain the building's integrity, ensuring safety for occupants and reducing the need for costly repairs after seismic events or strong winds. Their inclusion is a key component in modern engineering approaches aimed at constructing safer and more robust buildings.

RESPONSE SPECTRUM METHOD

The Response Spectrum Method outlined in IS 1893 (Part 1): 2016 is a seismic analysis approach used to assess how a building responds to earthquake-induced ground motion, considering its dynamic properties. This method is particularly essential for high-rise structures, buildings with irregularities, and those located in higher seismic zones. The method is mandatory for buildings exceeding 15 meters in height located in seismic zones III, IV, and V. It is also required for structures with irregularities (such as variations in mass, stiffness, or geometry) and where precise seismic response assessment is critical. IS 1893 provides a design response spectrum based on factors like seismic zone, building importance, and soil conditions. The response spectrum reflects the peak response of single-degree-of-freedom (SDOF) systems across different natural periods and damping levels during an earthquake.

Procedure for Dynamic Analysis

Modal Analysis: Initially, the structure's mode shapes, and natural frequencies are determined.

Modal Responses: The peak response for each mode is then calculated using the response spectrum.

Combining Modal Responses: These individual modal responses are combined using methods such as the Square Root of the Sum of the Squares (SRSS) or Complete Quadratic Combination (CQC) to account for modal interactions.

The base shear derived from the Response Spectrum Method should be compared with that obtained from the Equivalent Static Method. If the base shear from the Response Spectrum Method is lower, it must be adjusted upwards to ensure the building's safety. A default damping ratio of 5% is assumed for buildings, though different values may be used if justified by the structure's characteristics. The method also addresses torsional effects, particularly in buildings with plan irregularities, ensuring both translational and rotational responses are considered in the seismic analysis. The Response Spectrum Method in IS 1893 provides a more accurate prediction of a building's behavior under seismic forces by considering multiple modes of vibration and the dynamic characteristics of the structure. It ensures that buildings are designed to be strong and flexible enough to withstand earthquakes, thereby enhancing safety and structural resilience in seismic regions.

In this study we compared the structures with different resisting system which are shear walls and friction dampers. We considered G+40 story building which is irregular in nature. All the structure are analyzed in well-known FEM software ETABS. We analyzed this structure for all seismic zones. The results are drawn in the parameters like storey displacement and base shear. In this analysis the structures are considered for different parameters at the different storey levels.

2. Literature Review

Saurav Bhardwaj et.al (2022) conducted a study on the sequential series of response spectrum analysis of G+20 high-rise irregular structures, which were compared to similar structures after assigning shear walls, steel bracings, and friction dampers, and all the purposed structure responses was compared to a regular structure with the same lateral force resisting system. The well-known FEM integrated software "ETABS" is used in this study in the seismic zone IV by considering the relevant data. As per this study regular structure is stable in nature at the time of seismic event. It possesses more displacement that other irregular structure as per my study. As per this study shear walls are more capable in reducing the max displacement occur during earthquake caused due to ground motion. Even Bracing and Damper are also similarly able to reduce the displacement due to the external lateral force. Percentage average displacement reduced for shear wall-based structure is 61.33%. Percentage average displacement reduced for bracing and damper based system are 54.68% and 50.68%.

Sanjay Sapkota et.al (2022) conducted a study of dynamic analysis on regular and irregular building using ETABS software. Here in this study, they have used G+10 storey structure for the analysis. They did analysis for both gravity loads and lateral loads. They did this analysis for seismic zone IV. They did both time history analysis and response spectrum analysis for all the structures. In this study they concluded that the base shear is higher in irregular buildings compared to regular ones, indicating that irregular structures are more susceptible to seismic forces. Irregular buildings exhibit greater story displacement compared to regular buildings, which suggests increased vulnerability during an earthquake. The lateral loads are also higher in irregular structures. Irregular buildings show significant variation in time history analysis, indicating complex dynamic behaviour under seismic loads. The study concludes that irregular buildings experience higher base shear, story displacement, and lateral loads compared to regular buildings. This indicates that irregular structures are more vulnerable to seismic activities, emphasizing the need for careful design and analysis in such cases. The paper highlights the importance of using advanced analysis methods like time history analysis to understand the true behaviour of structures under earthquake conditions.

Rachakonda Divya et.al (2021) conducted a comparative study on the buildings with horizontal irregularity, vertical irregularity, stiffness irregularity and mass irregularity with and without shear walls. The responses of the structures are compared with each other. They analysed all the structures in ETABS software. They have taken G+15 storey building for the analysis. The plot dimensions are 30m X30m and the column-to-column distance is 5m in both X and Y direction. Storey height of the buildings is 3m. in this study they did response spectrum method for zone II and Hyderabad for wind analysis. They compared stiffness, displacement, shear and drift values and they evaluated which model performs better. They find out that by adding shear walls to the building the performance is increased by 60-70%. The story displacement of the buildings is reduced by 30%. They shear walls helped reduce the storey shear by reducing the mass of the overall structure. Finally, they concluded that the structure with vertical geometry irregularity with shear walls is performing better when compared other structures.

Shaik Akhil Ahamad et.al (2020) conducted a study how the response of the building varies with respect to the usage of shear walls in the G+ 20 building in different seismic zones. They adopted response spectrum method in this study. They analysed building in terms of storey drift, base shear, maximum allowable displacement and torsional irregularity. All structures are analysed in the ETABS software. They carried out this study in type III soil and all the seismic zones are considered. They made three structures caseA: building with no shear walls, caseB: building with shear wall at one end, caseC: building shear wall at four ends. They found that buildings are having maximum displacement and maximum storey drift values in zone V. In study the caseC building that is building with shear walls at four ends is performing better than the other two structures in all seismic zones.

N. Lingeshwaran et.al (2020) made a comparative analysis on symmetrical and asymmetrical buildings subjected to earthquake loads. They modelled buildings in different shapes such as H, L, Rectangular and T-shapes buildings for G+9 storeys. They analysed the structures in ETABS software. They evaluated building in terms of storey drift and storey displacement. They considered height of building as 30m, floor height is 3m. they analysed the buildings in seismic zone IV type of soil is medium. They concluded that symmetrical buildings performs better than asymmetrical. T shape building is more stable to the earthquake loads to symmetrical buildings. L and H shaped buildings are showing similar displacement.

Jaimin Dodiya et.al (2018) analysed a multistorey building with shear walls. They analysed the building using ETABS software. They considered G+20 storey building whose storey height is 3m area is 376m^2 and building height is 60m. They analysed the structure in seismic zone III and type of soil is II. They made three structures building with shear wall at corner, building with shear walls at the opposite direction and building with I shaped shear walls. They adopted response spectrum analysis, Time History analysis and Equivalent static method. They concluded that the building with building with the shear walls in opposite direction performs better than other two structures.

Sylviya B et.al (2018) made an analysis of RCC building with shear walls at different location and in different seismic zones. They performed response spectrum analysis using ETABS software. They analysed G+4 building with storey height 3m and plan are 375m^2. They made three structure Building with no shear wall building with shear wall at periphery. Building with shear wall at the intermediate walls. They observed that shear walls should be provided throughout the height of the building. They concluded that the structure with shear walls at periphery is performing more when compared to other structures. They concluded that the displacement values are high in the seismic zone V.

Ghusen Al-Kafri et.al (2018) made a comparative study between static and dynamic analysis for RC buildings with different heights in seismic zone V. They considered structures with 5,10,15 &20 stories. They used commercial software which is Autodesk ROBOT Structural Analysis 2018. They performed response spectrum method in this software to analyse the structures. They followed ASCE7-10. Results are drawn based on Displacement, Story drift, Base Shear, Story Shear and Story Moment. They concluded that response spectrum analysis is very important dynamic analysis tool in modelling and analysing the high rise structure.it gives more accurate results when compared to the equivalent static method. They concluded that even though the response spectrum method is important for high rise structures. It is always safer to compare response spectrum values with equivalent static method. Finally, they recommended to use response spectrum method for analysis instead of equivalent static method especially in high rise structures as it gives better results, easy computation and leads to more economic and safe design.

Gauri G. Kakpure et.al (2017) made a comparative study of static and dynamic analysis of RCC building due to earthquake loading by ETABS software. They considered two tall structures which are G+10 and G+25 storey. They did analysis in seismic zone III. They considered two different methods which are equivalent static method and response spectrum methods. The results are drawn out using the parameters like storey drift, storey displacement, axial load, Bending moment. They concluded that as the storey height increases the displacement values are increasing. Axial load is lesser in dynamic analysis when compared to the static analysis. And bending moment lesser in dynamic analysis than the static analysis.

Finally, they concluded that the dynamic analysis gives lesser results compared to static analysis. Hence dynamic analysis is more economical.

Kanchan Rana et.al (2017) made an study on seismic analysis of RCC structures with shear walls at various locations using STAAD Pro software. They analysed G+6 storey building. They made three models building with no shear walls, building with shear walls at the edges and building with shear walls at the centre of sides. Analysis is done for seismic zone V. The parameters like storey drift, lateral displacement, and base shear are considered for the evaluating the results. They used G+5 storey buildings, the plan size is 12m X 12m, total height of the building is 18m and floor to floor height is 3m. They analysed all the structures in seismic zone V and soil type is medium. They concluded that the building with shear walls centre of sides is showing least storey drift. They concluded that model 3 is most effective and most economical

Udaya bala K et.al (2017) performed a dynamic analysis of multi-storey building. They modelled a multi-storey building with different structural elements for minimum storey displacement. They performed this dynamic analysis in ETABS software. This multistorey building consists of 3 basement, ground floor and 14 upper floors. They performed this analysis in seismic zone IV with earthfill of 750mm on the ground floor for landscape requirements. Total height of the building is 61.5m, B-3 is 3.6m, B-2 is 3.6m, B-1 is 5.2m, ground floor is 4.8m and typical floor are 4.05m each. They modelled three structures building with floor slabs. They performed response spectrum method and time history analysis. They concluded that response spectrum method is not enough for the analysis time history analysis to be performed for the high-rise structures. They concluded usage of flat slabs; floor slabs and shear walls reduce the lateral deflections. Usage of flat slabs in high rise structures reduce the no. of beams in the building. But floor slabs reduce the storey displacement.

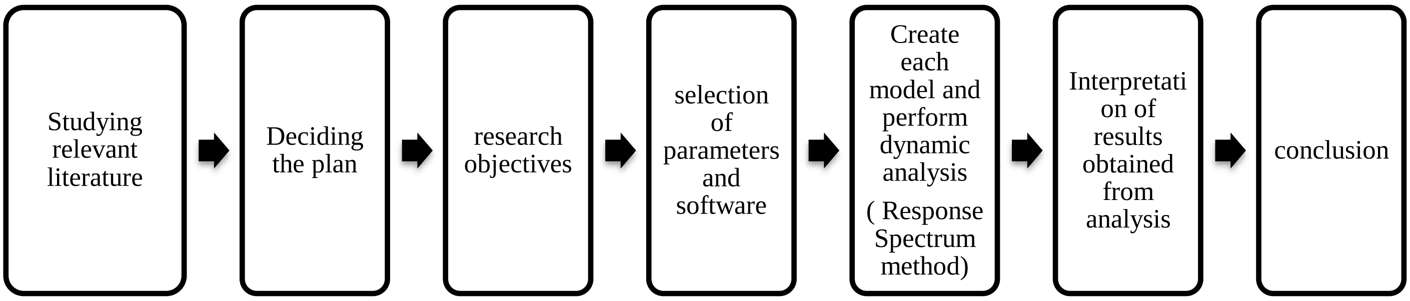
Dileshwar Rana et.al (2015) made an experimental study on performance and behaviour of regular and irregular vertical geometry irregular RCC framed structures under earthquake load. They analysed five structures one regular structure and four irregular structures. All models are analysed in the Staad Pro software. They drawn the results based on shear force, bending moment, storey drift, storey displacement. They made analysis in seismic zone IV and medium soil strata. They observed different seismic responses for different heights of building. They took four building types 4, 8, 12, and 16 storey building with different dimensions. They concluded that regular building possess very low shear force and bending moment than the irregular structures. As the building height increases there will greater response to the seismic loads. The seismic performance of regular building is better than the irregular structure in all the cases. They concluded that the structure should be constructed to minimize the seismic effect.

Rakesh Sakale et.al (2014) made a study on seismic behaviour of the structures with horizontal irregularities. They considered four structures with and without shear walls in this study. They are building 1 is regular structures, building 2 is L shape, building 3 is T shape and building 4 is C shape. The results are drawn based on the following parameters lateral displacement and storey drift. They considered all seismic zone in this study. They used Staad Pro software in this study. They considered 20 storey buildings with 7 X 7 bays. Floor height is 3.6m and total height of the building is 72m. They concluded that in drift point of view, in seismic zone II, III, IV the values are in permissible limits so there is no need of the shear walls in this zone and In zone V only C shaped buildings requires shear walls throughout the height. But in displacement point of view only zone II is in permissible limit and in remaining three zones we need to provide that shear walls.

3. Objectives

- To compare the behaviour of high-rise irregular structures consisting of shear walls and friction dampers with each other and simultaneously regular structure consisting of the same resisting components and the results obtained from analysis for each seismic zone.
- To perform dynamic analysis of high-rise irregular structures with shear walls and friction dampers and to analyse the structures in terms of
  - Maximum Displacement
  - Base Shear in different seismic zones

4. Methodology



5. Parameters

No.	Design data	
1.	**Details of structures**	
	1.1.No. of stories	G+40
	1.2.Storey Height	3m
	1.3.Dimensions of the plan	30m X 40m
	1.4.Centre to Centre distance between the columns	
	1.4.1. In X- direction	6m
	1.4.2. In Y- direction	8m
2.	Material Properties	
	2.1.**Ground Floor to 20th floor**	
	2.1.1. **Columns**	
	2.1.1.1. Grade of concrete	M60
	2.1.1.2.Size of the element	900X900mm
	2.1.2. **Beams**	
	2.1.2.1. Grade of concrete	M50
	2.1.2.2.Size of the element	450X900mm
	2.1.3. **Slabs**	
	2.1.3.1. Grade of concrete	M40
	2.1.3.2.Size of the element	250mm thick
	2.1.4. **Shear walls and core walls**	
	2.1.4.1. Grade of concrete	M60
	2.1.4.2.Size of the element	350mm thick
	2.2. **21st floor to 30th floor**	

	2.2.1. **Columns**	
	2.2.1.1. Grade of concrete	M50
	2.2.1.2.Size of the element	700X700mm
	2.2.2. **Beams**	
	2.2.2.1. Grade of concrete	M40
	2.2.2.2.Size of the element	400X700mm
	2.2.3. **Slabs**	
	2.2.3.1. Grade of concrete	M35
	2.2.3.2.Size of the element	220mm thick
	2.2.4. **Shear walls and core walls**	
	2.2.4.1. Grade of concrete	M50
	Size of the element	300mm thick
	2.3. **31st floor to 40th floor**	
	2.3.1. **Columns**	
	2.3.1.1. Grade of concrete	M40
	2.3.1.2.Size of the element	500X500mm
	2.3.2. **Beams**	
	2.3.2.1. Grade of concrete	M35
	2.3.2.2.Size of the element	350X500mm
	2.3.3. **Slabs**	
	2.3.3.1. Grade of concrete	M30
	2.3.3.2.Size of the element	200mm thick
	2.3.4. **Shear walls and core walls**	
	2.3.4.1. Grade of concrete	M40
	Size of the element	350mm thick
	2.4.**Rebar**	
	2.4.1. Longitudinal Reinforcement	HYSD 500
	2.4.2. Shear Reinforcement	HYSD 415
	2.5.**Friction dampers**	
	2.5.1. Link type	Plastic Wen
	2.5.2. Mass	492.32Kg
	2.5.3. Weight	4.2116kN
	2.5.4. Effective Stiffness	23772.83kN/m
	2.5.5. Effective damping	0 kN-s/m
	2.5.6. Yield Strength slip load	700kN
	2.5.7. Post yield stiffness Ratio	0.0001
	2.5.8. Yeilding exponent	10
3.	**Load Considerations**	
	3.1.**Dead load**	
	3.1.1. Beams	13.8kN/m
	3.1.2. **Slabs**	
	3.1.2.1.Ground floor to 20th floor	8.75 kN/m^2
	3.1.2.2.21st floor to 30th floor	8 kN/m^2

	3.1.2.3. 31st floor to 40th floor	7.5 kN/m^2
	3.2. **Live Load**	4.0 kN/m^2
	3.3.**Wind Load**	
	3.3.1. **Zone II**	
	3.3.1.1. Basic wind	33m/s
	3.3.1.2.Terrain category	4
	3.3.1.3.Structure class	C
	3.3.1.4.Risk co-efficient	1.0
	3.3.1.5.Topography	1
	3.3.2. **Zone III**	44m/s
	3.3.2.1. Basic wind	4
	3.3.2.2.Terrain category	C
	3.3.2.3.Structure class	1.0
	3.3.2.4.Risk co-efficient	1
	3.3.2.5.Topography	
	3.3.3. **Zone IV**	47m/s
	3.3.3.1.Basic wind	4
	3.3.3.2.Terrain category	C
	3.3.3.3.Structure class	1.0
	3.3.3.4.Risk co-efficient	1
	3.3.3.5.Topography	
	3.3.4. **Zone V**	47m/s
	3.3.4.1. Basic wind	3
	3.3.4.2.Terrain category	C
	3.3.4.3.Structure class	1.0
	3.3.4.4.Risk co-efficient	1
	3.3.4.5.Topography	
	3.4. **Earthquake load**	
	3.4.1. **Zone II**	II
	3.4.1.1.Site type	0.10
	3.4.1.2.Zone factor	1.2
	3.4.1.3.Importance factor	3.0
	3.4.1.4.Response Reduction factor	
	3.4.2. **Zone III**	I
	3.4.2.1.Site type	0.16
	3.4.2.2.Zone factor	1.2
	3.4.2.3.Importance factor	3.0
	3.4.2.4.Response Reduction factor	
	3.4.3. **Zone IV**	II
	3.4.3.1.Site type	0.24
	3.4.3.2.Zone factor	1.2
	3.4.3.3.Importance factor	3.0

	3.4.3.4.Response Reduction factor	
	3.4.4. **Zone V**	I
	3.4.4.1.Site type	0.36
	3.4.4.2.Zone factor	1.2
	3.4.4.3.Importance factor	3.0
	3.4.4.4.Response Reduction factor	

6. Modelling

G+40 reinforced concrete irregular is modelled and analysed for different seismic zones in well know FEM software ETABS. Later the same building is introduced with shear walls and friction dampers and analysed for the different seismic zones in India (zone II, Zone III, Zone IV, Zone V). The Plan if building varies at different heights of the building. Plans and 3-D model of the building is provided in below pictures of ETABS. In this study

- Structure 1 – Ordinary RC building with Moment resisting frame
- Structures 2- Dual system Ordinary RC building with shear walls
- Structure 3- Ordinary RC building with friction dampers

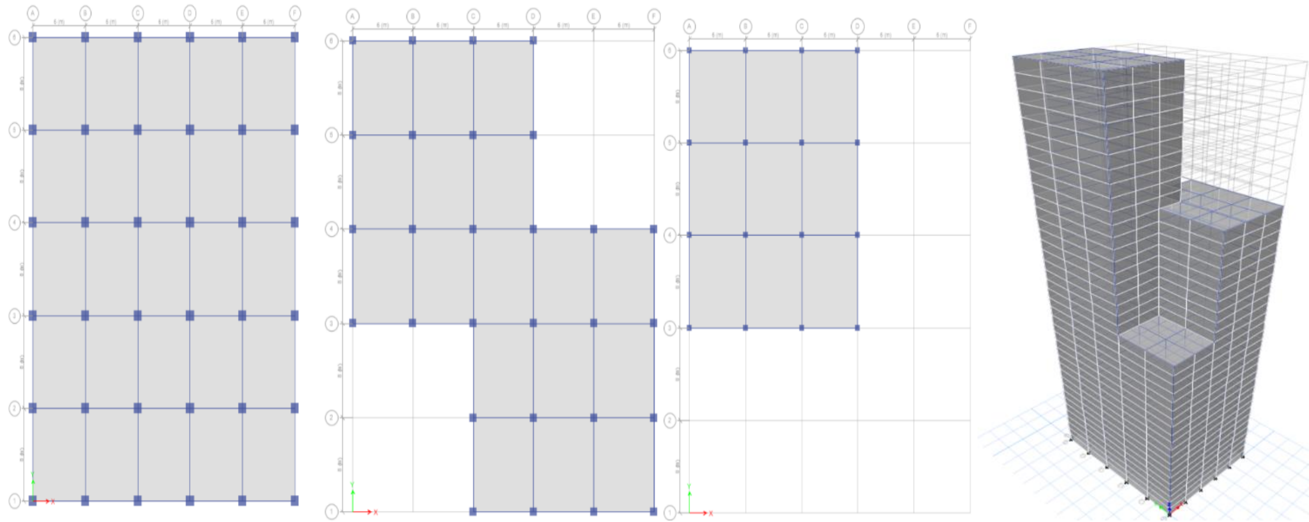


Figure *6.1* Plan of structure1

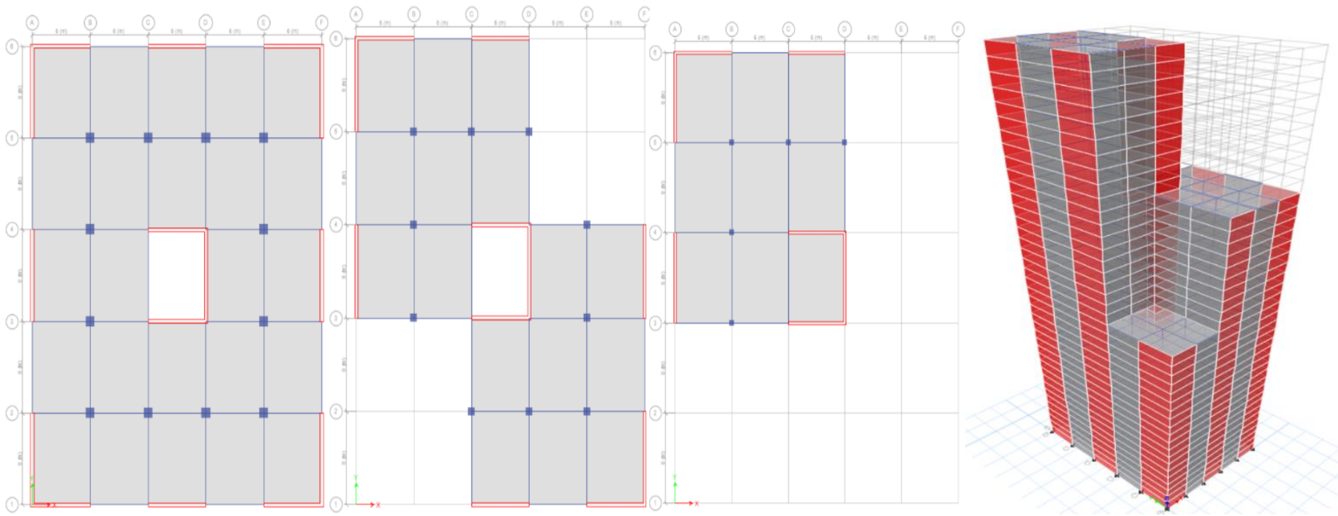


Figure *6.2* Plan of structure2

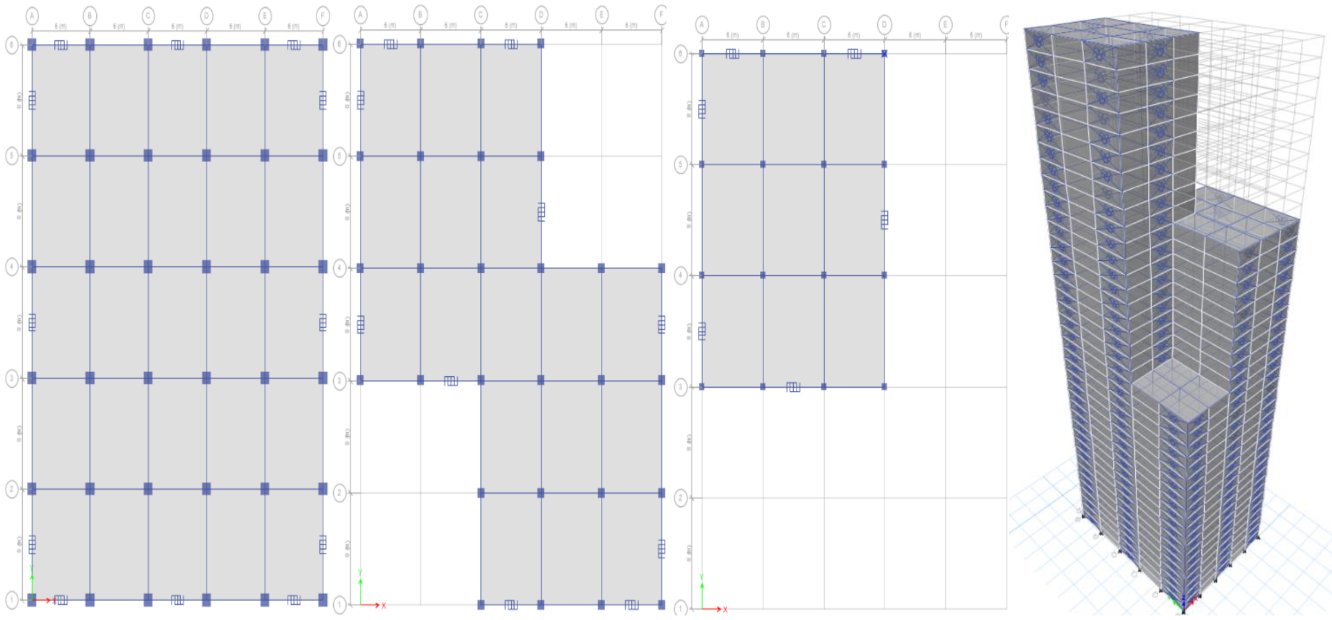


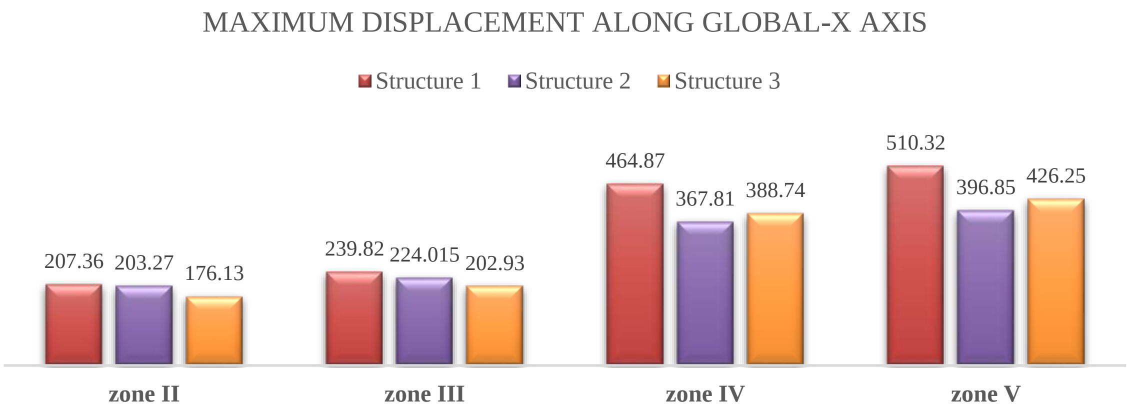
Figure *6.3* Plan of structure2

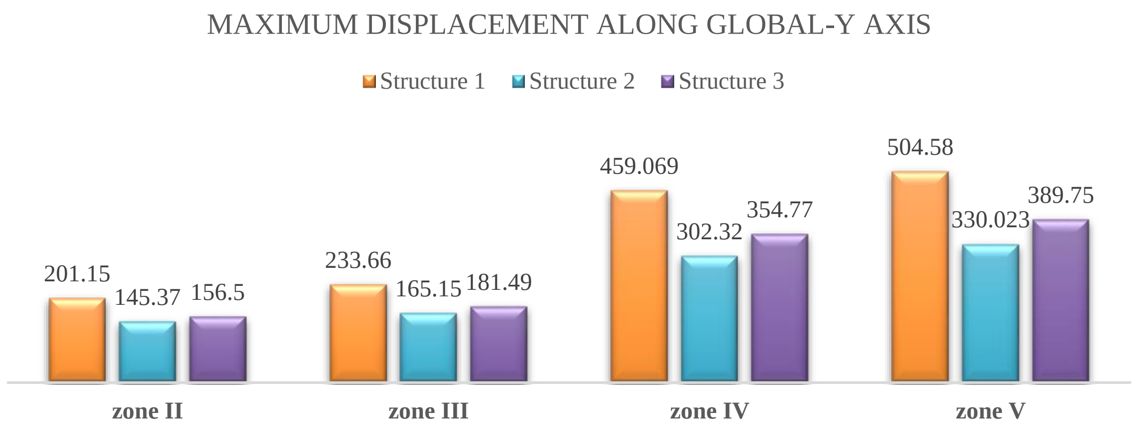
7. Results and Discussions

All the structures are analyzed according to the methodology as mentioned above. The results will be represented in the form of max displacement and base shear in which Global -X and Global -Y axes are considered without eccentricity. The Maximum Displacement is calculated for 40 mode shapes of each structure. Total 12 structures are analyzed which comprises of shear walls and friction dampers. All the properties of the component are mentioned in chapter 3.

Maximum Displacement

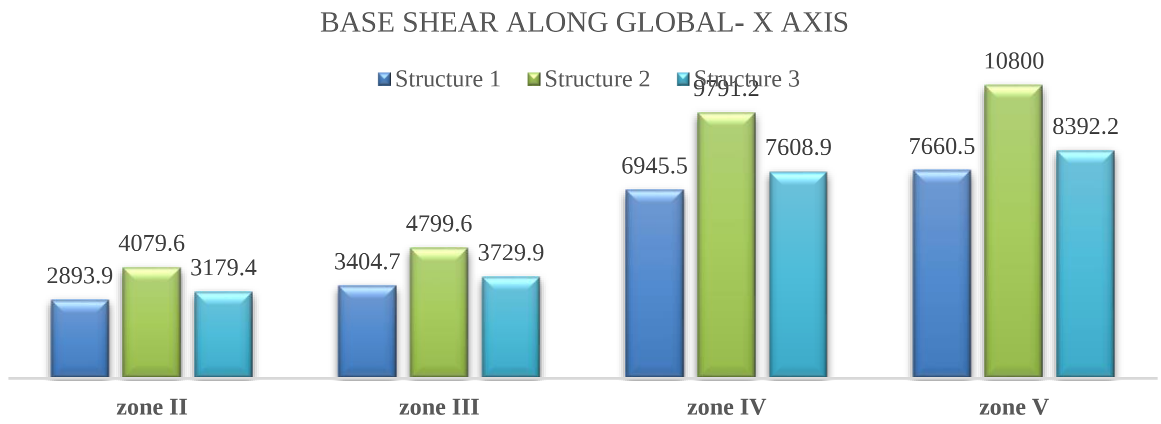
	Zone II		Zone III		Zone IV		Zone V	
	X	Y	x	y	x	Y	x	y
Structure 1	207.36	201.15	239.82	233.66	464.87	459.07	510.32	504.58
Structure 2	203.27	145.37	224.01	165.15	367.81	302.32	396.85	330.023
Structure 3	176.13	156.15	202.93	181.49	388.74	354.77	426.25	389.75

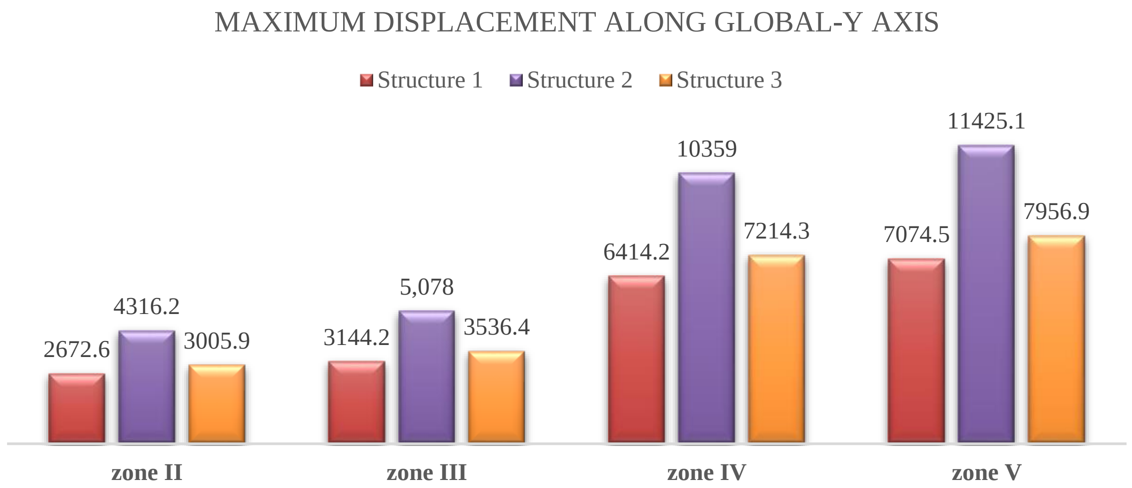




Base shear

	Zone II		Zone III		Zone IV		Zone V	
	X	Y	x	y	x	y	x	y
Structure 1	2893.9	2672.6	3404.7	3144.2	6945.5	6414.2	7660.5	7074.5
Structure 2	4079.6	4316.2	4799.6	5,078	9791.2	10359	10800	11425
Structure 3	3179.4	3005.9	3729.9	3536.4	7608.9	7214.3	8392.2	7956.9





8. Discussions

As we can see from the above results, we can see that structure 1 is having more than the maximum allowable displacement in zone V. Maximum displacement occurred in structure 1 in zone V that is 510.32 mm in Global-X direction and even in Global-Y direction also the maximum displacement of structure 1 is 504.58mm. These values are higher that maximum allowable deflection calculated above. Structure 1 has higher values of maximum displacement when compared to Structure 2 and Structure 3. In zone II and zone III, structure 3 is giving less displacement in Global-X direction when compared to remaining other two structures. And In zone IV and zone V, structure 2 is giving less displacement in Global-X and Y direction. As in Base shear structure 2 is giving better results in all the zones in Global X and Y directions. According to Base Shear even structure 3 is giving better results not as compared to the displacement. As per the above discussion we can conclude that the Structures which contains shear walls and Friction dampers are giving better stability to the lateral loading as compared to the regular structure that is ordinary moment resisting frame structure. But as per the above results we can conclude that the structure with the shear walls is giving greater stability as compared to remaining two structures. But we can suggest that in zone II and III ordinary moment resisting frame structure is suitable. But in zone V, structure with shear walls is more suitable as compared to the structure with the friction dampers but ordinary moment resistant frame structure is not suitable in this zone.

9. Conclusions

All the results are portrayed and discussed before regarding the effect of dynamic loading on the high-rise irregular structures using shear walls and Friction dampers. In this study, all the structure analysed using response spectrum method in ETABS software. All these results are evaluated with respect to IS 1893:2016. Conclusions are drawn from the results obtained and they are concluded in following points:

- Structure 1 which is ordinary moment resisting frame is having less displacement in zone II and zone III whereas it is failing in the zone V.
- Shear walls and friction damper are showing greater stability when lateral loads are applied.
- In all the zones shear walls are reducing the maximum displacement compared to the friction dampers.
- Shear walls are showing more base shear compared to the friction dampers.
- Shear walls are in lead when compared to the friction dampers. In zone IV and V maximum displacement is reduced by shear is 34% in Global-Y direction and 30% in Global-X direction.
- In terms of base shear, in zone IV and V it is increasing by 61% in Global-Y direction and 41% in Global-X direction.
- In zone II and III structure 1 which is ordinary moment resisting frame structure is suitable and economical
- In zone IV and V structure 2 which is the ordinary moment resisting frame structure with shear walls is suitable.

10. Acknowledgement

This research was supported by Manipal Institute of Technology, Udupi, Karnataka, India. The authors show gratitude for technical assistance.

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