DESIGN AND ANALYSIS OF G+7 EARTHQUAKE RESISTANT STRUCTURE

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Abstract: The development of new codes for earthquake-resistant structures has made possible to guarantee a better performance of buildings, when they are subjected to seismic actions The turf of seismic activity Engineering has existed in our nation for over 35 years now. Indian Earthquake Engineers have made momentous hand-outs to the seismic safety of a number of important structures in the country. However, as the recent earthquakes have shown, the performance of normal structures during past Indian earthquakes has been less satisfactory. This is mainly due to the lack of awareness amongst most practicing engineers of the special provisions that need to be followed in earthquake G+7 resistant design and thereafter in construction. Earthquakes compose one of the supreme hazards of living and assets on the earth. Due to abruptness of their happening, they are least understood and most dreaded. The earthquake resistant construction is considered to be very important to mitigate their effects. This paper presents the concise prerequisites of earthquake resistant construction and a few techniques to improve the resistance of building and building materials to earthquake forces, economically.

Keywords: - Earthquake, Structure, Resistant Design, Economically

1. Introduction

These days earthquakes has become very frequent in the nature due to several reasons, here we don't discuss about the reasons of earthquake rather our subject is how to with stand the earthquake loads on the structures or buildings. This becomes the major criteria for us, as the earthquakes are becoming quite common to us designing the building or analysing the buildings in general regular format using the static loads such as live load, dead load etc., we can't design a safer building especially in the case of high raised building it is because in high raised building there will be wind pressure on the building at greater magnitude which varies time to time depending upon the intensity, velocity and direction of wind i.e., dynamic in nature similarly to earth quake loads so as to withstand these type of loads, static methods are not enough and hence we go for dynamic analysis and we model the required structure using ETABS software and analyse the structure in the ETABS using the response spectra method.

Need for the work

Tall building developments have been rapidly increasing worldwide. The growth of multi-storey building in the last several decades is seen as the part of necessity for vertical expansion for business as well as residence in major cities. As the height of the building increases the lateral resisting system becomes more important than the structural system that resists the gravitational loads. From the research papers it is observed the response of the structures subjected to Earthquake excitation. They are found to be incresing in the Natural time period, reduction in lateral displacement and reduction in story drift of the building. In this present study, it is proposed to compare between the performances of conventional structure and geo-polymer concrete structure in the high-rise buildings. The performance index includes displacement, base shear, storey drifts and relative performance should be investigated. Two buildings, one with conventional structure and other with geo-polymer concrete structure considering the earthquake zone as per IS 1893:2002(part 1) is being analyzed by using finite element software package ETABS 2016. For analysis various IS codes have been referred, for Gravity load combination IS 456:2000 and for seismic load combinations as per IS 1893:2002(part 1) code is referred. To analyze the structures, the static and dynamic analysis method is adopted. The response spectrum functions are defined to carry out dynamic analysis.

Scope of the work

The study focuses on comparison of seismic analysis of conventional concrete structure and geo-polymer concrete structure. For the analysis, the model of RC building G+7storey is considered. The performance of the building is analyzed in Zone III. Modeling and analyzation of the structure is done in ETABS 2016 software. The model of the building with conventional concrete structure and geo-polymer concrete will be implemented in the software and it would be analyzed for response spectrum. Time period of the structures is retrieved from the software and as per IS 1893(part 1):2002 seismic analysis has undergone and storey displacements, storey drifts, storey shear will be compared.

2.Literature Review

Dr. Savita Maru, Mohit Sharma [1] Results from STADD PRO show minimal difference in axial forces between static and dynamic analysis. Torsion values are negative in static and positive in dynamic analysis, while moments and displacements are 10–28% higher under dynamic analysis. Alhamd Farqaleet [2] Storey drift increases from base to top, with maximum drift within permissible IS 1893:2002 limits. Maximum base shear in X and Y directions suggests time history analysis is more accurate than response spectrum analysis. D. Gouse Peera, Mohammed Rizwan Sultan [3] Irregular-shaped buildings are more vulnerable during earthquakes. L-shaped structures show the lowest base shear, rectangular the highest, and C-shaped buildings undergo more deformation than other shapes. Meghashree T N, P. Sudheer Kumar, T. Pranay Kumar [4] Axial forces in static and dynamic steel structure analyses are similar. Static analysis shows higher moments and lower displacements compared to dynamic analysis, while seismic parameters increase from floor to floor. Akshay Agrawal, Pravina [5] SCM treats seismic loads as static, giving approximate results, whereas RSM accounts for dynamic effects and is more accurate. SMRF with shear wall shows higher lateral forces due to added shear wall loads. Amresh A. Das, G. B. Bhaskar [6] Static analysis shows higher axial and shear forces, while dynamic analysis produces higher bending moments in beams. Deflection is higher under static loads. Ignoring earthquake loads may lead to structural failure and uneconomical design. Dr. P. S Bokare, Suchi Nag Choudhary [7] RSM is more accurate than SCM as it considers the dynamic nature of seismic loads, although SCM is simpler to apply. Dr. Lingaraj Shastri, Sanjeev, Prof. Lokesh G, Prof. Sahebgouda Patil [8] Shear walls at external frame corners improve seismic performance in tall buildings. Placement at corners or middle frames effectively regulates storey shear, drift, displacement, and time period. Nilesh J. Jain, Sunil M. Rangari [9] Irregular buildings are more susceptible to earthquake damage, especially soft storeys. Composite structures perform better than RCC in terms of displacement and structural force resistance. Irregular designs require careful seismic analysis.

3.Methdology

The tests were carried out in accordance with relevant IS Standards. The aggregates were tested for physical properties such as specific gravity and particle distribution test. The fresh concrete was subjected to the slump test followed by casting of concrete in moulds for further investigations. All the mixes were prepared by mixing the concrete in laboratory mixer along with water and super plasticizer. All the structures are designed for the combined effects of gravity loads and seismic loads to verify that adequate vertical and lateral strength and stiffness are achieved to satisfy the structural performance and acceptance deformation levels prescribed in the governing building code. Because of the inherent factor of safety used in the design specification, most structures tend to adequately protected against vertical shaking. Vertical acceleration should also be considered in structures with large spans, those in which stability for design, or for overall stability analysis of structures.

In general, most earthquake code provisions implicitly require the structures be able to resist:-

- Minor earthquake without any damage.
- Moderate earthquake with negligible structural damage and some non-structural damage.
- Major earthquake with some structural damage and non-structural damage without collapse.
- The structure is expected to undergo fairly large deformation by yielding in some structural members.

Seismic codes are unique to a particular region or country. In India, IS 1893:2002 (part-1) is the main code that provided outline for calculation of seismic design force. This force depends on the mass and seismic coefficient of the structure and later in turn depends on properties like seismic zone in which structure lies, importance of the structure, its stiffness, the soil on which it rests and ductility. IS 1893:2002 (part-1) deals with assessment of seismic loads on various structures and buildings.

The whole centers on the calculation of base shear and its distribution over height. The analysis can be performed on the basis of external action, the behavior of the structure or structural materials and the type of structural mode selected. In all that treated as discrete system having concentrated mass at floor levels, which include half the column and walls above and below the floor. In addition, appropriate of live load at this floor is also lumped with it.

Modeling And Analysis

This chapter deals with the modeling and analysis of the structure under various loads. The finite element package ETABS V16.2.1.0 has been used for the analysis. A three-dimensional model of the structure have been created to undertake static and dynamic analysis. The model ideally represents the complete three dimensions (3D) characterizes of the building, including its mass distribution, strength, stiffness deformability.

The step wise procedure that is followed in ETABS Software is

- Modeling of structural elements
- Loading, analysis and design
- Output

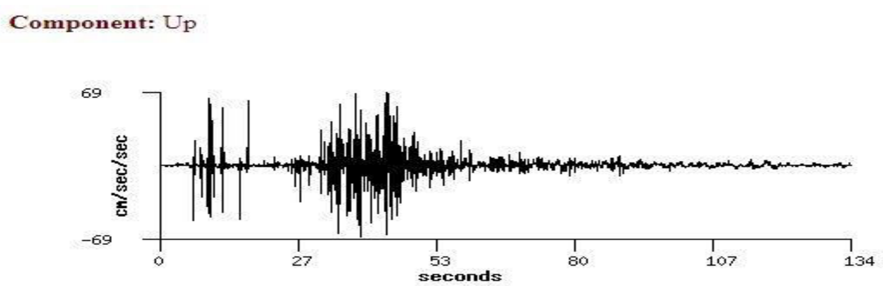
ETABS also features interoperability with related software products, providing for the import of architectural models from various technical drawing software, or export to various platforms and file formats. SAFE, the floor and foundation slab design software with post-tensioning (PT) capability, is one such option for export. CSI coordinated SAFE to be used in conjunction with ETABS such that engineers could more thoroughly detail, analyze, and design the individual levels of an ETABS model. While ETABS features a variety of sophisticated capabilities, the software is equally useful for designing basic systems. ETABS is the practical choice for all grid-like applications ranging from simple 2D frames to the most complex high rises.

Problem Formulation

Two tall buildings of 10 storey's with plan area 10.5 mx14.5 m is analyzed in ETABS V16.2.1.0 package to determine dynamic control of those buildings. Wind and Earthquake parameters for analysis are taken and dynamic analysis is performed as per IS: 1893-2002 code. Analysis is performed to find Time History, Time Period, Storey Displacement, Storey Drift and base shear for the two structures. General description of the building is tabulated in table 4.1

Table 1: Description of the Building data

1	**Details of the building**			
i)	Structure		OMRF	
ii)	Number of stories		G+7	
iii)	Type of building		Regular and Symmetrical in plan	
iv)	Height of the building		21 m	
v)	Support		Fixed	
vi)	Seismic zones		III	
2	**Material properties**			
i)	Grade of concrete		M30	
ii)	Grade of steel		Fe415	
iii)	Density of reinforced concrete		25 kN/m^3	
iv)	Young's modulus of M30 concrete, E_c		27386.13 kN/m^2	
v)	Poissions ration, μ_c		0.2	
vi)	Young's modulus steel, E_s		2 x 10^8 kN/m^2	
3	**Type of Loads & their intensities**			
i)	Floor finish		1.5 kN/m^2	
ii)	Live load on floors		5 kN/m^2	
iii)	External wall load on beams		11.5 kN/m^2	
iv)	Internal wall load on beams		5.27 kN/ m^2	
4	**Seismic Properties**			
i)	Zones	III	0.16	
ii)	Importance factor (I)		1	
iii)	Response reduction factor (R)		5%	
iv)	Soil type		II	
v)	Damping ratio		0.05	
vi)	Wind Speed - Zone III		39 m/sec	
vii)	Wind coefficients Terrain category Risk coefficient Topography		 2 1 1	
5	**Member Properties**	**No. of stories**	**Grade**	**Section sizes (mm)**
i)	Column	ALL	M30	450 x 450
ii)	Beam	ALL	M30	500 x 230
iii)	Slab	ALL	M 30	175



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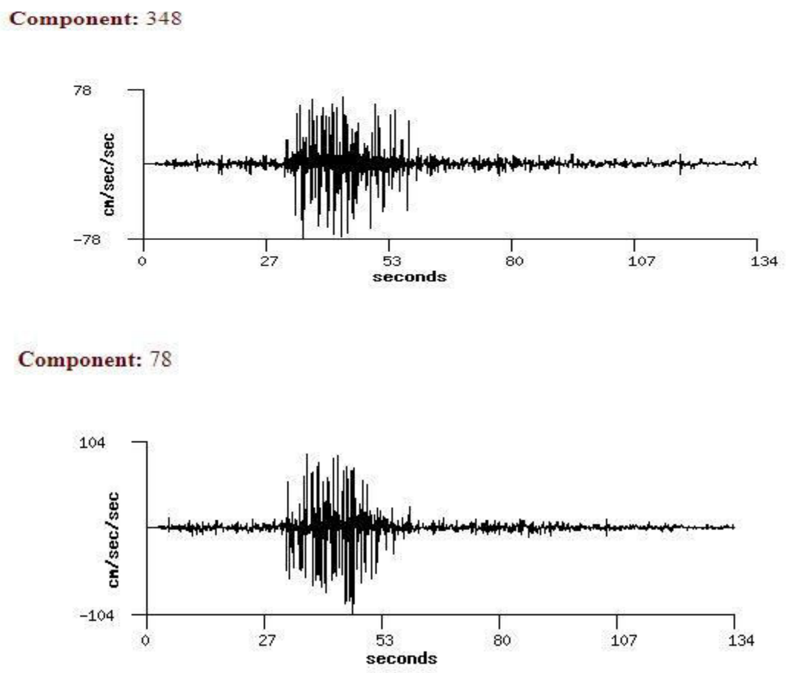

Figure 1: Peak accelerations of bhuj earthquake

In the present study, 10 storied reinforced concrete structures IS considered. The 1st model is for RC building with conventional concrete and 2nd model is with geo polymer concrete. The modeled structures are situated in earthquake zone III of India having medium stiff soil is considered. Plan and 3D view of the structures is shown in Figure

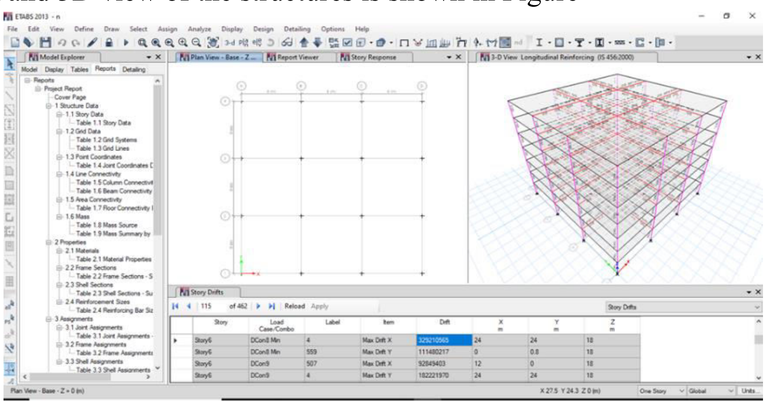

Figure 2: Plan and 3D view of the structure

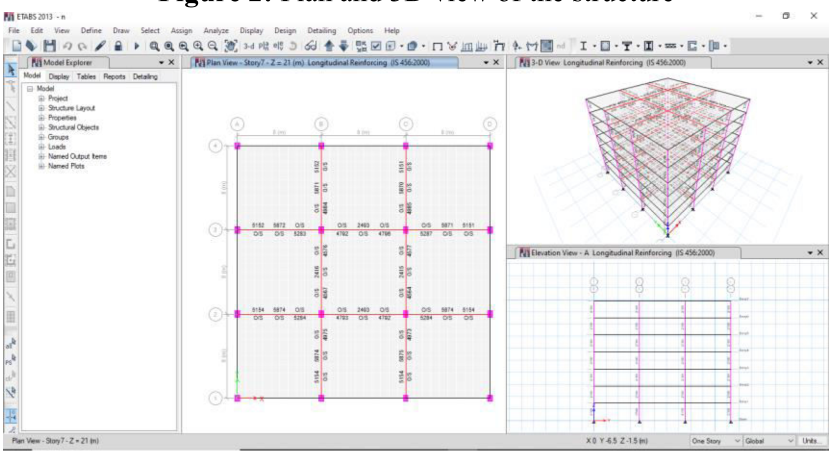

Figure 3: Plan, Elevation and 3D view of the structure

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After completing the modeling we need to define materials such as concrete, steel etc. which are required in defining the structural members such as beams, columns, stair case etc., when we define the type of material we are also allowed to choose the grade of the material at the same time, after this selection we will define the structural members such as beams, columns along with this we also define shape of the structure such as rectangle, circle etc

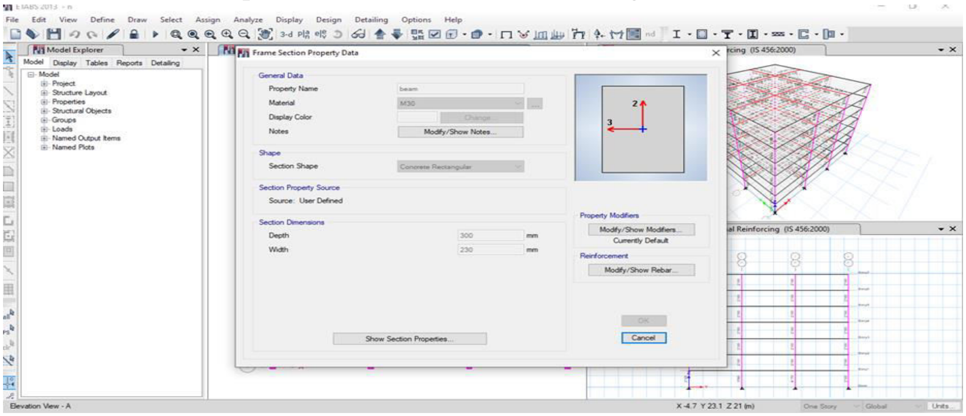

Figure 4: Defining of beam

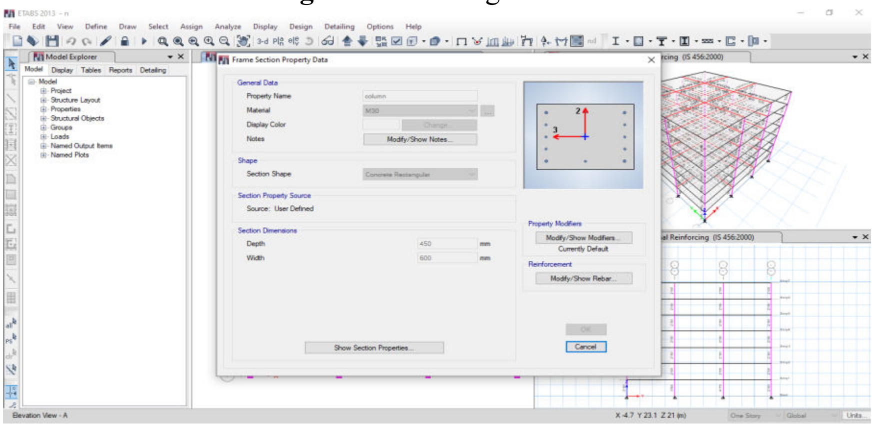

Figure 5: Defining of column

After we complete defining beams and columns we then assign them to the model as per our requirements, we shall assign the properties carefully such that there should not be any flaw in the assignment and after this is done we shall define the dead load, live load, earth quake load, wind load as per our requirements and then we assign these loads on the beams and columns of the structure.

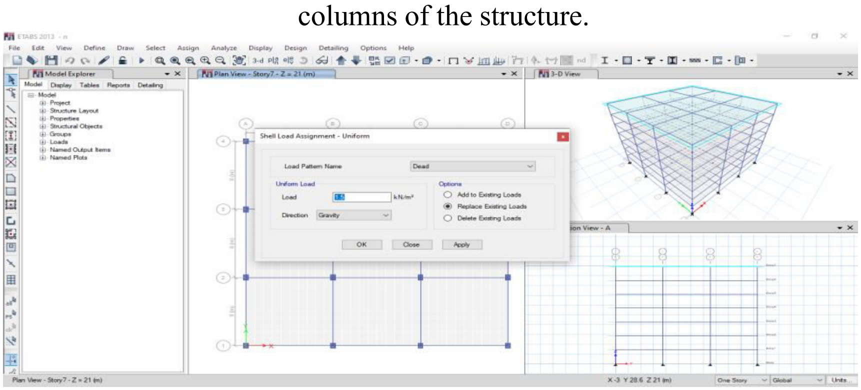

Figure 6: Defining Floor Finish load (DEAD LOAD)

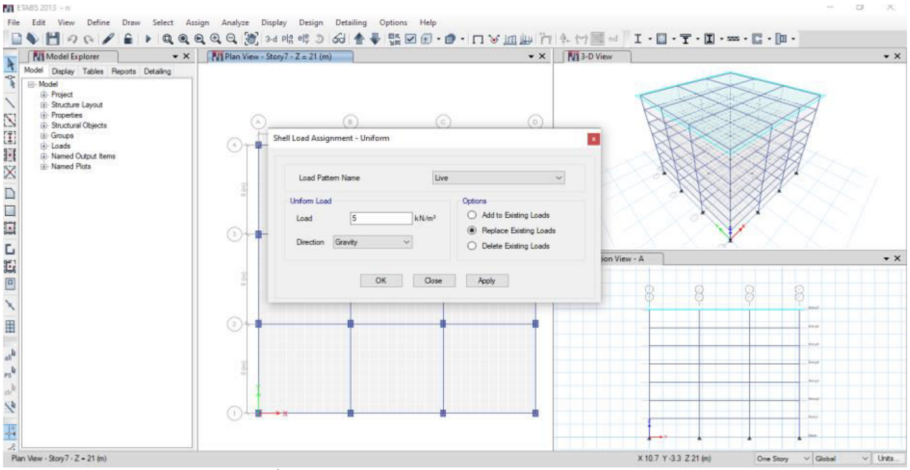

Figure 7: Defining Live Load

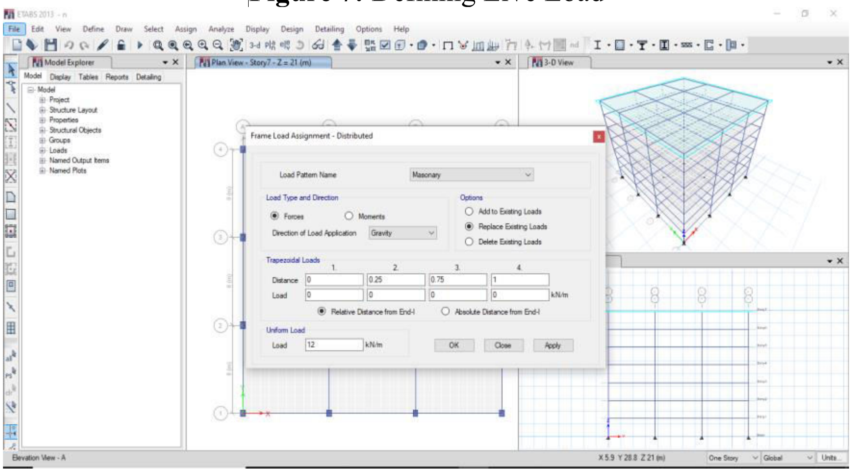

Figure 8: Defining Outer Wall Load

4. RESULTS AND DISCUSSIONS

The seismic analysis of the modeled structures with shear walls and diagrids spanning in two directions are carried out by using ETABS software and the results are given in the following sections. The parameters studied are story displacement, story drifts, base shear and storey stiffness in seismic zones III. Comparison of seismic behavior is made between the structures with conventional concrete and geo-polymer concrete. The comparison has done in Response Spectrum method.

Story displacement

It is the total displacement of i^{th} story with respect to ground. The story displacements of the modeled structures located in zone III using response spectrum method and time history analysis in X – direction is shown in Table

Table 2: Story displacements of the structures in zone III in X-direction

Displacements(mm) in Zone III in X-direction			
Story	**Elevation (m)**	**X** Displacement(mm)	**Y** Displacement(mm)
Story7	21	-1.74	-0.5297
Story6	18	-1.063	-0.3476
Story5	15	-0.337	-0.514
Story4	12	-0.886	-0.2058

Story3	9	-0.1442	-0.1479
Story2	6	-0.12711	-0.05726
Story1	3	-0.1195	-0.01442
Base	0	0	0

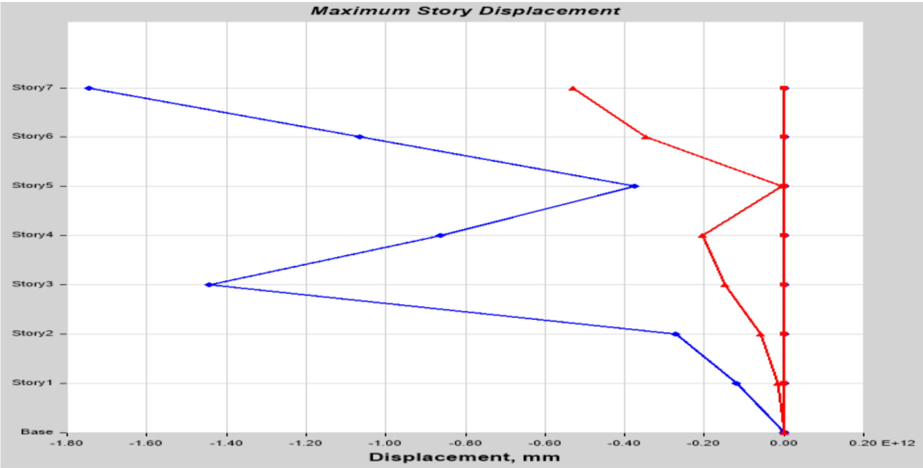

Figure 9: Story displacement of conventional concrete in zone III in X- direction & Y-direction

Story drifts

Story Drift is defined as ratio of displacement of two consecutive floors to the height of that floor. Drifts in frame structure are due to the result of flexure and shear mode contributions. In high rise structures, higher axial forces and deformations in columns and accumulations of their effects over greater heights cause flexure component displacement to become dominant.

Table 3: Story drifts of the structures in zone III in X-direction

Drift(mm) in Zone III in X-direction			
Story	**Elevation (m)**	**X**	**Y**
		Drift(mm)	Drift(mm)
Story7	21	-1.745	-0.5297
Story6	18	-1.063	-0.3476
Story5	15	-3.732	-0.0515
Story4	12	-0.8604	-0.2058
Story3	9	-1.442	-0.1479
Story2	6	-0.2711	-0.05726
Story1	3	-0.1195	-0.01442
Base	0	0	0

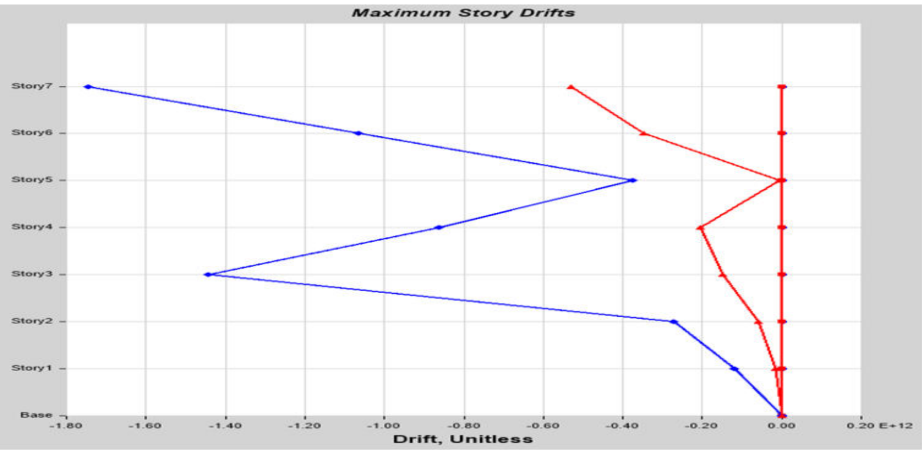

Figure 10: Story drifts of the structures in zone III in X-direction

Story shear

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. Storey shear factor is the ratio of the story shear force when story collapse occurs to the story shear force when total collapse occurs.

Table 4: Story shear of the structures in zone III in X-direction

			Storey Shear in Zone III in X-direction
Story	**Elevation (m)**		**X**
			Conventional
Story7	21	Top	10971.79
		Bottom	11457.65
Story6	18	Top	22429.44
		Bottom	22915.3
Story5	15	Top	32015.09
		Bottom	32500.95
Story4	12	Top	43472.74
		Bottom	43958.6
Story3	9	Top	54930.39
		Bottom	55416.24
Story2	6	Top	58516.89
		Bottom	59002.75
Story1	3	Top	69974.54
		Bottom	70460.39
Base	0	Top	0
		Bottom	0

Conclusions

In these conclusions the seismic behavior of the modeled concrete structures is analyzed using the Response Spectrum Method, focusing on story displacement, story drift, base shear, and natural time period across different seismic zones. Story displacement highlights lateral movements of floors, while story drift indicates inter-story deformation, which is important for assessing potential damage. Base shear shows the total horizontal forces acting at the base, and the natural time period provides insight into the dynamic characteristics of the structure. The results are discussed to understand how the structure responds under seismic loading, how irregularities and design features affect performance, and how the findings can guide safer and more efficient structural design in earthquake-prone areas

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