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RESEARCH ARTICLE OPEN ACCESS

Analysis of High-Rise Structures in Different Seismic Zones for Soil Type 1

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Abstract:

In the present paper, response spectrum analysis is carried out using Etabs software to study the effects of soil type 1 for different seismic zones for a high-rise building of G+ 29 storeys. . In this work, total 4 models are analyzed for various seismic zones are systematically compared and discussed for a seismic performance of multi-storey building. Response spectrum is used to study the difference in behaviour of the models under four seismic zones (i.e. Zone II, III, IV & V) and comparison is base on base reaction, storey drift, modal period and storey stiffness. Steel and concrete quantities required for the frame structure is calculated The obtained results are analyzed and compared to determine the most suitable condition for the construction of given high-rise building to have maximum service life.

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I. INTRODUCTION

GENERAL

High rise structures are the structures more than 23m (75ft) or 7-10 storey height. Due to increase in urban population cities are growing outwards which has made procuring basic facilities such as water supply, sewage collection and other basic needs more complicated. So the alternative solution to this problem is to build vertical that is building high-rise structures within the city which are compact and concentrate the population of a large area into a single structure.

But construction of high-rise building is more complicated as the factors to be contemplated are significant. The soil type and seismic zone on which it is builthas a significant role which determines the stability and height of the structure.

Vibrations which disturb the earth's crust caused by waves generated inside the earth are termed as earthquakes. The convergence or divergence of tectonic plates triggers earthquakes. It is said that earthquakes are not fatal for humans but structures which are not constructed in considering the earthquake forces do.

High rise structures are the one of most complex structures to construct since there are a lot of contradictory requirements and complex building systems. The design of high rise structures is getting more and more slender, which leads to the possibility of more sway of the structure in comparison with pervious designs. Thus the impact of wind, seismic forces acting and soil type on which it is constructed becomes a significant aspect of the design. However, different seismic and soil conditions may have a different effect on the static and dynamic characteristics of high rise structures and manipulate their static and dynamic performance.

Scaling up and innovating the structural systems of high rise structures can have power over their dynamic response. Beyond 10 stories, the lateral drift of the structure becomes a significant part which controls the design, the stiffness rather than strength becomes the dominant factor.

THE GROWTH OF HIGH-RISE STRUCTURESIN DIFFERENT PARTS OF INDIA-

Until recently, Mumbai was the Indian city with significant number high-rise structures. The financial capital continues to see the highest demand for skyscrapers, as the only option to grow there is vertically due to high land costs. It seems that in the next decade, Maximum City will have an even more cohesive skyline, with projects in the race to touch the sky being constructed. The demand for high-rise buildings is certainly in surge, and other cities are catching up.

Mumbai continues to maintain its position of the maximum number of tall buildings approved or under construction.
New Delhi, the national capital, has around a dozen of high-rise buildings coming up of varying heights of range 150-300 meters.Bengaluruis witnessing a huge surge in the number of skyscrapers being built in different parts of the city.
Mantri Pinnacle (topped out in August 2013) is currently the tallest building in the city. It is 153 meters (502 ft) tall and has 46 floors. TheWorld Trade Center, the UB Tower, the CNTC Presidential Tower, Sobhaindraprasthaand Phoenix One Bangalore West are some of the various prominent skyscrapers in the city.

LITRATURE REVIEW

1. W. Bourouaiah**"Influence of the soil properties on the seismic response of structures".**(2019). The study is to model the interaction between Concrete wall & soil under seismic loading. The purpose of the study is to calibrate the effects of soil properties and the soil structure interaction on the seismic response of the structure. The obtained results show that soil properties have a great influence on seismic behaviour of a structure.

2. Amir Hassan, Shilpa Pal "**Effect of soil condition on seismic response of isolated base buildings**" (2018) .In this study, analysis is carried out using Etabs-2015 software to study the influence of soil condition beneath the isolated base of G+12 story building. Various types of soils are methodically compared and discussed for a seismic performance of multi story buildings. The value of base shear is directly proportional to soil flexibility and superstructure stiffness.

3. Arun Babu M, Ajisha R "**Analysis of Multi-storeyed Building in Different Seismic Zones with Different Soil Conditions**" (2018).This paper aims on the effect of high-rise building in different seismic zones with different soil conditions for G+10 storey building. Here 3 dimensional modelling and analysis of structure is done using the software by ETABS. The story displacement and base shear will help to compare
the performance of all models and can identify which building has more performance against earthquake.

4. Bhalchandra P. Alone, Dr. Ganesh Awchat "**Study on seismic analysis of high-rise building by using software**" (2017).This paper addresses the Case study on seismic analysis of high rise building system (Ground+3 Basements+50) storey RCC by STAAD pro v8i with application of IS provisions. The main parameters considered in this study are to compare the seismic performance of different models based on storey drift, base shear, story deflection and time period.

5. Gourav Sachdeva, Vinamra Bhushan Sharma "**Impact of Different Soils and Seismic Zones on Varying Height of Framed Structures**" (2017).To determines the impact of different soil and seismic zones on varying height of framed structure. For three different soils types -soft, medium and hard. Stories i.e., G+4,G+5, G+6 & G+7 of heights

15m,18m, 21m & 24m respectively are considered and analyzed for different seismic zones that is Zone II,III,IV & V. This paper concludes that in Seismic Zone - 2, 3 & 5 the values of maximum Shear forces & maximum bending moment are decreasing in hard soil strata in comparison to soft soil strata & found the least for the same.

AIM

To Analyze the High-Rise Structures in different soil types and seismic zones.

OBJECTIVES

- To Analyze and study the RC buildings in different seismic zones of India as per is 1893: 2016.
- To Analyze and study the RC buildings in different soil types present in India.
- To compare the results obtained from different seismic zones and soil types.

METHODOLOGY

The first step involved in the process of this project was to initially select a suitable plan for a high-rise building. This project was mainly carried out to analyze the effects of different soil and seismic zones for a high-rise building. For modelling and analysis we made use of e-tabs software which is one of the most efficient and popular software for structural analysis of the buildings.

During the process, we used IS code books which are IS 456:2000, IS 875:1987 and IS 1893:2016. The material properties are defined as per IS 456:2000- Plain and Reinforced Concrete. The loads and load combinations are defined as per is 875:1987 which is a code of practice for design loads. The earthquake resistant structures are designed as per is 1893:2016 part 1 which is a criteria for earthquake resistant design of structure. After analyzing different models with different soil types and seismic zones, the results will be compared to obtain the best model out of different combinations.

DATA FOR DEVELOPING THE MODEL

A plan of 16mx16m is taken into consideration having 4mx4m bays on both the sides. The high rise building (hrb) of g+29 stories in which floor to floor height is taken as 3m for all the models. The plan and elevation is shown. An analytical study on multi-storey building of g+29 stories was carried out for different seismic zones and soil type 1.these building models are analyzed, using e tabs 2015 software using response spectrum method as per is 1893 (part i): 2002

A. Material and geometrical properties:

Following material properties are considered for the modelling of the proposed structure frame:-

INPUT TABLE

Support condition	Fixed
Number of story	G+29
Grade of concrete	M35
Grade of steel	HYSD500
Size of plan	16m X 16m
Type of plan	Symmetrical
Floor to floor height	3m
Ground floor height	3m
Seismic zone	ZONE 2 ,ZONE 3, ZONE 4, ZONE 5
Soil type	1 (IS 1893:2016,Table 2)
Slab thickness	150mm
Beams	450mmx600mm

Table 1: Input Data

B. Loading Conditions:

Following loadings are adopted for analysis:

Design variable	Value
Live load on all foors	$2KN/m^2$
Super Dead load	$0.8KN/m^2$
Wall load on peripheral beams	$10.8KN/m^2$
Response reduction factor (R)	5
Zone factor (Z)	1
Importance factor (I)	1
Damping ratio	5%

Table 2: Loading condition data

Seismic zone	ZONE 2	ZONE 3	ZONE 4	ZONE 5
Seismic zone factor	0.1	0.16	0.24	0.36

Table 3: Seismic zone factors

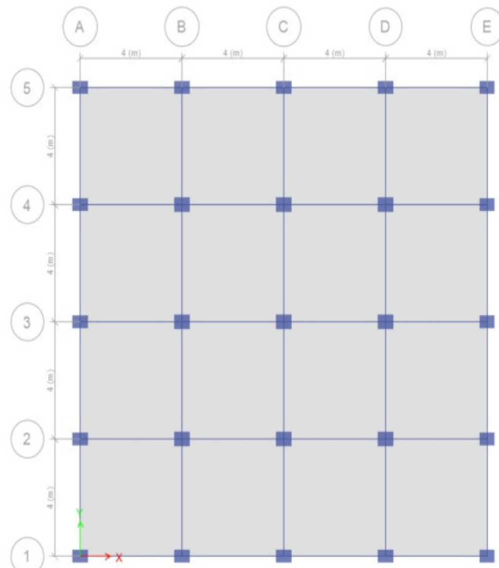


Fig 1: Plan of the Structure

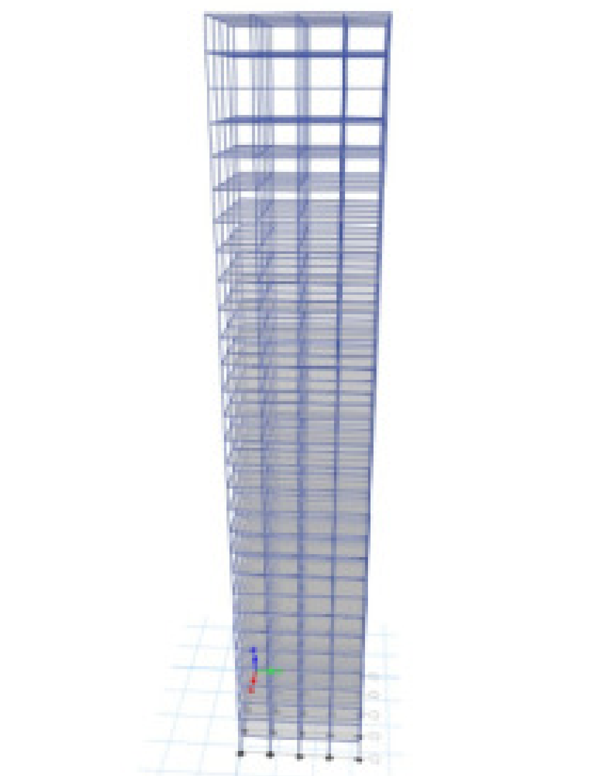


Fig 2: Undeformed Shape of the structure

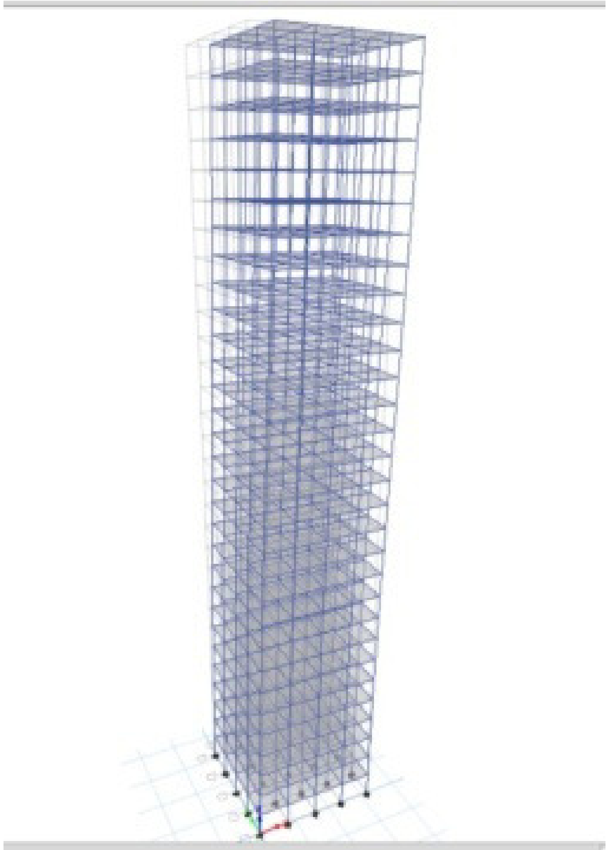


Fig 3: Deformed shape of the structure

COLUMN DETAILS

ZONE 2 -

Floor	C4	C3	C2	C1
G TO 9	600x500	600X500	600X450	600X450
10 TO 15	450x450	450x450	400X450	400X450
16 TO 29	300x450	300x450	400X450	400X450

Table 4: Column detail of structure in zone 2

ZONE 3 –

Floor	C4	C3	C2	C1
G TO 9	600x500	600X500	600X450	600X450
10 TO 15	450x450	450x450	400X450	400X450
16 TO 29	300x450	300x450	400X450	400X450

Table 5: Column detail of structure in zone 3

ZONE 4 –

Floor	C4	C3	Floor	C2	C1
G TO 9	600x500	600X500	G TO 11	600X450	600X450
10 TO 15	450x450	450x450	12 TO 29	400X450	400X450
16 TO 29	300x450	300x450			

Table 6: Column detail of structure in zone 4

ZONE 5 –

Floor	C4	C3	Floor	C2	C1
G TO 9	600x600	600x600	G TO 13	600X500	600X500
10 TO 15	450x450	450x450	14 TO 29	450x400	450x400
16 TO 29	300x450	300x450			

Table 7: Column detail of structure in zone 5

RESULTS

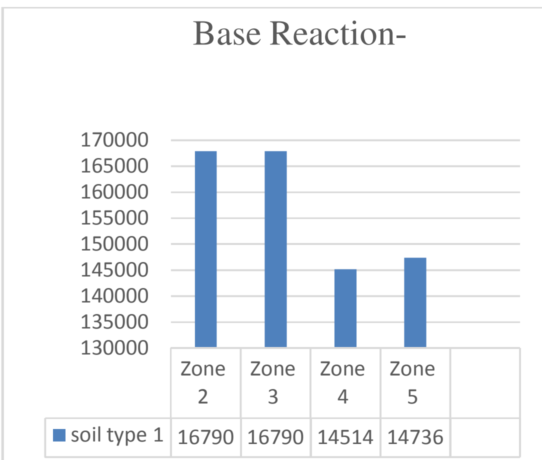
An analytical study on multi-Storey building of G+29 stories was carried out for different seismic zones and soil type 1. The Structural responses on Storey drift, Modal period, Base reaction, Storey Stiffness analysed using Response spectrum method for dynamic load for soil type 1. Steel and concrete quantities required for the frame structure is calculated and are presented below.

BASE REACTION F_z (KN)

Base Reaction is an estimate of the maximum expected lateral force on the base of the structure due to seismic activity.

BASE REACTION F_z (KN)		
Zone 2 soil 1	167901.81	DCON 2
Zone 3 soil 1	167901.8	DCON 2
Zone 4 soil 1	145141.2	DCON 2
Zone 5 soil 1	147367	DCON 2

Table 8: Base reaction in different seismic zones

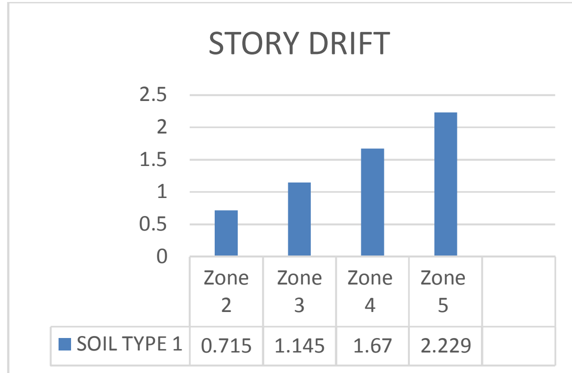


STORY DRIFT

It is defined as the drift of the one story with respect to the below story of the building.

STORY DRIFT, mm			
Zone 2 soil 1	0.715	STORY 30	EQX
Zone 3 soil 1	1.145	STORY 30	EQX
Zone 4 soil 1	1.67	STORY 30	EQX
Zone 5 soil 1	2.229	STORY 30	EQX

Table 9: Storey Drift in different seismic zones

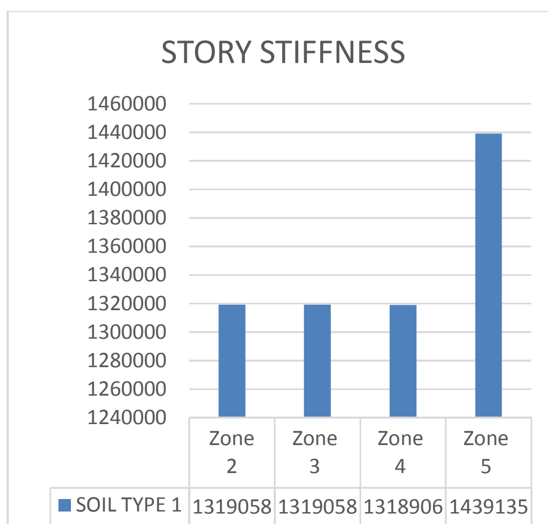


STORY STIFFNESS

It is defined as the ratio of Story shear to Story drift for frames subjected to lateral load distribution.

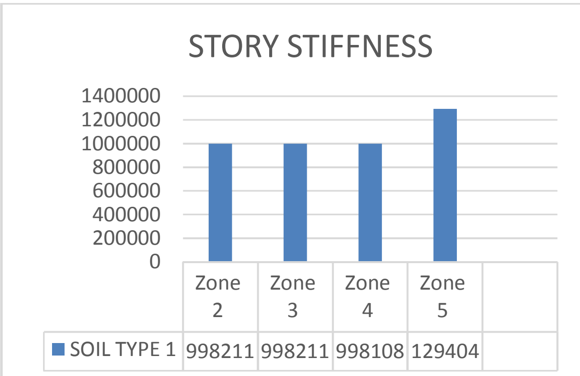
STORY STIFFNESS, KN/m			
Zone 2 soil 1	1319058.1	STORY 1	EQX
Zone 3 soil 1	1319058.1	STORY 1	EQX
Zone 4 soil 1	1318906.5	STORY 1	EQX
Zone 5 soil 1	1439135	STORY 1	EQX

Table 10: Storey Stiffness in X-direction



STORY STIFFNESS, KN/m			
Zone 2 soil 1	998210.75	STORY 1	EQY
Zone 3 soil 1	998210.75	STORY 1	EQY
Zone 4 soil 1	998108.47	STORY 1	EQY
Zone 5 soil 1	1294049	STORY 1	EQY

Table 11: Storey Stiffness in Y-direction

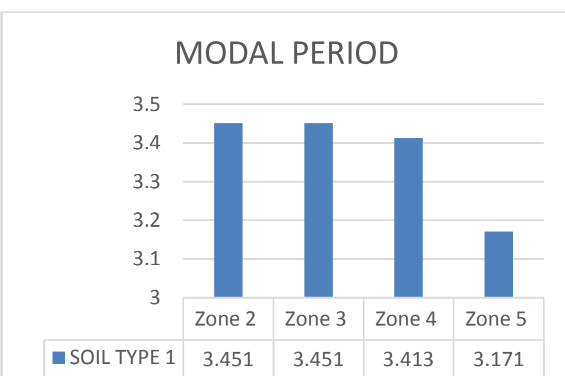


MODAL PERIOD

The modal period is proportional to the inverse of the spectrally weighted peak frequency (T= 1/f = 2P/ω)

MODAL PERIOD, Sec		
Zone 2 soil 1	3.451	MODE 1
Zone 3 soil 1	3.451	MODE 1
Zone 4 soil 1	3.413	MODE 1
Zone 5 soil 1	3.171	MODE 1

Table 12: Modal Period in different Seismic Zones



CONCRETE QUANTITY

Concrete Quantity(m3)	
Zone 2	2902.95
Zone 3	2902.95
Zone 4	2911.549
Zone 5	2956.59

Table 13: Concrete quantity in m^3 for different zones

STEEL QUANTITY

STEEL QUANTITY(Tonnes)	
ZONE 2	158.9707
ZONE 3	162.5812
ZONE 4	180.0789
ZONE 5	195.116

Table 14: Steel quantity in tonnes for different zones

OBSERVATIONS& CONCLUSION

- Base reaction decreases as the earthquake zone changes from II to V by **12.2302%**
- Modal period decreases as the earthquake zone changes from II to V by **8.1135%**
- Story drift increases as the earthquake zone changes from II to V by **211.748%**
- Story stiffness (EQX) increases as the earthquake zone changes from II to V by **9.1032%**
- Story stiffness (EQY) increases as the earthquake zone changes from II to V by **29.6369%**
- Concrete quantity increases as the earthquake zone changes from II to V by **1.8477%**
- Steel quantity increases as the earthquake zone changes from II to V by **22.7371%**

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6) IS 456:2000 Plain and Reinforced Concrete- Code of Practice
7) IS 875:1987 Part 1 And Part 2 Code of Practice for Design Loads for Buildings and Structures
8) IS 1893:2016 Criteria for Earthquake Resistant Design of Structures