Seismic Analysis of High Rise Building by Using Response Spectrum Method

Anup sale [#1], Nitika waghule[#2], Aishwarya waghmode[#3], Swapnali saykar[#4],

Ashish R. Kondekar [#5],

[#1-4]UG Students, Civil Engineering Department, Savitribai Phule Pune University, Pune
[#5]Assistant Professor, Civil Engineering Department, Savitribai Phule Pune University, Pune
[1] anuprsale97@gmail.com
[2] waghulenitika98@gmail.com
[3] aishwaryawaghmode99@gmail.com
[4] swapna.saykar@gmail.com
[5] ashish.kondekar.sits@sinhgad.edu

Abstract

Reinforced Concrete Frames are the most commonly adopted buildings construction practices in India. With growing economy, urbanization and unavailability of horizontal space increasing cost of land and need for agricultural land, high-rise sprawling structures have become highly preferable in Indian. With high-rise structures, not only the building has to take up gravity loads, but as well as lateral forces. Many important Indian cities fall under high risk seismic zones; hence strengthening of buildings for lateral forces is a prerequisite. In this study the aim is to analyze the response of a high-rise building using Response Spectrum method. The Different models, which are G+ 15, G+ 20, and G+ 25, are considered for analysis. The modelling and analysis of the building has been done by using structure analysis tool ETABS 2016, to study the effect of varying height of the column in bottom storey at different position during the earthquake. High-rise buildings are designed as per Earthquake code IS: 1893-2016 Earthquake causes different shaking intensities at different locations and the damage induced in buildings at these locations is also different. There is necessary to construct a structure which is earthquake resistance at a particular level of intensity of shaking a structure. The aim of present study is to compare seismic performance of high-rise structures situated in earthquake zone IV. All frames are designed under same gravity loading response spectrum method is used for seismic analysis. ETABS software is used and the results are compared.

Keywords— RCC Buildings, Earthquake, Response Spectrum Method, Wind Load, ETABS

I. INTRODUCTION

General Introduction

Earthquake causes random ground motions, in all possible directions emanating from the epicentre. Vertical ground motions are rare, but an earthquake is always accompanied with horizontal ground shaking. The ground vibration causes the structures resting on the ground to vibrate, developing inertial forces in the structure. As the earthquake changes directions, it can cause reversal of stresses in the

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structural components, that is, tension may change to compression and compression may change to tension. Earthquake can cause generation of high stresses, which can lead to yielding of structures and large deformations, rendering the structure non-functional and unserviceable. There can be large storey drift in the building, making the building unsafe for the occupants to continue living there.

The main parameters of the seismic analysis of structures are load carrying capacity, ductility, stiffness, damping and mass. The design can be divided into two main steps. First, a linear analysis is conducted with appropriate dimensioning of all structural elements, ensuring the functionality of the structure after minor earthquakes, and then the behaviour of structures during strong earthquakes has to be controlled using nonlinear methods. Dynamic analysis should be performed for symmetrical as well as unsymmetrical building. Due to unsymmetrical section of building the major parameter to be considered is Torque. The structural engineers perform for both regular as well as irregular buildings.

And design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, Etabs 2016 is the professional's choice for steel, concrete, timber, aluminium and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more. Etabes 2016 consists of the following: The Etabs 2016 Graphical User Interface: It is used to generate the model, which can then be analyzed using the Etabs 2016 engine. After analysis and design is completed, the GUI can also be used to view the results graphically. The Etabs 2016 analysis and design engine: It is a general-purpose calculation engine for structural analysis and integrated Steel, Concrete, Timber and Aluminium design. To start with I have solved some sample problems.

II.RESEARCH METHODOLOGY

Response spectrum method

1. Earthquake motion causes vibration of the structure leading to inertia forces.

Thus, a structure must be able to safely transmit the horizontal and the vertical inertia forces generated in the super structure through the foundation to the ground. Hence, for most of the ordinary structures, earthquake-resistant design requires ensuring that the structure has adequate lateral load carrying capacity.

2. Seismic codes will guide a designer to safely design the structure for its intended purpose

Diaphragm

1. It is a horizontal or nearly horizontal system, which transmits lateral forces to the vertical resisting elements, for example, reinforced concrete floors and horizontal bracing systems Centre of Mass.
2. The point through which the resultant of the masses of a system acts. This point corresponds to the centre of gravity of masses of system.
3. Centre of Stiffness.
4. The point through which the resultant of the restoring forces of a system acts.

Seismic Base Shear

According to IS 1893 (Part-I): 2016, Clause 7.5.3 the total design lateral force or design seismic base shear (VB) along any principal direction is determined by

$VB = A_h*W$

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Where,A_h is the design horizontal acceleration spectrum, *W is* the seismic weight of building

Design Horizontal Acceleration Spectrum Value

For determining the design seismic forces, the country (India) classified into four seismic zones (II, III, IV, and V). Previously, there were five zones, of which Zone I and II Are merged into Zone II in fifth revision of code. According to IS 1893: 2016 (Part 1), Clause6.4.2 Design Horizontal Seismic Forces coefficient Ah for a structure shall be determined by following expression:

$A_h = (Z/2) * (I/R) * (Sa/2g)$

Where,

Z = Zone factor seismic intensity

III. PROBLEM FORMULATION

In G+15, G+20 and G+25-story reinforced concrete moment resisting space frame have been analyzed using professional software. Model G+15 and G+20 and G+25 building is analyzed by response spectrum method. The plan dimensions of buildings are shown in table below. The plan view of building, elevation of different frames is shown in figures below.

Table no I: Detail Features of Building

Sr. No	Parameters	Values
1	Material Used	Concrete-M30 Reinforcement Fe500&Fe415MPA
3	Height Of Each Storey	3.0m
4	Height Of Ground Storey	3.0m
5	Density Of Concrete	30KN/M3
6	Poisson Ratio	0.2-Concrete And 0.15-Steel
9	Code Of Practice Adopted	IS456:2000 , IS1893:2016
10	Seismic Zone For IS1893:2016	IV
12	Importance Factor	1.5
13	Response Reduction Factor	5
14	Foundation Soil	Medium
15	Slab Thickness	150mm
16	Wall Thickness	150mm
17	Floor Finish	1KN/M2
18	Live Load	2.5KN/M2
19	Earthquake Load	As Per IS 1893-2016
20	Size Of Beam	430mmx230mm
21	Size Of Column	530mmx230mm

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23	Model To Be Analyzed	G+15 And G+20and G+25 Building
24	Ductility Class	IS1893:2016 SMRF

1. G+15 Building 3d Model:

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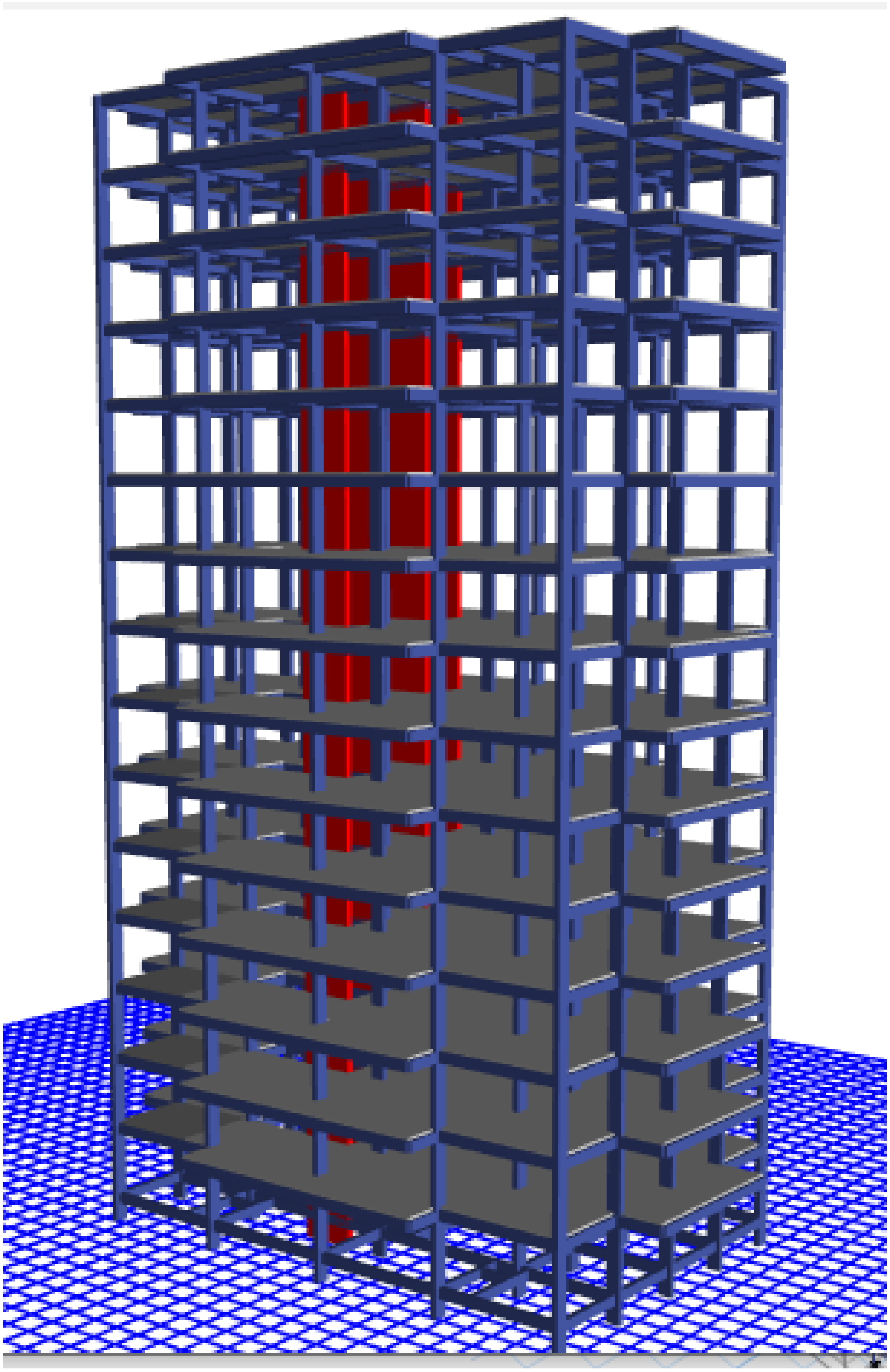

Fig. G+15 Building Software Rendering Model

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2. G+20 Building 3d Model:

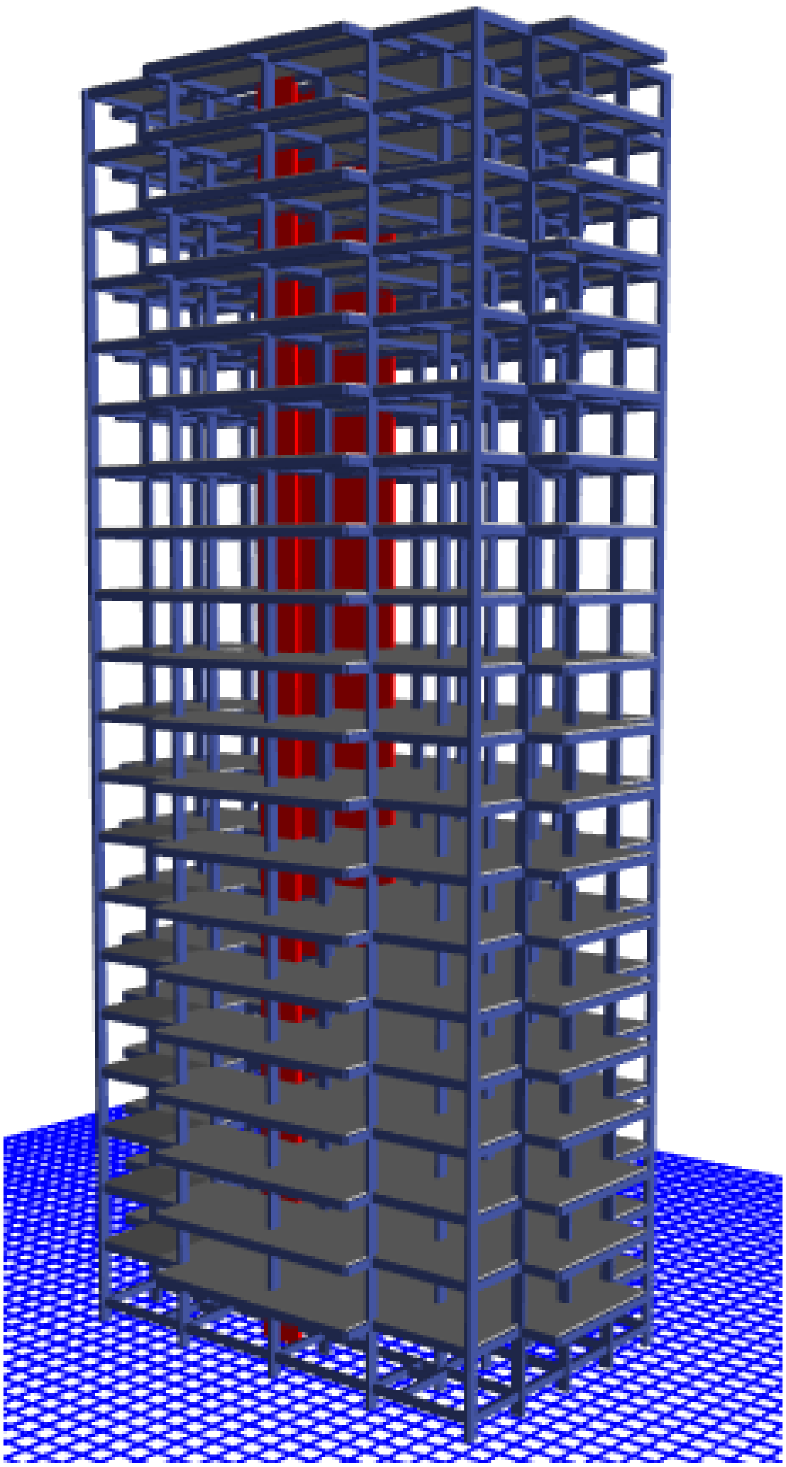

Fig. G+20 Building Software Rendering Model

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3. G+25 Building 3d Model:

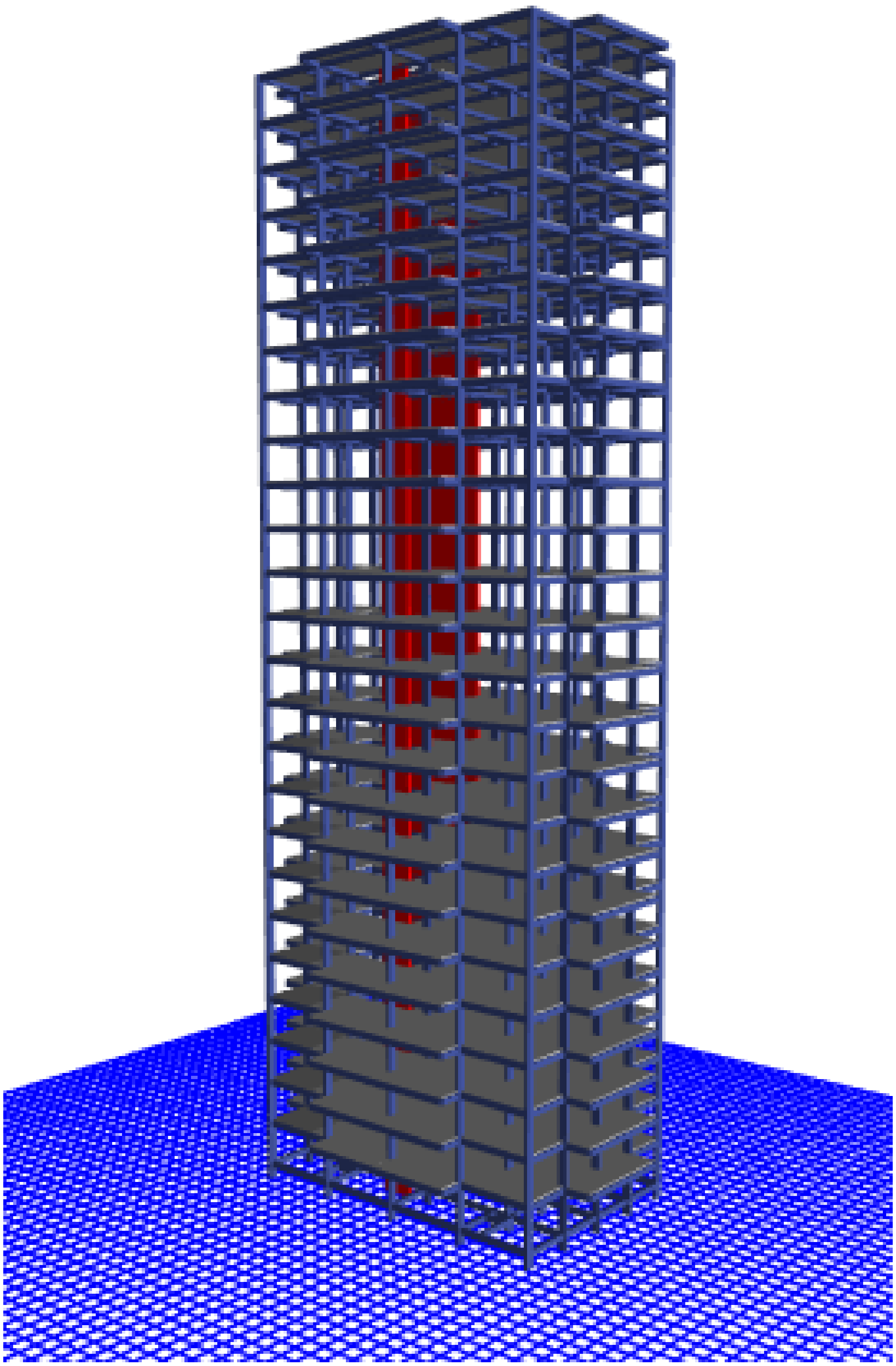

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Fig. G+25 Building Software Rendering Model

Table No: II Base Shear G+15 Story Building

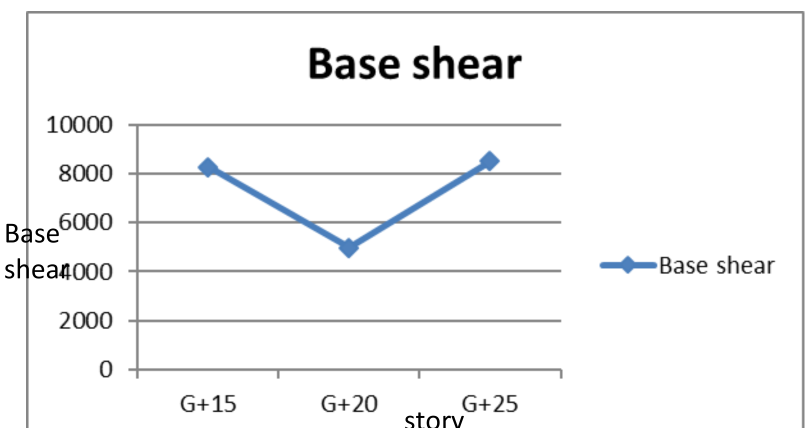
Auto Seismic - IS 1893:2002			
Load Pattern	Ah	Weight Used(w)	Base Shear(Vb)
		kN	kN
EQ+X	0.09	91865.0961	8267.8586
EQ-X	0.09	91865.0961	8267.8586
EQ+Y	0.09	91865.0961	8267.8586
EQ-Y	0.09	91865.0961	8267.8586

Table No: III Base Shear G+20 Story Building

Seismic - IS 1893:2002			
Load Pattern	Ah	Weight Used(w)	Base Shear(Vb)
		kN	kN
EQ+X	0.052645	94572.1299	4978.765
EQ-X	0.052645	94572.1299	4978.765
EQ+Y	0.042207	94572.1299	3991.5961
EQ-Y	0.042207	94572.1299	3991.5961

Table No IV: Base Shear G+25 Story Building

Auto Seismic - IS 1893:2002			
Load Pattern	Ah	Weight Used(w)	Base Shear(Vb)
		kN	kN
EQ+X	0.09	94572.1299	8511.4917
EQ-X	0.09	94572.1299	8511.4917
EQ+Y	0.09	94572.1299	8511.4917
EQ-Y	0.09	94572.1299	8511.4917



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Graph: I Base Shear Graph G+15, G+20 and G+25 Story Building

Table No: V Earthquake Displacement G+15 Story Building

Diaphragm Centre Of Mass Displacements			
Story	Load Case/Combo	UX	UY
		m	m
Story16	EQ+X	0.425618	0.000007
Story15	EQ+X	0.40603	0.00006
Story14	EQ+X	0.383807	0.000059
Story13	EQ+X	0.358941	0.000057
Story12	EQ+X	0.331398	0.000055
Story11	EQ+X	0.301458	0.000052
Story10	EQ+X	0.269539	0.000048
Story9	EQ+X	0.236139	0.000044
Story8	EQ+X	0.201816	0.000039
Story7	EQ+X	0.167179	0.000034
Story6	EQ+X	0.132898	0.000029
Story5	EQ+X	0.099727	0.000023
Story4	EQ+X	0.068555	0.000018
Story3	EQ+X	0.040534	0.000012
Story2	EQ+X	0.017314	0.000005
Story1	EQ+X	0.002048	4.399E-10
Base	EQ+X	0	0

Table No: VI Earthquake Displacement G+20 Story Building

Diaphragm Centre of Mass Displacements

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Story	Load Case/Combo	UX	UY
		m	m
Story21	EQ+X	0.299603	0.000352
Story20	EQ+X	0.291004	0.000197
Story19	EQ+X	0.283829	0.000199
Story18	EQ+X	0.27634	0.0002
Story17	EQ+X	0.268317	0.000202
Story16	EQ+X	0.25892	-3.535E-08
Story15	EQ+X	0.24916	0.000542
Story14	EQ+X	0.236205	0.00053
Story13	EQ+X	0.221276	0.000511
Story12	EQ+X	0.204525	0.000487
Story11	EQ+X	0.186222	0.000458
Story10	EQ+X	0.166673	0.000425
Story9	EQ+X	0.146214	0.000388
Story8	EQ+X	0.1252	0.000348
Story7	EQ+X	0.104005	0.000306
Story6	EQ+X	0.083035	0.000262
Story5	EQ+X	0.062739	0.000215
Story4	EQ+X	0.043645	0.000165
Story3	EQ+X	0.026426	0.000113
Story2	EQ+X	0.012031	0.00006
Story1	EQ+X	0.00207	-4.177E-10
Base	EQ+X	0	0

Table No: VII Earthquake Displacement G+25 Story Building

Diaphragm Centre of Mass Displacements			
Story	Load Case/Combo	UX	UY
		m	m
Story26	EQ+X	0.55602	0.000587
Story25	EQ+X	0.543214	0.000327
Story24	EQ+X	0.533002	0.000328
Story23	EQ+X	0.522688	0.000328
Story22	EQ+X	0.512216	0.000328
Story21	EQ+X	0.501512	0.000329
Story20	EQ+X	0.490475	0.00033
Story19	EQ+X	0.478964	0.000332
Story18	EQ+X	0.466767	0.000334

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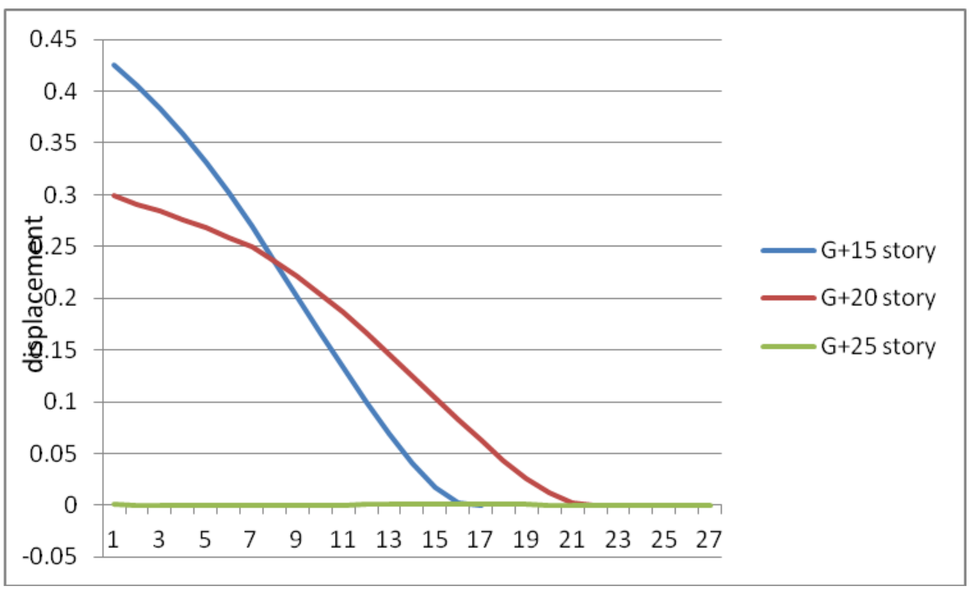
Story17	EQ+X	0.453542	0.000336
Story16	EQ+X	0.437899	-1.815E-07
Story15	EQ+X	0.421501	0.000902
Story14	EQ+X	0.399635	0.00088
Story13	EQ+X	0.374349	0.000848
Story12	EQ+X	0.345915	0.000806
Story11	EQ+X	0.314796	0.000756
Story10	EQ+X	0.281526	0.0007
Story9	EQ+X	0.24668	0.000637
Story8	EQ+X	0.210868	0.000569
Story7	EQ+X	0.174736	0.000497
Story6	EQ+X	0.138979	0.000421
Story5	EQ+X	0.104374	0.000341
Story4	EQ+X	0.071832	0.000256
Story3	EQ+X	0.042539	0.000168
Story2	EQ+X	0.018203	0.000079
Story1	EQ+X	0.002107	-8.104E-10
Base	EQ+X	0	0



Graph: II Story vs. Earthquake Displacement graph G+15, G+20 and G+25 story buildings

Table No: VIII Wind Displacement G+15 Building

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Diaphragm Centre of Mass Displacements			
Story	Load Case/Combo	UX	UY
		m	m
Story16	WL+X	0.054685	0.000001
Story15	WL+X	0.05251	0.000009
Story14	WL+X	0.05007	0.000008
Story13	WL+X	0.047359	0.000008
Story12	WL+X	0.044336	0.000008
Story11	WL+X	0.040991	0.000008
Story10	WL+X	0.037332	0.000007
Story9	WL+X	0.033377	0.000007
Story8	WL+X	0.029161	0.000006
Story7	WL+X	0.024732	0.000006
Story6	WL+X	0.020157	0.000005
Story5	WL+X	0.015529	0.000004
Story4	WL+X	0.010977	0.000003
Story3	WL+X	0.006687	0.000002
Story2	WL+X	0.00295	0.000001
Story1	WL+X	0.000362	6.013E-11
Base	WL+X	0	0

Table IX: Wind Displacement G+20 Building

Diaphragm Centre of Mass Displacements			
Story	Load Case/Combo	UX	UY
		m	m
Story21	WL+X	0.061556	0.000083
Story20	WL+X	0.059899	0.000047
Story19	WL+X	0.058592	0.000047
Story18	WL+X	0.057238	0.000047
Story17	WL+X	0.055802	0.000047
Story16	WL+X	0.05413	-8.834E-09
Story15	WL+X	0.052545	0.000128
Story14	WL+X	0.050369	0.000126
Story13	WL+X	0.047844	0.000124
Story12	WL+X	0.044951	0.00012
Story11	WL+X	0.041696	0.000116
Story10	WL+X	0.038094	0.00011
Story9	WL+X	0.034172	0.000103

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Story8	WL+X	0.029967	0.000095
Story7	WL+X	0.025531	0.000086
Story6	WL+X	0.020932	0.000075
Story5	WL+X	0.016265	0.000063
Story4	WL+X	0.011655	0.00005
Story3	WL+X	0.007286	0.000035
Story2	WL+X	0.003436	0.000019
Story1	WL+X	0.000616	-1.159E-10
Base	WL+X	0	0

Table No .X: Wind Displacement G+25 Building

Story	Load Case/Combo	UX	UY
		m	m
Story26	WL+X	-1.478E-08	0.040521
Story25	WL+X	-1.332E-08	0.040029
Story24	WL+X	-1.416E-08	0.039532
Story23	WL+X	-1.486E-08	0.039023
Story22	WL+X	-1.539E-08	0.038495
Story21	WL+X	-1.572E-08	0.03794
Story20	WL+X	-1.579E-08	0.037348
Story19	WL+X	-1.552E-08	0.036704
Story18	WL+X	-1.475E-08	0.035991
Story17	WL+X	-1.337E-08	0.035182
Story16	WL+X	-9.717E-09	0.034237
Story15	WL+X	-7.92E-09	0.033102
Story14	WL+X	-6.723E-09	0.031734

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Story13	WL+X	-6.168E-09	0.030112
Story12	WL+X	-6.005E-09	0.028227
Story11	WL+X	-6.07E-09	0.026082
Story10	WL+X	-6.243E-09	0.023691
Story9	WL+X	-6.434E-09	0.021076
Story8	WL+X	-6.562E-09	0.018268
Story7	WL+X	-6.552E-09	0.015314
Story6	WL+X	-6.331E-09	0.012273
Story5	WL+X	-5.819E-09	0.00923
Story4	WL+X	-4.934E-09	0.006296
Story3	WL+X	-3.614E-09	0.00363
Story2	WL+X	-1.895E-09	0.001468
Story1	WL+X	-2.022E-10	0.000168
Base	WL+X	0	0

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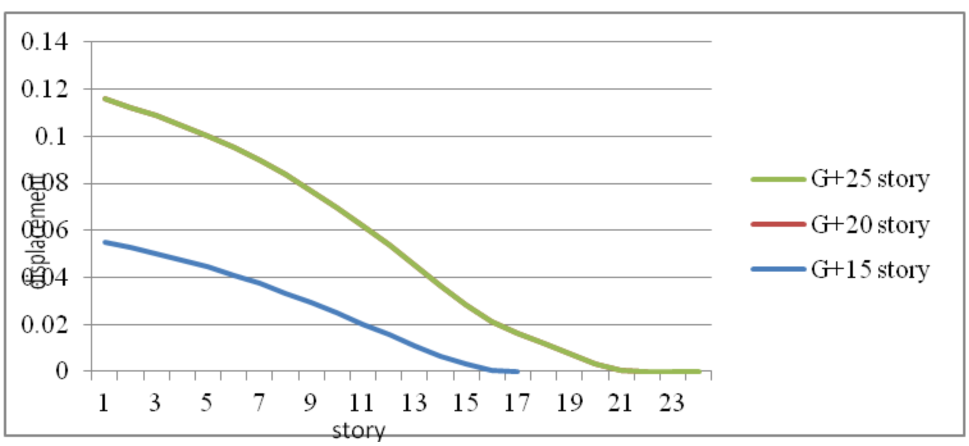

Graph No: III Story vs. Wind Displacement Graph G+15, G+20 and G+25 Story Buildings

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IV. CONCLUSION

In the present study, comparative evaluation of high-rise structure with soils has been carried out for different number of storey. The buildings are analyses for earthquake load (zone IV). Comparison has been made on different structural parameters viz. base shear, Earthquake displacement, wind displacement and member forces etc.

Based on the analysis results following conclusions have been drawn:

1. Base shear is maximum in X-direction at G+15, G+20 and G+25 stories building in zones IV. Also in G+15 building base shear is increases approximate 25% as compare to G+20 building and 30% increases in G+25 stories building in zone IV in medium soil.
2. In G+15, G+20 and G+25 building due to earthquake loading, the displacement is maximum in G+25 story building as compare to G+15 & G+20 story in zone IV.
3. In G+15 building due to wind loading, the displacement is maximum in G+20 building as compare to G+ 15and G+ 25 stories building in zone IV in medium soil.

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REFFERENCES

[1]. Sanjay Kumar Sadh, Dr.Umesh Pendharkar, "Influence of Aspect Ratio & Plan Configuration on Seismic Performance of Multistoried Regular R.C.C. Buildings: An Evaluation by Response Spectrum Analysis" IRJET vol 03, Issue 01 Jan 2016

[2]. Anupam Rajmani, Prof. Priyabrata Guha, "Analysis of Wind & Earthquake Load for Different Shapes of High Rise Building", IJCIET vol 6, Issue 2, Feb 2015 pp. 38-45. Mohod, M. V. (2015). "Effect of Shape and Plan Configuration on Seismic Response of Structure." International Journal of Scientific & Technology Research, 4, 84-88.

[3]. Mahesh, M. S., & Rao, M. D. B. P. (2014). Comparison of analysis and design of regular and irregular configuration of multi-Story building in various seismic zones and various types of soils using ETABS and STAAD. Journal of Mechanical and Civil Engineering (IOSR-JMCE), 11, 490-495.

ISCODE

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[A]. IS 875 (part 1): 1987, Dead loads, “Code of practice for Design loads (other than earthquake) for buildings and structures”, Bureau of Indian Standards, New Delhi.
[B]. IS 875 (part 2): 1987, Live loads, “Code of practice for Design loads (other than earthquake) for buildings and structures”, Bureau of Indian Standards, New Delhi.
[C].IS 1893 (part 1): 2002, “Criteria for earthquake resistant design of structures”, Bureau of Indian Standards, New Delhi. IS 456:2000, “Code of practice for plain and reinforced concrete”, Bureau of Indian Standards, New Delhi.

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