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Seismic Analysis and Design of Multistorey (G+9) RCC Building Using Staad Pro

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Abstract

Reinforced Concrete Frames are the most commonly adopted buildings construction practices in India. With growing economy, urbanisation and unavailability of horizontal space increasing cost of land and need for agricultural land, high-rise sprawling structures have become highly preferable in Indian buildings scenario, especially in urban. 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 analyse the response of a high-rise structure to ground motion using Response Spectrum Analysis. On multistorey building in this project G+9 RCC building is analysed through response spectrum analysis using STAAD PRO software in medium soil of zone (v). The analysis results evaluated the dynamic response in terms of deflection, moment, and designing of the building corresponding to the resulted forces.

Keywords: seismic zones, deflection, moment, seismic loads.

1. Introduction

Earthquake has always been a threat to human civilization from the day of its existence, devastating human lives, property and man-made structures. The very recent earthquake that we faced in our neighbouring country Nepal has again shown nature's fury, causing such a massive destruction to the country and its people. And the most recent one which took place in turkey has taken the lives of over 50k people. It is such an unpredictable calamity that it is very necessary for survival to ensure the strength of the structures against seismic forces.

Therefore, there is continuous research work going on around the globe, revolving around development of new and better techniques that can be incorporated in structures for better seismic performance. Obviously, buildings designed with special techniques to resist damages during seismic activity have much higher cost of construction than normal buildings, but for safety against failures under seismic forces it is a prerequisite. 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. Reinforced Concrete frames are the most common construction practices in India, with increasing numbers of high-rise structures adding up to the landscape. There are many important Indian cities that fall in highly active seismic zones. Such high-rise structures, constructed especially in highly prone seismic zones, should be analysed and designed for ductility and should be designed with extra lateral stiffening system to improve their seismic performance and reduce damages. A building should possess four main attributes, mainly having simple and regular configuration, adequate lateral strength, stiffness and ductility. Buildings having simple regular geometry in plan as well as in elevation, suffer much less damage than the irregular configuration. These irregularities may cause problem in continuity of force flow and stress concentrations. Structural analysis is mainly concerned with finding out the behaviour of a structure when subjected to some action.

1.1 Importance of seismic analysis? this right here

The seismic analysis allows us to visualize the response of a bridge during the earthquake, which enables us to obtain the additional forces or deformations that would generate because of an earthquake. The forces can be of the following type:

1. Lateral loads applied by the earthquake
2. Vibration loads
3. Additional forces due to P-Delta effect
4. Non-linear behaviour of steel and concrete

1.2 Importance of seismic zoning.

Seismic zonation is useful for hazard reduction such as earthquake-resistant design of structures, risk analysis, land-use planning, etc. Many earthquake-prone countries developed seismic zonation maps. Seismic zonation map is usually revised or updated periodically with the progress in methodology and accumulation of new data.

India has been divided into four zones with respect to severity of earthquake zone factor (Z)

Seismic Zone	II	III	IV	V
Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

1.3 Objective of the project.

1. To perform the seismic analysis of multistorey (G + 9) Rcc building in medium soil in zone (V) using STAAD PRO.
2. To analyse the behaviour of the building due to different load combinations.
3. To design the building for the analysed behaviour using staad pro.
4. To ensure the safety of the building against seismicity.

1.4 Future scope of the project.

1. This work can be compared with an irregular structure by using ETAB software.
2. Also, can be done with another software and compare the results.
3. This work also can be performed on composite structures.

2. Methodology.

2.1 Properties of building and material.

Sr no.	Design data for the building	
I	Detail of building	
A	Type of building	Residential
B	Number of story	(G + 9)
C	Story height	
	Upper story	3m
	Lower story	3m
D	length	12m
E	width	16m
II	Material properties	
A	Grade of concrete	M30
B	Grade of steel	Fe 500
C	Density of reinforced concrete	$25KN/m^2$
D	Density of steel	$78.5\ KN/m^3$
III	Member properties	
A	Beam	
i	Grade	M30
ii	size	0.3m x 0.3m
B	column	
i	Grade	M30
ii	Size	0.35m x 0.35m
C	Slab	
i	Grade	M30
ii	thickness	125mm
IV	Seismic properties	
A	Seismic zone	5
i	Seismic factor	0.36
ii	Response reduction factor	5
iii	Damping factor	0.05
iv	Soil type	Medium

2.2 Loads

1. EX - EARTHQUAKE IN X DIRECTION

2. EZ - EARTHQUAKE IN Z DIRECTION

3. WX – WIND IN X DIRECTION

4. WZ – WIND IN Z DIRECTION

5. DL- DEAD LOAD

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6. LL – LIVE LOAD

2.3 Modelling.

The Staad pro software is used for modelling.

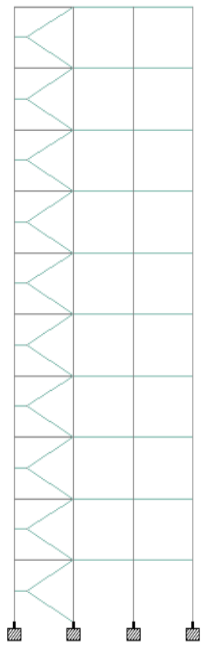


Figure 1

(Elevation of building)

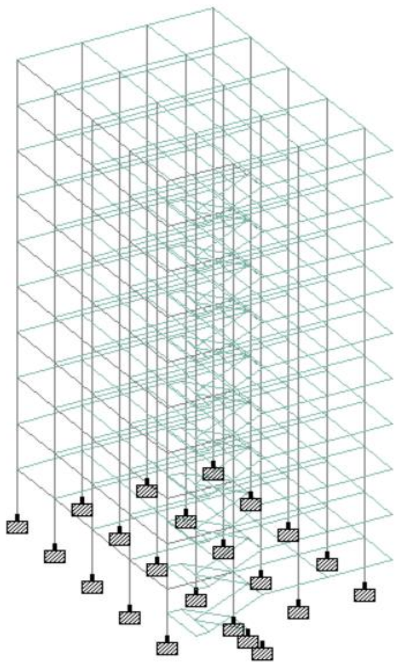


Figure2

3D view

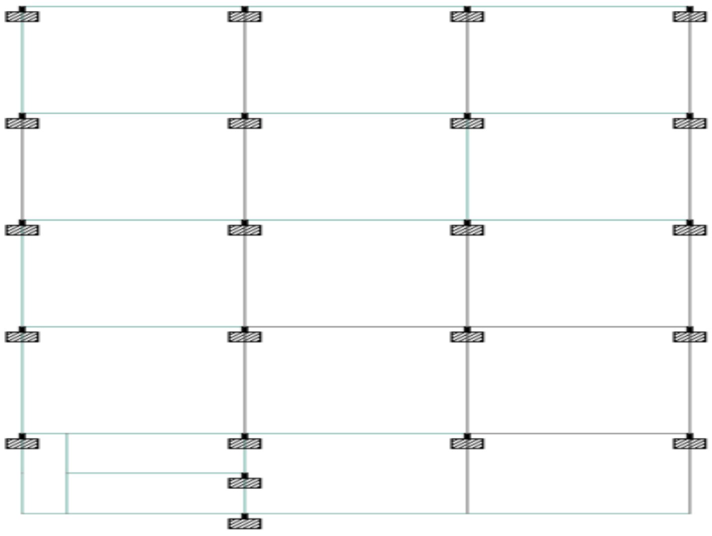
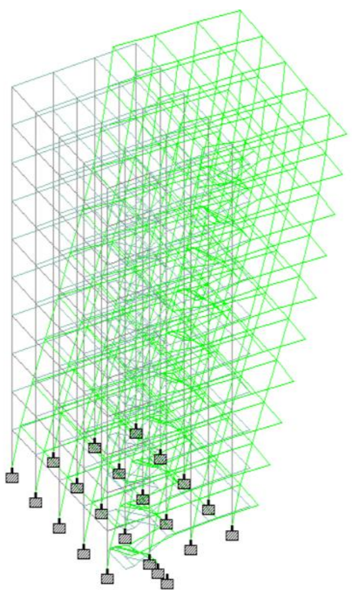


Figure 3 (top View)

3. Analysis and design.

3.1 The analysis and design is done by using STAAD PRO.



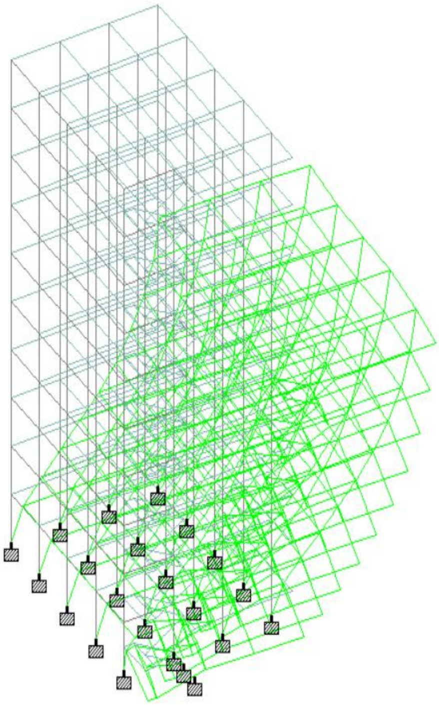


Figure 1

(Efect of earthquake in X direction)

Figure 2

(Efect of earthquake in Z direction)

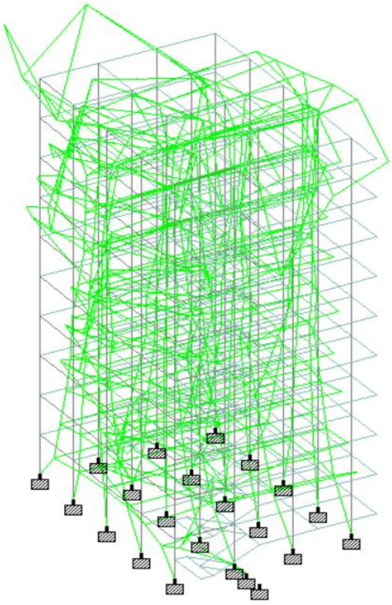


Figure 3 (Wind in Z direction)

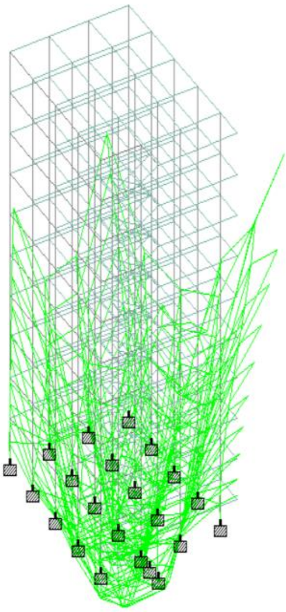


Figure 4 (Wind in X direction)

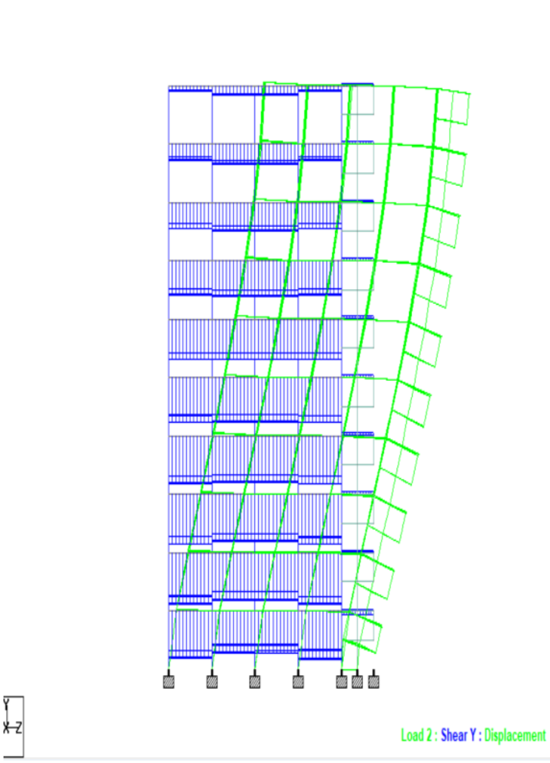


FIGURE 5

DISPLACEMENT DUE TO LIVE LOAD

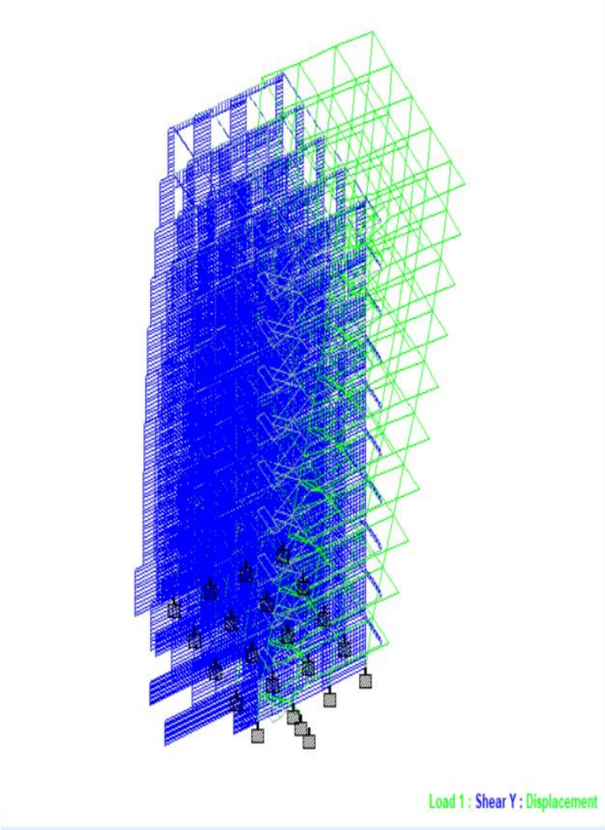


FIGURE 6

SHEAR FORCE IN X DIRECTION

BE G+9B - Beam Relative Displacement Detail:

All Relative Displacement | Max Relative Displacements

Beam	L/C	Length m	Max x mm	Dist m	Max y mm	Dist m	Max z mm	Dist m	Max mm	Dist m	Span/Max
1	1 EX	4.000	0.000	2.333	-0.723	1.000	-0.003	0.333	0.723	1.000	5529
	2 EZ	4.000	-0.000	3.000	0.048	2.333	0.002	0.250	0.048	2.333	>10000
	3 WX	4.000	-0.000	3.667	-0.001	0.667	0.002	0.250	0.002	1.000	>10000
	4 WZ	4.000	-0.000	3.667	0.000	0.333	-0.002	0.333	0.002	1.333	>10000
	5 DL	4.000	-0.000	3.000	-0.109	2.000	-0.002	0.750	0.109	2.000	>10000
	6 LL	4.000	-0.000	3.000	-0.213	2.000	-0.000	0.250	0.213	2.000	>10000
	7 GENERATE	4.000	-0.000	3.667	-0.483	2.000	-0.004	0.750	0.483	2.000	8275

TABLE NO.3

MAXIMUM RELATIVE DISPLACEMENT OF BEAM

BE G+9B - Node Displacements:

All | Summary

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	41	20 GENERAT	**90.048**	-1.160	8.989	90.503	0.001	-0.000	-0.001
Min X	44	26 GENERAT	**-88.505**	-0.080	5.760	88.692	0.000	0.000	0.001
Max Y	250	1 EX	22.356	**8.023**	-0.226	23.753	-0.001	0.002	0.000
Min Y	264	22 GENERAT	-55.470	**-32.433**	5.822	64.519	0.009	-0.005	0.000
Max Z	220	21 GENERAT	-2.208	-7.385	**106.916**	107.194	0.002	-0.000	0.001
Min Z	44	27 GENERAT	-0.849	-3.288	**-86.852**	86.919	-0.001	0.000	0.000
Max rX	246	22 GENERAT	-22.329	-27.226	2.512	35.300	**0.011**	0.002	0.002
Min rX	240	27 GENERAT	0.336	-0.445	-23.989	23.996	**-0.004**	-0.000	-0.000
Max rY	236	24 GENERAT	12.818	1.341	1.027	12.928	0.003	**0.003**	0.001
Min rY	236	22 GENERAT	-15.335	-28.638	-0.176	32.486	0.009	**-0.006**	-0.000
Max rZ	238	22 GENERAT	-15.213	-18.484	1.386	23.980	0.005	-0.001	**0.008**
Min rZ	238	24 GENERAT	9.895	4.130	0.316	10.727	0.002	-0.001	**-0.005**
Max Rs	313	21 GENERAT	-3.061	-21.535	106.916	**109.106**	0.006	-0.000	0.000

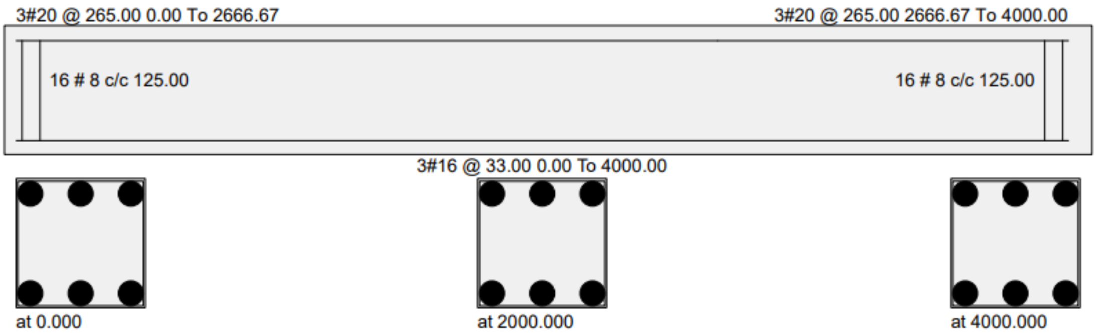
TABLE 4

SUMMARY OF NODE DISPLACEMENT

3.2 DESIGN

Beam no. 351

Design Code: IS-456



Design Load

Mz(Kn Met)	Dist.et	Load
50.790001	0.000000	25
-53.740002	0.000000	23
-52.450001	4.000000	21

Design Parameter

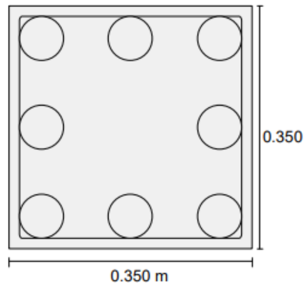
Fy(Mpa)	415.000000
Fc(Mpa)	30.000000
Depth(m)	0.300000
Width(m)	0.300000
Length(m)	4.000000

FIGURE NO.7

DESIGN OF BEAM NO.351

Beam no. 35

Design Code: IS-456



Design Load

Load	2
Location	End 1
Pu(Kns)	-191.039993
Mz(Kns-Mt)	5.020000
My(Kns-Mt)	34.990002

Design Results

Fy(Mpa)	415
Fc(Mpa)	30
As Reqd(mm²)	1372.000000
As (%)	1.313000
Bar Size	16
Bar No	8

FIGURE NO.08

DESIGN OF COLUMN

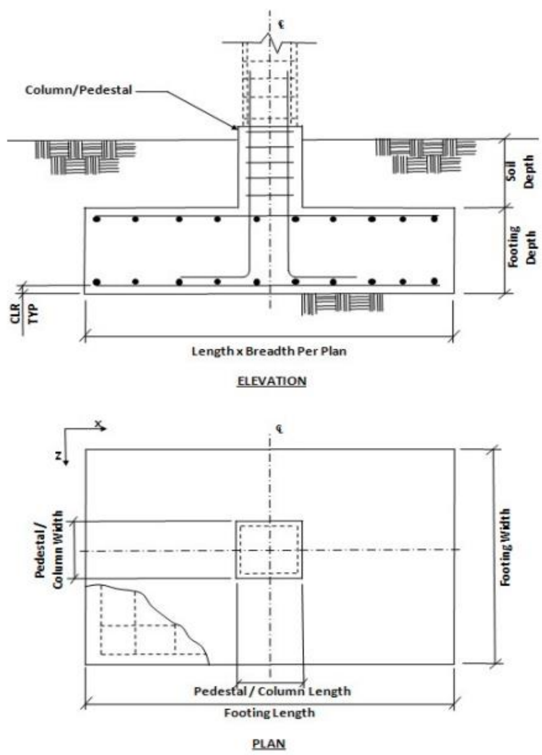


FIGURE NO.09

DESIGN OF FOOTING

4.Conclusion

In this project we put our small effort to analyse and design of multi story (G+ 9) RCC building of dimensions 12 mx12 m using staad Pro. Staad pro which is truly a versitile software has the capability to analyse and design any structure and save the most precious time which could have been taken by manual analysis and design. Through this software we calculated the enforcement needed for any concrete section to counteract the lateral deflections due to earthquake and also wind the forces. The design contains many parameters which are designing as per IS-1983-2002 and IS-456.

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