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Variation of Steel Percentage in Different Sesmic Zone Including Wind Effect VS Gravity Load

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ABSTRACT: *Apart from gravity loads, the structure will experience dominant lateral forces of considerable magnitude during earthquake shaking and wind force. It is essential to estimate & specify these lateral forces in order to design the safe and stable structure. It is highly impossible to prevent an earthquake occurring but the damage to the building can be controlled through proper design & detailing. This study mainly focuses on the comparison of percentage steel quantities when building is designed for gravity loads as per IS 456:2000 & when the building is designed for earthquake forces in different zone as per IS 1893:2002 along with wind load as per IS: 875 Part-3. A G+10 existing RCC framed unsymmetrical structure has been analyze and designed using Staad pro V8i. According to IS-875 the earthquake load exceed the wind load but in various foreign codes E.g. structural loads-2012 IBC and ASCE/SEI 7-10 etc we can consider both earthquake and wind load and such combinations is adopted practically in various tall structure analysis and design. E.g. Burj Al-Khalifa. According to IS-875 Part-III clause 0.3.1 earthquake load should be considered along with followings, dead load, imposed load, snow load, special load and load combination.*

I. INTRODUCTION

The work of a civil engineer especially in a seismic region is to provide maximum safety in the structures designed and constructed by him against the earthquake shocks at the acceptable economical costs. Apparently a simple statement but in actual practice it remains as yet most difficult and complicated task. During last five decades a lot of research and practical works has been done in this direction. Earthquake engineering has already come to be recognized as a well defined discipline among advance engineering fields requiring specialization.

Plainly speaking with the present state of knowledge, earthquake can never be predicted accurately. Hence to develop a system for forewarning & eliminating the risks of loss of life is yet a distant dream. Identifying potential hazards ahead of time and advance planning to save lives and significantly reduces injuries and property damage. Hence it is mandatory to do the seismic analysis & design structures against collapse. It is tempting to think that the risk of earthquake is concentrated only in areas of high seismicity but this reasoning does not hold. In region of low to moderate seismicity can be predominate risk as well. To analyze and design a RC structure by considering the combination of gravity load and seismic load is common. But for a tall structure there is always a risk due to wind load along with seismic and gravity load .In this project we consider wind load along with the combination of gravity loading and earthquake loading.

According to IS-875 the earthquake load exceed the wind load but in various foreign codes E.g. structural loads-2012 IBC and ASCE/SEI 7-10 etc we can consider both earthquake and wind load and such combinations is adopted practically in various tall structure analysis and design. E.g. Burj Al-Khalifa. According to IS-875 Part-III clause 0.3.1 page no. 3 earthquake load should be considered along with following dead load, imposed load, snow load, special load and load combination.

II. LITERATURE REVIEW

1. Kiran Kumar and G.papa Rao research on comparison of percentage steel and concrete quantities of a R.C building in different seismic zone (**IJRET**) **July 2013.**

In their paper they addresses the performance and variation of percentage steel and concrete quantities of RCC framed structure in different seismic zones and the study mainly focus on the comparison of percentage steel and concrete quantities when the building is design for gravity loads as per IS-456-2000 and when the building is design for earthquake forces in different seismic zones as per IS-1893-2002.

They Reaches To The Following Conclusions That: the variation of support reactions in exterior columns increasing from 11.59% to 41.71% and in edge columns increasing from 17.72% to 63.7% in seismic zones II to V. however the variation of support reactions are very small in interior columns.

The variation of percentage of steel at support section in external beams is 0.54% to 1.23% and in internal beams is 0.78% to 1.4% in the external and internal beams the percentage of bottom middle reinforcement is almost the same for both earthquake and non earthquake design.

2. T. Anusha, S.V. Narsi Reddy & T. Sandeep research on earthquake resistance design-impact on cost of reinforced concrete buildings (**IJMER**) **June 2014.**

In their research paper the study mainly focus on the comparison of percentage steel and quantities when the building is designed for gravity loads as per IS-456-2000 and when the building is designed for earthquake forces in different zones as per IS-456-2000.A 5storied RCC framed structure has been analyzed and designed using STADD-Pro V8i.Ductile detailing has been done in conformation with IS-1392-0.

They reach to the following conclusion that: The percentage variation of cost for the whole structure, between gravity load and seismic zones II, III, IV &V varies as 2.53, 3.33, 7.17 & 14.59 respectively.
The volume of concrete in exterior and edge column footings in seismic zones III, IV, V, due to increase of support reactions with the effect of lateral forces however the variation is very small in interior column footings.

3. Sunayana Varma, A. Malar, S. Thenmozhi, T. suriya, G. Murali, B. Vengopal, K. Karthikeyan research on the comparative study of seismic base shear of reinforced concrete framed structure in different seismic zone **(IJST) august 2014.**

In their research paper the study mainly focus on the comparison between the base shear of RC frame located at various zones. For this purpose four building models are developed. The base shear for the four models was calculated manually as well as using STADD Pro and E-Tabs software package and was compared with each other.
They reach to the following conclusion that: The base shear is high in E-Tabs when compare to STAAD Pro and manual calculation, were as a less difference was observed between the STAAD Pro and manual calculation. It is suggested that the STAAD Pro software package is more reliable than E-Tabs.
4. B. Suresh, P.M.B Raj Kiran Nanduri research on the earthquake analysis and design VS non earthquake analysis and design using STAAD Pro **(IJAET) December 2012.**

In their research paper the study mainly focus on the opinion that designing new buildings to be earthquake resistance will cause substantial additional cost among the constructional professionals. In a Swiss survey estimates between 3 and 17% on the total building were given.

They reach to the following conclusion that: The opinion of substantial additional cost in designing a earthquake resistance building is un founded.
In a country of a moderate seismicity adequate seismic resistance of new buildings may achieved at no significant additional cost.

5. Karunakar Perla research on earthquake resistant designed-impact on cost of reinforced concrete buildings **(IJESIT) November 2014.**

In their research paper the study mainly focus on the necessity of seismic analysis and design to a structure against collapse. The study addresses the performance and variation of percentage steel and concrete quantity of RC framed structure in different seismic zones and influence on overall cost of construction.

They reach to the following conclusion that: The percentage increase of steel for the whole structure with ductile detailing compare to non ductile detailing is 16%.
The percentage increase in cost for the whole structure with ductile detailing compare to non ductile detailing is 4.06%.

III. OBJECTIVES

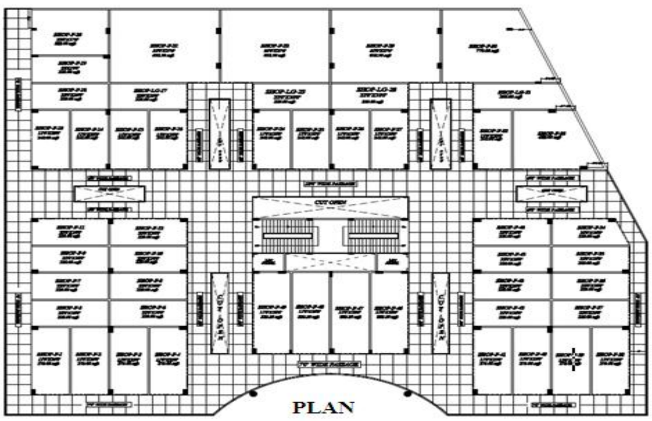
- To analyze and design an unsymmetrical R C structure by considering combination loads (i.e. Earthquake load and Wind load).
- To compare the results with a R C unsymmetrical structure analyze and design for gravity loading.
- To compare the variation of steel percentage in different seismic zone including wind effect vs. gravity load.

IV. METHODOLOGY

Preliminary Data Of The Structure Considered For Analysis And Design

TYPE OF THE STRUCTURE	RCC FRAMED STRUCTURE
NUMBER OF STORIES	G+10
FLOOR TO FLOOR HEIGHT	3m
PLINTH HEIGHT	1.2m
WALL THICKNESS	0.2m & 0.3m
GRADE OF CONCRETE	M40
GRADE OF STEEL	Fe500
EARTHQUAKE LOAD	AS PER IS:1893:2002
SLAB THICKNESS	0.15m
SIZE OF BEAM	0.375mX0.6m & 0.3mX0.5m
SIZE OF THE COLUMN	0.6mx0.8m & 0.6mx1m
SBC OF SOIL	300Kn/m^2
TYPE OF SOIL	HARD ROCKY SOIL
WIND LOAD	AS PER IS:875 PART-III
LIVE LOAD	5Kn/m^2
FLOOR FINISHES	1Kn/m^2
TYPE OF WALL	BRICK MASONRY
SOFTWARE USED FOR DESIGN & ANALYSIS	STAAD.Pro V8i

PLAN



Basic Load Cases

Number	Name
1	EQ IN X+VE
2	EQ IN X-VE
3	EQ N Z+VE
4	EQ IN Z-VE
5	DL
6	LL
7	WIND IN X+VE
8	WIND IN X-VE
9	WIND IN Z+VE
10	WIND IN Z-VE

Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
101	1.5(DL+LL)	5	DL	1.50
		6	LL	1.50
102	1.2(DL+LL+EQ X+VE)	5	DL	1.20
		6	LL	1.20
		1	EQ IN X+VE	1.20
103	1.2(DL+LL+EQ X-VE)	5	DL	1.20
		6	LL	1.20
		2	EQ IN X-VE	1.20
104	1.2(DL+LL+EQ Z+VE)	5	DL	1.20
		6	LL	1.20
		3	EQ N Z+VE	1.20
105	1.2(DL+LL+EQ Z-VE)	5	DL	1.20
		6	LL	1.20
		4	EQ IN Z-VE	1.20
106	1.5(DL+EQ X+VE)	5	DL	1.50
		1	EQ IN X+VE	1.50
107	1.5(DL+EQ X-VE)	5	DL	1.50
		2	EQ IN X-VE	1.50
108	1.5(DL+EQ Z+VE)	5	DL	1.50
		3	EQ N Z+VE	1.50
109	1.5(DL+EQ Z-VE)	5	DL	1.50
		4	EQ IN Z-VE	1.50
110	0.9DL+1.5EQ X+VE	5	DL	0.90
		1	EQ IN X+VE	1.50
111	0.9DL+1.5EQ X-VE	5	DL	0.90
		2	EQ IN X-VE	1.50
112	0.9DL+1.5EQ Z+VE	5	DL	0.90
		3	EQ N Z+VE	1.50
113	0.9DL+1.5EQ Z-VE	5	DL	0.90

Combination Load Cases Cont...

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
		4	EQ IN Z-VE	1.50
114	1.2(DL+LL+WIND IN X+VE)	5	DL	1.20
		6	LL	1.20
		7	WIND IN X+VE	1.20
115	1.2(DL+LL+WIND IN X-VE)	5	DL	1.20
		6	LL	1.20
		8	WIND IN X-VE	1.20
116	1.2(DL+LL+WIND IN Z+VE)	5	DL	1.20
		6	LL	1.20
		9	WIND IN Z+VE	1.20
117	1.2(DL+LL+WIND IN Z-VE)	5	DL	1.20
		6	LL	1.20
		10	WIND IN Z-VE	1.20
118	1.5(DL+WIND IN X+VE)	5	DL	1.50
		7	WIND IN X+VE	1.50
119	1.5(DL+WIND IN X-VE)	5	DL	1.50
		8	WIND IN X-VE	1.50
120	1.5(DL+WIND IN Z+VE)	5	DL	1.50
		9	WIND IN Z+VE	1.50
121	1.5(DL+WIND IN Z-VE)	5	DL	1.50
		10	WIND IN Z-VE	1.50
122	0.9DL+1.5WIND IN X+VE	5	DL	0.90
		7	WIND IN X+VE	1.50
123	0.9DL+1.5WIND IN X-VE	5	DL	0.90
		8	WIND IN X-VE	1.50
124	0.9DL+1.5WIND IN Z+VE	5	DL	0.90
		9	WIND IN Z+VE	1.50
125	0.9DL+1.5WIND IN Z-VE	5	DL	0.90
		10	WIND IN Z-VE	1.50
126	1(D+L)	5	DL	1.00
		6	LL	1.00

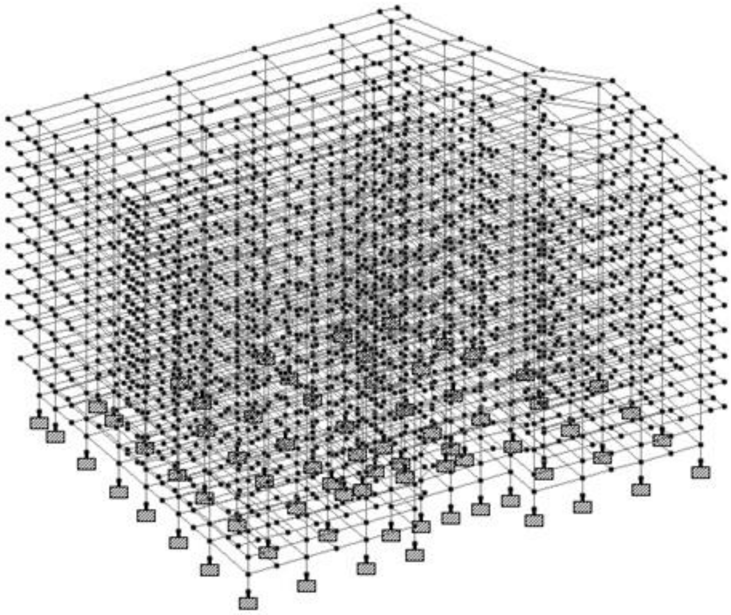


Figure Specifying Model with Nodes

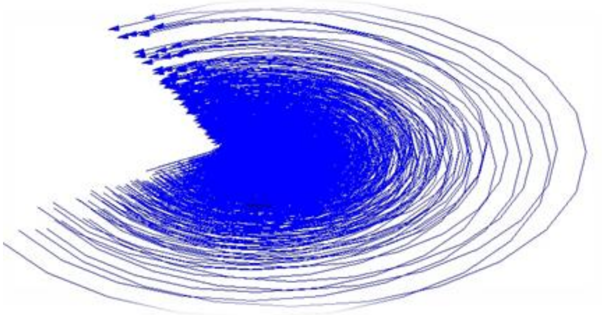


Figure Earthquake Load in X –ve,

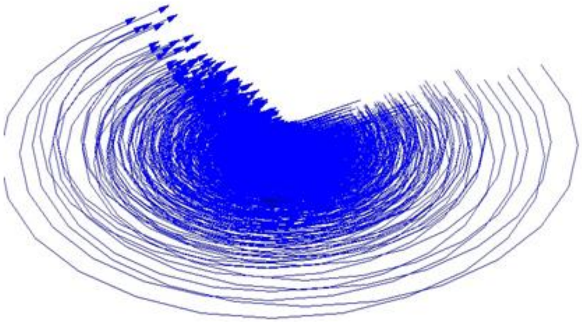


Figure Earthquake Load in X +ve

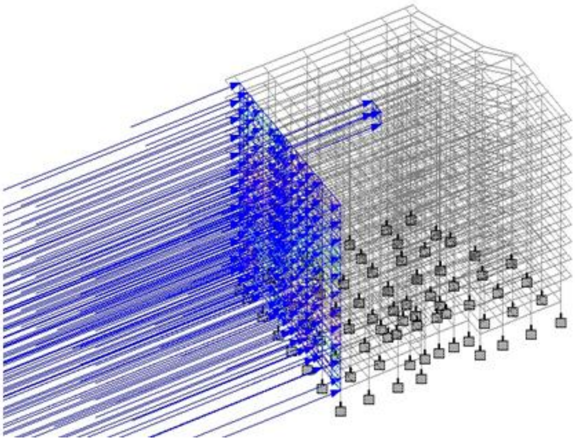


Figure Wind Load in X +ve,

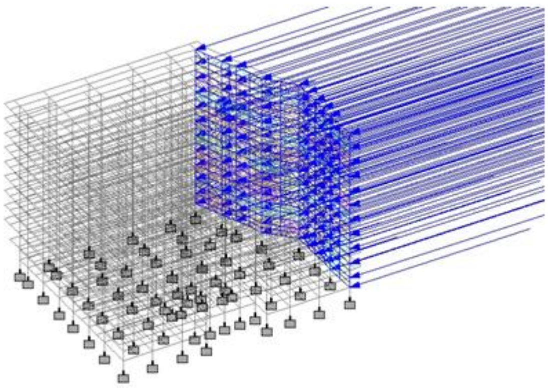
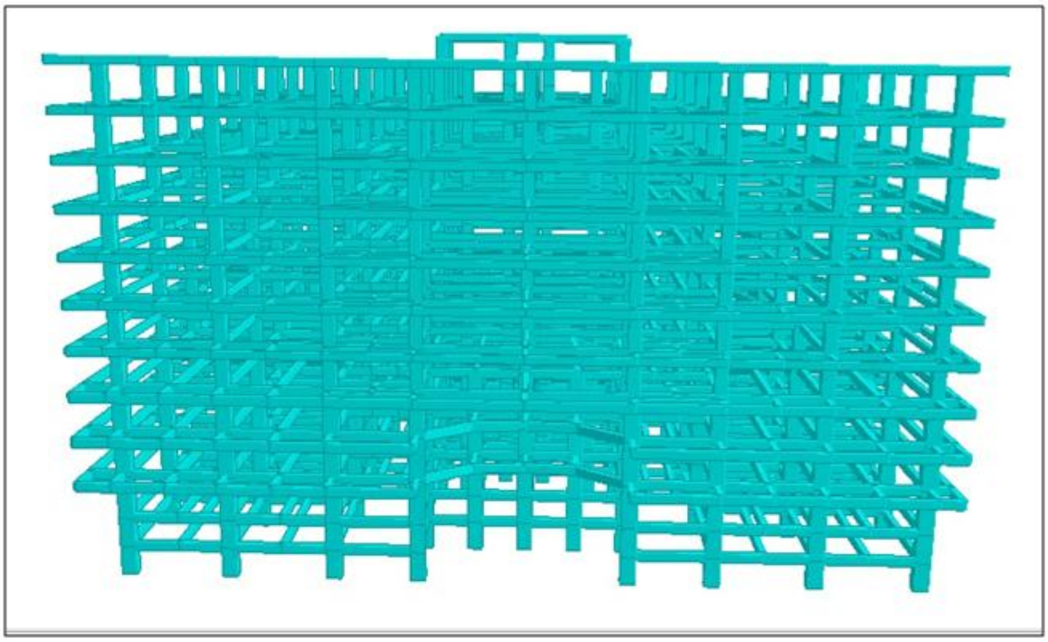


Figure Wind Load in X -ve



3D MODEL

V. RESULTS

Comparison Of Steel For Columns In Different Seismic Zones Including Wind Effect:

Note: for the comparison purpose at each location, the cross-sectional dimensional of Columns was kept same in all the zones.

	Area of Steel in mm²					% Difference between Gravity Load Vs Seismic + Wind			
Particular	Gravity Load	Seismic Zone-II + WL	Seismic Zone-III + WL	Seismic Zone-IV + WL	Seismic Zone-V + WL	Seismic Zone-II + WL	Seismic Zone-III + WL	Seismic Zone-IV + WL	Seismic Zone-V + WL
Columns	2263824	2308770	2398905	2641635	3292461	1.985	5.966	16.689	45.438

Comparison Of Steel For Beams In Different Seismic Zones Including Wind Effect:

Note: For the comparison purpose at each location, the cross-sectional dimensional of Beams was kept same in all the zones.

	Area of Steel in mm²					% Difference between Gravity Load Vs Seismic + Wind			
Particular	Gravity Load	Seismic Zone-II + WL	Seismic Zone-III + WL	Seismic Zone-IV + WL	Seismic Zone-V + WL	Seismic Zone-II + WL	Seismic Zone-III + WL	Seismic Zone-IV + WL	Seismic Zone-V + WL
Beams	4463736.84	6031049.04	6430404.33	7012160.19	8743006.08	35.112	44.058	57.091	95.867

VI. CONCLUSION

The following conclusion can be made based on the analysis and design of a commercial building (G+10) design for gravity loads and earthquake forces in all zones including wind load.

1. The variation of percentage steel in columns with maximum load is 1.985% to 45.438%.
2. The variations of percentage steel in beams of basement floor is 35.112% to 95.867%.
3. The variation of percentage steel is greater in beams compare to columns for different seismic zone including wind load.
4. The variation of percentage steel in an unsymmetrical structure is greater compare to a symmetrical structure.
5. As the height of building increases, support reaction is also increases, therefore increase in variation of steel compare to small structure.
6. As the grade of concrete increases the required area of steel decreased.
7. The steel percentage in exterior and edge column is more compare to interior columns.
8. The steel percentage in external beams is less compare to internal beams.

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