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A Study on Comparison of Percentage Steel and Concrete Quantities of A R.C Irregular Building in Different Seismic Zones

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Abstract - *One of the devastating hazards on the earth is earthquake, which causes damage to all forms of life. It is impossible to stop earthquake but loss or damage to the structure can be minimized through proper design and detailing. The main objectives of present study were to study the performance and variation in steel percentage and quantities concrete in R.C framed irregular building in gravity load and different seismic zones. And to know the comparison of steel reinforcement percentage and quantities of concrete when the building is designed as per IS 456:2000 for gravity loads and when the building is designed as per IS 1893(Part 1):2002for earthquake forces in different seismic zones. In this present study five (G+4) models were considered. All the four models were modeled and analyzed for gravity loads and earthquake forces in different seismic zones. ETABS software was used for the analysis of the models. After analysis the results of support reactions, volume of concrete and weight of steel reinforcement in footings, steel reinforcement percentage in beams and columns were tabulated.*

***Key Words*: Earthquakes, Reinforcement, seismic zones E-Tabs, Static Lateral Force Method (ESLM) and Response Spectrum Method (RSM)**

1.INTRODUCTION

A noticeable movement of the surface of the earth is known as earthquake. They are the result of an unexpected sudden release of enormous amount of energy in the earth's crust which in turn generates seismic waves. India is divided into 4 seismic zones according to the Indian earthquake zoning map. The four seismic zones are zone II, III, IV & V in which zone II has lowest level of seismicity and zone V has highest level of seismicity.

No structures will completely resist seismic forces without damage. Most of the structures will undergo minor or major damage due to earthquake. The damage to the structure may be minor if the magnitude of the earthquake is small, whereas structure may collapse if the magnitude of the earthquake is very high. Thus in recent days every structure is designed for earthquake resistance. The main objectives of present study is to study the performance and variation in steel percentage and quantities of concrete in R.C framed irregular building under gravity load and in different seismic zones. And to know the comparison of steel reinforcement percentage and quantities of concrete when building is designed as per IS 456:2000 for gravity loads and when the building is designed as per IS 1893 (Part 1):2002 for earthquake forces in different seismic zones.

2.METHODOLOGY

In this present work, the methods used for the analysis of building are Equivalent Static Lateral Force Method (ESLM) and Response Spectrum Method (RSM). Most codes in practice permits the analysis by equivalent linear static methods for simple, regular and low to medium height buildings as often sufficient. Regular, low to medium height buildings can also be designed using equivalent static analysis. Response spectrum analysis is required for tall buildings or those buildings with significant irregularities in plan or elevation.

This work is carried out to study the performance and variations in steel percentage and quantities of concrete in R.C framed irregular building in gravity load and different seismic zones. Also to know the comparison of steel rebar percentage and quantities of concrete when building is designed by using IS 456:2000 for gravity loads and when building is designed by using IS 1893 (Part 1):2002 for earthquake forces in seismic zones II to V. Totally 5 models were considered. One of the models was analyzed by equivalent static force method and the remaining 4 models were analyzed by response spectrum method in different seismic zones.

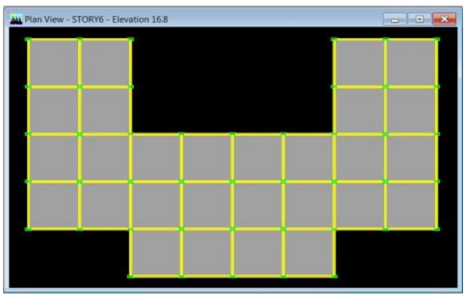

Fig 3.2: Plan of the building

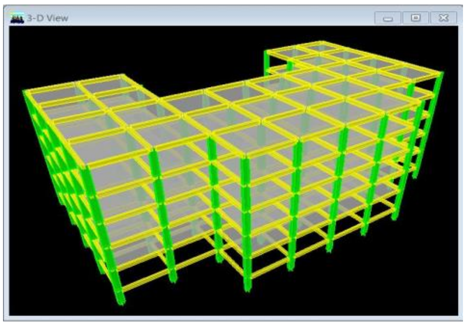

Fig 3.3: 3D view of the building

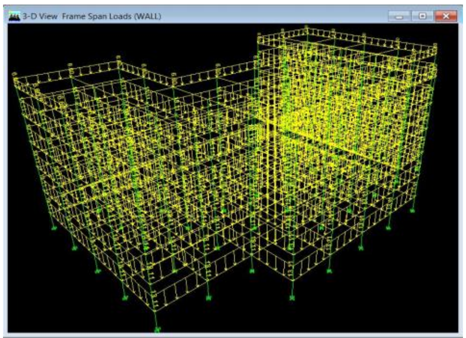

Fig 3.4: Vertical loading on the structure

2.1 PRELIMINARY DATA OF THE STRUCTURE

Type of structure	RC Framed structure (SMRF)
Total number of stories	G+4
Floor to floor height	3 m
Height of plinth	1.8 m
Wall thickness	230 mm
Grade of concrete for footings and column	M 25
Grade of concrete for beams and slabs	M 20
Grade of steel	Fe 415
Earthquake loads considered	As per IS1893 (Part 1) : 2002
Dimension of the columns	0.3m X 0.6m and 0.45m X 0.6m
Dimension of the beam	0.23m X 0.45m
Thickness of slab	0.15m
SBC of soil considered	230kN/m^2
Soil Type	Hard rocky soil
Seismic zones considered	II,III,IV,V
Type of wall	Brick masonry

2.2 LOADING DETAILS

2.2.1 Dead load(DL)

Default values taken by ETABS

2.2.2 Live load(LL)

1. On terrace floor – 2.5 kN/m^2
2. On other floors – 3 kN/m^2

2.2.3 Floor finishes/Super imposed(SI)

1. On terrace floor – 2 kN/m^2
2. On Other floor – 1.5 kN/m^2

2.2.4 Response spectrum analysis

1. Damping – 5%
2. Important factor (I) – 1.5
3. Response reduction factor(R)– 5.0
4. Scale Factor –(I*g)/ (2*R)
=(1.5X9.81)/(2X5)
=1.4715

2.3 LOAD COMBINATIONS

1.5(DL+LL+RS) is taken as the load combination for the analysis of the models.

3 RESULTS

Support reactions: Support reactions exert a major influence in design of footings. In the present study, the variations in gravity load and in zone II, zone III, zone IV and zone V in edge columns are 2.98%, 4.76%, 7.51% and 14.53% respectively. The variations in exterior columns are 6.05%, 9.81%, 14.99% and 31.10% in gravity load and in zone II, zone III, zone IV and zone V respectively. The variations in interior columns are less.

Table-1: Support reactions in gravity load and different seismic zones

SUPPORT REACTIONS IN TON					
LOCATION OF THE COLUMNS	GRAVITY LOAD (GL)	SEISMIC ZONE			
		II	III	IV	V
EDGE COLUMNS	188.73	194.35	197.72	202.91	216.15
EXTERIOR COLUMNS	117.97	125.11	129.54	135.66	154.66
INTERIOR COLUMNS	304.20	304.62	304.88	305.22	306.26

Table-2: Percentage difference in support reactions in gravity load with different seismic zones

PERCENTAGE DIFFERENCE				
LOCATION OF THE COLUMNS	GL & SEISMIC ZONE II	GL & SEISMIC ZONE III	GL & SEISMIC ZONE IV	GL & SEISMIC ZONE V
EDGE COLUMNS	2.98%	4.76%	7.51%	14.53%
EXTERIOR COLUMNS	6.05%	9.81%	14.99%	31.10
INTERIOR COLUMNS	0.14%	0.22%	0.34%	0.68%

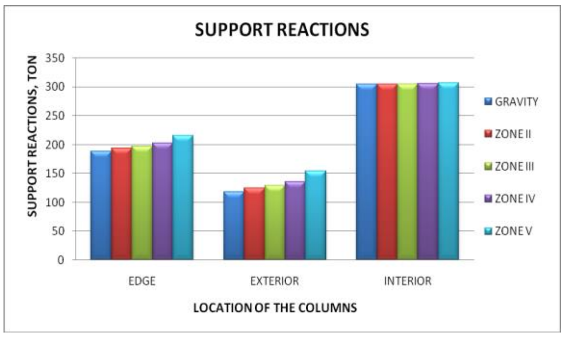

Chart-1: Graphical representation showing variations of support reactions in different seismic zones

Volume of concrete in footings: The variations of volume of concrete in footings in gravity load and in zone II, zone III, zone IV and zone V in edge columns are 2.38%, 5.06%, 8.63% and 23.51% respectively. The variations in exterior columns are 6.33%, 23.42%, 28.48% and 60.13% in gravity load and in zone II, zone III, zone IV and zone V respectively. The variations in interior columns are less.

Table-3: Volume of concrete in footings in gravity load and different seismic zones

VOLUME OF CONCRETE IN FOOTINGS, m^3					
LOCATION OF THE COLUMNS	GRAVITY LOAD (GL)	SEISMIC ZONE			
		II	III	IV	V
EDGE COLUMN FOOTING	3.36	3.44	3.53	3.65	4.15
EXTERIOR COLUMN FOOTING	1.58	1.68	1.95	2.03	2.53
INTERIOR COLUMN FOOTING	6.23	6.23	6.23	6.72	6.77

Table-4: Percentage difference in volume of concrete in footings in gravity load with different seismic zones

PERCENTAGE DIFFERENCE				
LOCATION OF THE COLUMNS	GL & SEISMIC ZONE II	GL & SEISMIC ZONE III	GL & SEISMIC ZONE IV	GL & SEISMIC ZONE V
EDGE COLUMN FOOTING	2.38%	5.06%	8.63%	23.51%
EXTERIOR COLUMN FOOTING	6.33%	23.42%	28.48%	60.13%
INTERIOR COLUMN FOOTING	0	0	7.87%	8.67%

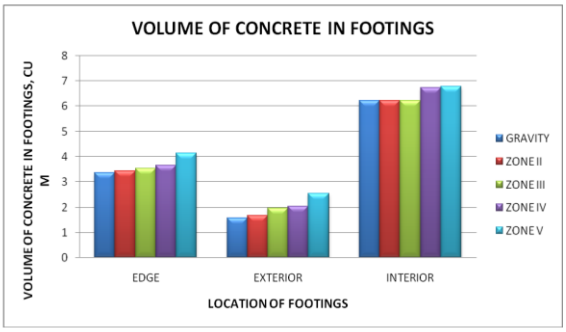

Chart-2: Graphical representation showing variations of volume of concrete in footings in different seismic zones

Weight of steel reinforcement in footings: The variations of weight of steel reinforcement in footings in gravity load and in zone II, zone III, zone IV and zone V in edge columns are 6.63%, 7.74%, 14.94% and 20.33% respectively. The variations in exterior columns are 5.60%, 17.56%, 22.63% and 46.98% in gravity load and in zone II, zone III, zone IV and zone V respectively. The variations in interior columns are less.

Table-5: Weight of steel reinforcement in footings in different seismic zones

WEIGHT OF STEEL REINFORCEMENT IN FOOTINGS, KG					
LOCATION OF THE COLUMNS	GRAVITY LOAD (GL)	SEISMIC ZONE			
		II	III	IV	V
EDGE COLUMN FOOTING	91.95	98.05	99.07	105.69	110.64
EXTERIOR COLUMN FOOTING	45.74	48.30	53.77	56.09	67.23
INTERIOR COLUMN FOOTING	192.54	192.54	192.54	193.09	193.64

Table-6: Percentage difference in weight of steel reinforcement in footings in gravity load with different seismic zones

PERCENTAGE DIFFERENCE				
LOCATION OF THE COLUMNS	GL & SEISMIC ZONE II	GL & SEISMIC ZONE III	GL & SEISMIC ZONE IV	GL & SEISMIC ZONE V
EDGE COLUMN FOOTING	6.63%	7.74%	14.94%	20.33%
EXTERIOR COLUMN FOOTING	5.60%	17.56%	22.63%	46.98%
INTERIOR COLUMN FOOTING	0	0	0.29%	0.57%

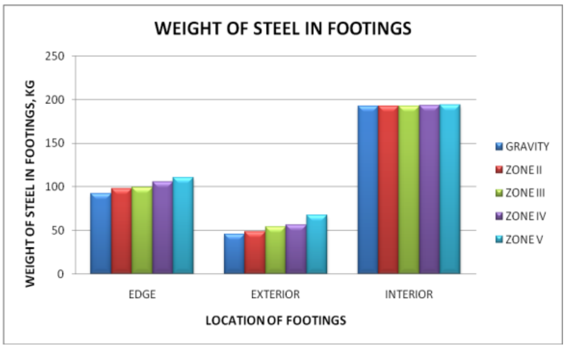

Chart-3: Graphical representation showing variations of weight of steel in footings in different seismic zones

Steel reinforcement percentage in columns: The variations of steel reinforcement percentage in columns in gravity load and in zone II, zone III, zone IV and zone V in edge columns are 0.80%, 0.84%, 1.15%, 1.80% and 3.68% respectively. In exterior columns, in gravity load, seismic zones II and III %age of steel reinforcement in columns is 0.80% whereas in seismic zones IV and V, the variations are 1.08% and 3.01%, respectively. The variations in interior columns in gravity load and seismic zones II is 0.80%, whereas in zone III, zone IV and zone V are 1.23%, 1.83% and 3.87%, respectively.

Table-7: Steel reinforcement percentage in columns in different seismic zones

STEEL REINFORCEMENT PERCENTAGE IN COLUMNS					
LOCATION OF THE COLUMNS	GRAVITY LOAD (GL)	SEISMIC ZONE			
		II	III	IV	V
EDGE COLUMNS	0.80	0.84	1.15	1.80	3.68
EXTERIOR COLUMNS	0.80	0.80	0.80	1.08	3.01
INTERIOR COLUMNS	0.80	0.80	1.23	1.83	3.87

Note: The cross sectional dimension of columns at each location was kept same in all gravity and seismic zones for comparison purpose.

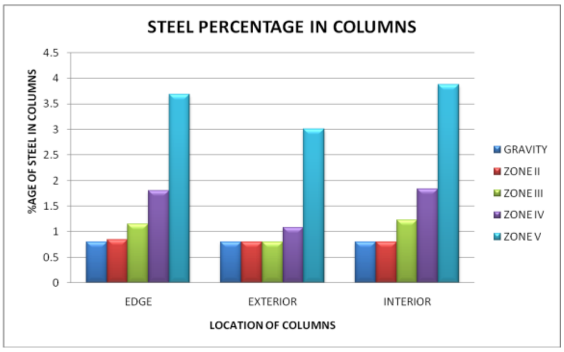

Chart-4: Graphical representation showing variations of steel percentage in columns in different seismic zones

Steel reinforcement percentage in beams: The variations of steel reinforcement percentage in beams in gravity load and in zone II, zone III, zone IV and zone V in external beams are 0.57%, 0.84%, 0.99%, 1.17% and 1.64% respectively. The variations in internal beams are 0.87%, 1.10%, 1.23%, 1.41% and 1.96% in gravity load and in zone II, zone III, zone IV and zone V respectively.

Table-8: Steel reinforcement percentage in beams in different seismic zones

PERCENTAGE OF STEEL REINFORCEMENT IN BEAMS					
LOCATION OF THE BEAMS	GRAVITY LOAD (GL)	SEISMIC ZONE			
		II	III	IV	V
EXTERNAL BEAMS	0.57	0.84	0.99	1.17	1.64
INTERNAL BEAMS	0.87	1.10	1.23	1.41	1.96

Note: The cross section dimension of the beams at each location was kept same in all gravity and seismic zones for comparison purpose.

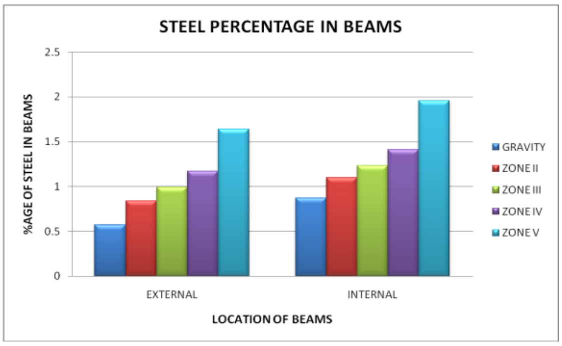

Chart-5: Graphical representation showing variations of steel percentage in beams in different seismic zones

3 CONCLUSIONS

From the obtained results of R.C irregular building the following conclusions can be drawn:

1) From the above it can be inferred that support reactions tended to increase as the zone varied from II to V which in turn increased volume of concrete and weight of steel reinforcement in footings.
2) In the case of footings in the interior portions the variations are comparatively lesser through zones II to V.
3) In the case of columns variations are drastically higher through zones II to V whether they were interior or exterior.
4) In case of beams, percentage of steel reinforcement increased through zones II to V.

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