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Study of Variation in Reinforcement of L Shaped RC Building for Various Seismic Zones in India

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Abstract—Most of the Indian land is insecure because of the vibrations caused by the earthquakes. The damages due to earthquake can be controlled by means of effective seismic designs. The design can be done by considering various limit states specified by the codes and applying the economical ones. The structure can be designed as semi elastic and it is economical rather than elastic because designing of structure for total elastic in response is very uneconomical. The study mainly focuses on determination of variation in reinforcement percentages of an irregular building in various seismic zones in India. The current IS code for seismic design i.e.IS 1893-2002 (part1) suggest that maximum amount of reinforcement shall be provided for higher seismic zones. But it doesn't provide clear information, how much percentage of reinforcement can be used for various seismic zones. In this work it was the attempt made to find the percentage required for various seismic zones. For the study an L shaped building plan is used with 9 storeys and analysed and designed by using STAAD Pro.

Index Terms— Dynamic Analaysis, Earthquake, Economy, Effective Seismic Design, Plan irregularity, Reinforcement, Seismic Zones.

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1 Introduction

RECENTLY several earthquakes have caused severe damages in structures all over world. Earthquakes are most unpredictable and devastating of all natural disasters, which are very difficult to save over engineering properties and life, against it. To protect structures from significant damage, the zone factor of building is an important topic in structural engineering. There are several guide lines all over the world which has been repeatedly updating on this topic. The analysis procedure quantifying the earthquake forces and its demad depending on the performane and cost, the method of analyzing the structure varies from linear to nonlinear. The behavior of a building during an earthquake depends on several factors, stiffness, and adequate lateral strength, and ductility, simple and reular configurations. The buildings with regular geometry and uniformly distributed mass and stiffness in plan as well as in elevationsuffer much less damage compared to irregular configurations. But nowadays need and demand of the latest generation and growing population has made the architects or engineers inevitable towards planning of irregular configurations.

In this paper a nine storey building is modelled in STAAD Pro. In this building component like beam, column and footing are amalysed & designed in various zones. All the beams and columns properties are kept same and the building is irregular. The structure is analysed and designed as per IS-456-2000. In this model the earthquake forces are automatically generated.

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2 Objective of work

- To find out the change of steel in beam at different level in different seismic zones in India.
- To find out change of steel in column at Different level and different Seismic Zones.

3 Geometric definition

A nine storey building for a commercial complex as shown in Figure 1. Design of building is done by seismic loads as perIS 1893 (PART I): 2002.

TABLE 1
DESIGN DATA

Type of structure	Ordinary moment resisting RC frame
Grade of concrete	M 40 (Fck =40 N/mm^2)
Grade of reinforcing steel	Fe 415 (Fy =415 N/mm^2)
Plan area	832m^2
Number of stories	G +9
Floor height	3.5m
Column size	600 x 600mm
Beam size	300 x 450mm
Slab thickness	150mm
Wall thickness	230mm
Density of concrete	25N/mm^3
Live load on floors and roof	3 KN/m^2 and 1.5 KN/m^2

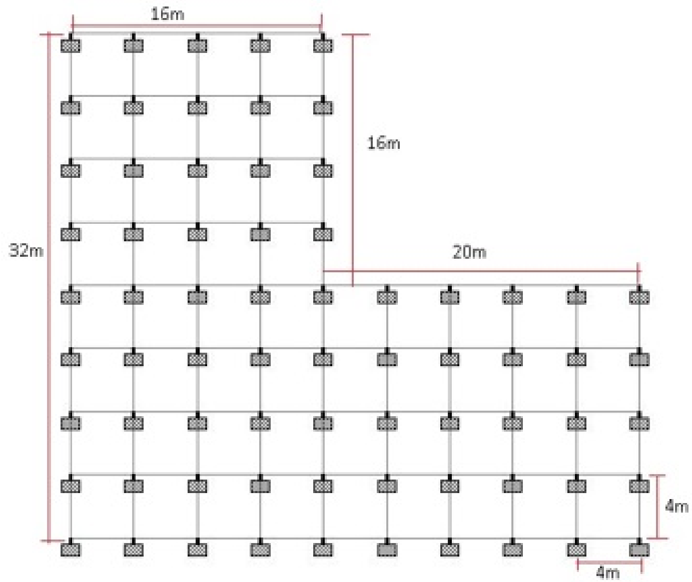

Fig. 1. Plan of L shaped Building

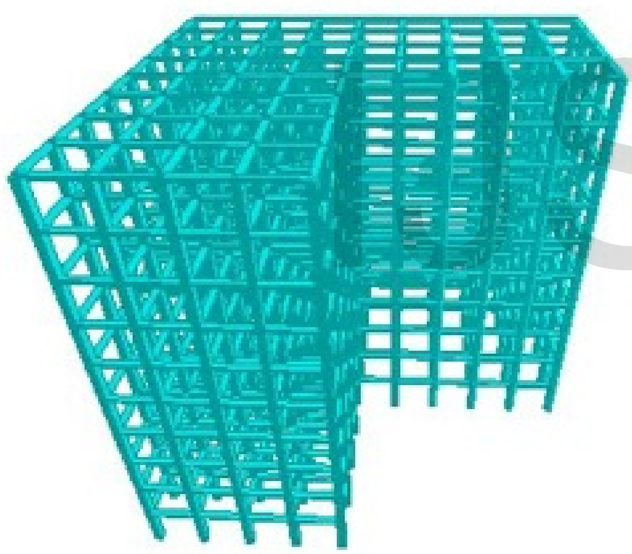

Fig. 2. General layout of the building

4 LOAD CALCULATION

The following load combinations are used in seismc analysis, as mentioned in the code IS 1893 (Part 1): 2002, Clause No. 6.3.1.2

1. 1.5 (DL+LL)
2. 1.2(DL+LL+EQX)
3. 1.2(DL+LL-EQX)
4. 1.2(DL+LL+EQZ)
5. 1.2(DL+LL-EQZ)
6. 1.5(DL+EQX)
7. 1.5(DL-EQX)
8. 1.5(DL+EQZ)
9. 1.5(DL-EQZ)
10. 0.9(DL+1.5EQX)
11. 0.9(DL-1.5EQX)
12. 0.9(DL+1.5EQZ)
13. 0.9(DL-1.5EQZ)

Earthquake load was considered in +X, -X, +Z and –Z directions. Thus a total of 13 load combinations are taken for analysis. Since large amount of data is difficult to handle manually, all load combinations are analysed using software STAAD Pro.

5 COMPARISON OF BEAMS AT DIFFERENT LEVELS AND DIFFERENT ZONES

5.1 Comparison of beam at different levels in zone II

In this case Design of some selected beams using envelop of load combination, show the various floor levels of beam design result and variation in perentage of reinforcement.

TABLE 2
COMPARISON OF BEAMS AT DIFFERENT LEVEL IN ZONE II

		LEFT JOINT	MID POINT	RIGHT POINT	TOTAL	CHANGE AT DIFF: FLOOR W.R.T TOP FLOOR (%)
9 TH FLOOR	TOP	314.16	314.16	314.16	942.48	
	BOTTOM	314.16	314.16	314.16	942.48	
		628.32	**628.32**	**628.32**	**1884.96**	**0**
8 TH FLOOR	TOP	339.29	339.29	339.29	1017.87	
	BOTTOM	314.16	314.16	314.16	942.48	
		653.45	**653.45**	**653.45**	**1960.35**	**3.99**
7 TH FLOOR	TOP	339.29	339.29	339.29	1017.87	
	BOTTOM	314.16	314.16	314.16	942.48	
		653.45	**653.45**	**653.45**	**1960.35**	**3.99**
6 TH FLOOR	TOP	392.7	314.16	392.7	1099.56	
	BOTTOM	603.19	603.19	402.12	1608.5	
		995.89	**917.35**	**794.82**	**2708.06**	**43.66**
5TH FLOOR	TOP	392.7	314.16	471.24	1178.1	
	BOTTOM	314.16	314.16	314.16	942.48	
		706.86	**628.32**	**785.4**	**2120.58**	**12.5**
4TH FLOOR	TOP	392.7	314.16	549.78	1256.64	
	BOTTOM	549.78	314.76	314.16	1178.7	
		942.48	**628.92**	**863.94**	**2435.34**	**29.19**
3RD FLOOR	TOP	603.19	603.19	603.19	1809.57	
	BOTTOM	603.19	603.19	402.12	1608.5	
		1206.38	**1206.38**	**1005.31**	**3418.07**	**81.33**
2ND FLOOR	TOP	603.19	402.12	603.19	1608.5	
	BOTTOM	603.19	603.19	402.12	1608.5	
		1206.38	**1005.31**	**1005.31**	**3217**	**70.66**
1ST FLOOR	TOP	314.16	314.16	549.78	1178.1	
	BOTTOM	549.78	314.16	314.16	1178.1	
		863.94	**628.32**	**863.94**	**2356.2**	**25**
GROUND FLOOR	TOP	314.16	314.16	392.7	1021.02	
	BOTTOM	392.7	314.16	314.16	1021.02	
		706.86	**628.32**	**706.86**	**2042.04**	**8.33**

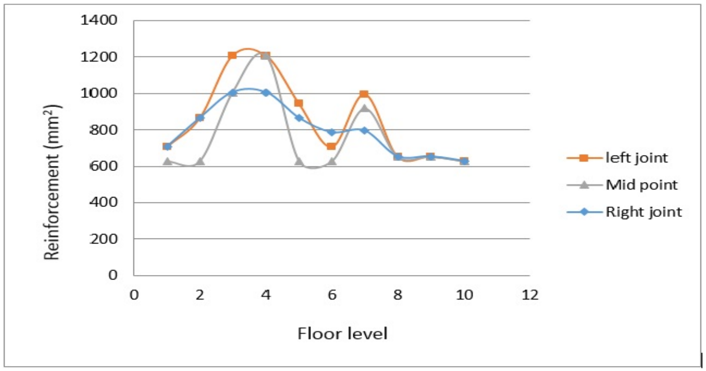

Fig. 3. Graphical representation of required Ast of beam in Zone II

Above table shows the reinforcement required for various floor levels at various seismic zones. From the above results it can be seen that amount of reinforcement in third floor is greater than all other floors in seismic zone II. One of the reason behind this behaviour is the increase in base shear in third floor as compared to other floors.

5.2 Comparison of beam at different levels in zone III

In this case Design of some selected beams using envelop of load combination, show the various floor levels of beam design result and variation in perentage of reinforcement.

TABLE 3
COMPARISON OF BEAMS AT DIFFERENT LEVEL IN ZONE III

		LEFT JOINT	MID POINT	RIGHT POINT	TOTAL	CHANGE AT DIFF: FLOOR W.R.T TOP FLOOR (%)
9 TH FLOOR	TOP	314.16	314.16	314.16	942.48	
	BOTTOM	314.16	314.16	314.16	942.48	
		628.32	**628.32**	**628.32**	**1884.96**	**0**
8 TH FLOOR	TOP	339.29	339.29	339.29	1017.87	
	BOTTOM	314.16	314.16	314.16	942.48	
		653.45	**653.45**	**653.45**	**1960.35**	**3.99**
7 TH FLOOR	TOP	392.7	314.16	471.24	1178.1	
	BOTTOM	471.24	314.16	314.16	1099.56	
		863.94	**628.32**	**785.4**	**2277.66**	**20.83**
6 TH FLOOR	TOP	339.29	339.29	678.58	1357.16	
	BOTTOM	678.58	339.29	339.29	1357.16	
		1017.87	**678.58**	**1017.87**	**2714.32**	**43.99**
5TH FLOOR	TOP	339.29	339.29	791.68	1470.26	
	BOTTOM	804.25	603.19	402.12	1809.56	
		1143.54	**942.48**	**1193.8**	**3279.82**	**73.99**
4TH FLOOR	TOP	339.29	339.29	904.78	1583.36	
	BOTTOM	942.48	942.48	628.32	2513.28	
		1281.77	**1281.77**	**1533.1**	**4096.64**	**117.33**
3RD FLOOR	TOP	1472.62	981.75	1472.62	3926.99	
	BOTTOM	1472.62	1472.62	981.75	3926.99	
		2945.24	**2454.37**	**2454.37**	**7853.98**	**316.66**
2ND FLOOR	TOP	1472.62	981.75	1472.62	3926.99	
	BOTTOM	1472.62	1472.62	981.75	3926.99	
		2945.24	**2454.37**	**2454.37**	**7853.98**	**316.66**
1ST FLOOR	TOP	339.29	339.29	904.78	1583.36	
	BOTTOM	904.78	339.29	339.29	1583.36	
		1244.07	**678.58**	**1244.07**	**3166.72**	**67.99**
GROUND FLOOR	TOP	942.48	628.32	942.48	2513.28	
	BOTTOM	678.58	339.29	339.29	1357.16	
		1621.06	**967.61**	**1281.77**	**3870.44**	**105.33**

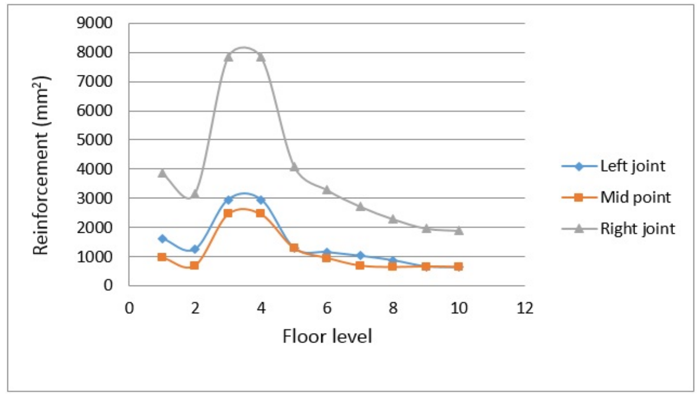

Fig. 4. Graphical representation of required Ast of beam in Zone III

Above table shows the reinforcement required for various floor levels at various seismic zones. From the above results it can be seen that amount of reinforcement in second and third floor is greater than all other floors in seismic zone II. One of the reason behind this behaviour is the increment in base shear in seond and third floor as compared to other floors.

5.3 Comparison of beam at different levels in zone IV

In this case Design of some selected beams using envelop of load combination, show the various floor levels of beam design result and variation in perentage of reinforcement.

TABLE 4
COMPARISON OF BEAMS AT DIFFERENT LEVEL IN ZONE IV

		LEFT JOINT	MID POINT	RIGHT POINT	TOTAL	CHANGE AT DIFF: FLOOR W.R.T TOP FLOOR (%)
9 TH FLOOR	TOP	314.16	314.16	314.16	942.48	
	BOTTOM	314.16	314.16	314.16	942.48	
		628.32	**628.32**	**628.32**	**1884.96**	**0**
8 TH FLOOR	TOP	339.29	339.29	452.39	1130.97	
	BOTTOM	452.39	339.29	339.29	1130.97	
		791.68	**678.58**	**791.68**	**2261.94**	**19.99**
7 TH FLOOR	TOP	392.7	314.16	785.4	1492.26	
	BOTTOM	785.4	314.16	314.16	1413.72	
		1178.1	**628.32**	**1099.56**	**2905.98**	**54.16**
6 TH FLOOR	TOP	603.19	402.12	1005.31	2010.62	
	BOTTOM	1017.88	339.29	339.29	1696.46	
		1621.07	**741.41**	**1344.6**	**3707.08**	**96.66**
5TH FLOOR	TOP	942.48	942.48	1256.64	3141.6	
	BOTTOM	1256.64	942.48	628.32	2827.44	
		2199.12	**1884.96**	**1884.96**	**5969.04**	**216.66**
4TH FLOOR	TOP	339.29	339.29	1470.27	2148.85	
	BOTTOM	1470.27	339.29	339.29	2148.85	
		1809.56	**678.58**	**1809.56**	**4297.7**	**127.99**
3RD FLOOR	TOP	942.48	628.32	1570.8	3141.6	
	BOTTOM	1570.8	942.4	628.42	3141.62	
		2513.28	**1570.72**	**2199.22**	**6283.22**	**233.33**
2ND FLOOR	TOP	942.48	942.48	1570.8	3455.76	
	BOTTOM	1570.8	942.48	628.32	3141.6	
		2513.28	**1884.96**	**2199.12**	**6597.36**	**250**
1ST FLOOR	TOP	663.19	402.12	1407.43	2472.74	
	BOTTOM	1470.27	339.29	339.29	2148.85	
		2133.46	**741.41**	**1746.72**	**4621.59**	**145.18**
GROUND FLOOR	TOP	1472.62	981.75	1472.62	3926.99	
	BOTTOM	1472.62	1472.62	981.75	3926.99	
		2945.24	**2454.37**	**2454.37**	**7853.98**	**316.66**

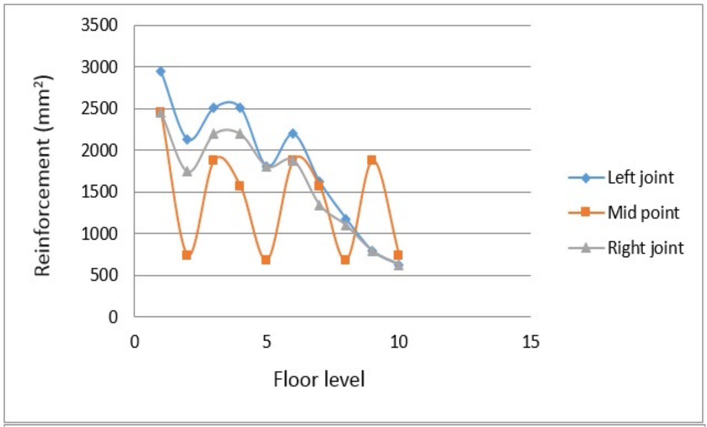

Fig. 5. Graphical representation of required Ast of beam in Zone IV

Above table shows the reinforcement required for various floor levels at various seismic zones. From the above results it can be seen that amount of reinforcement in third floor is greater than all other floors in seismic zone II. One of the reason behind this behavior is the increase in base shear in third floor as compared to other floors.

5.4 Comparison of beam at different levels in zone V

In this case Design of some selected beams using envelop of load combination, show the various floor levels of beam design result and variation in parentage of reinforcement.

TABLE 5
COMPARISON OF BEAMS AT DIFFERENT LEVEL IN ZONE V

		LEFT JOINT	MID POINT	RIGHT JOINT	TOTAL	CHANGE AT DIFF: FLOOR W.R.T TOP FLOOR (%)
9 TH FLOOR	TOP	314.16	314.16	392.7	1021.02	
	BOTTOM	392.7	314.16	314.16	1021.02	
		706.86	**628.32**	**706.86**	**2042.04**	**0**
8 TH FLOOR	TOP	339.29	339.29	678.58	1357.16	
	BOTTOM	678.58	339.29	339.29	1357.16	
		1017.87	**678.58**	**1017.87**	**2714.32**	**32.92**
7 TH FLOOR	TOP	339.29	339.29	1130.97	1809.55	
	BOTTOM	1130.97	339.29	339.29	1809.55	
		1470.26	**678.58**	**1470.26**	**3619.1**	**77.22**
6 TH FLOOR	TOP	942.48	628.32	1570.8	3141.6	
	BOTTOM	1809.56	603.19	402.12	2814.87	
		2752.04	**1231.51**	**1972.92**	**5956.47**	**191.69**
5TH FLOOR	TOP	942.48	628.32	2199.11	3769.91	
	BOTTOM	2199.11	942.48	628.32	3769.91	
		3141.59	**1570.8**	**2827.43**	**7539.82**	**269.22**
4TH FLOOR	TOP	603.19	402.12	2412.74	3418.05	
	BOTTOM	2454.37	1472.62	1472.62	5399.61	
		3057.56	**1874.74**	**3885.36**	**8817.66**	**331.80**
3RD FLOOR	TOP	942.48	942.48	2513.27	4398.23	
	BOTTOM	2827.43	942.4	942.48	4712.31	
		3769.91	**1884.88**	**3455.75**	**9110.54**	**346.14**
2ND FLOOR	TOP	942.48	628.32	2827.43	4398.23	
	BOTTOM	2827.43	942.48	942.48	4712.39	
		3769.91	**1570.8**	**3769.91**	**9110.62**	**346.15**
1ST FLOOR	TOP	603.19	402.12	2412.74	3418.05	
	BOTTOM	2412.74	603.19	603.19	3619.12	
		3015.93	**1005.31**	**3015.93**	**7037.17**	**244.61**
GROUND FLOOR	TOP	942.48	628.32	1570.8	3141.6	
	BOTTOM	1570.8	942.48	628.32	3141.6	
		2513.28	**1570.8**	**2199.12**	**6283.2**	**207.69**

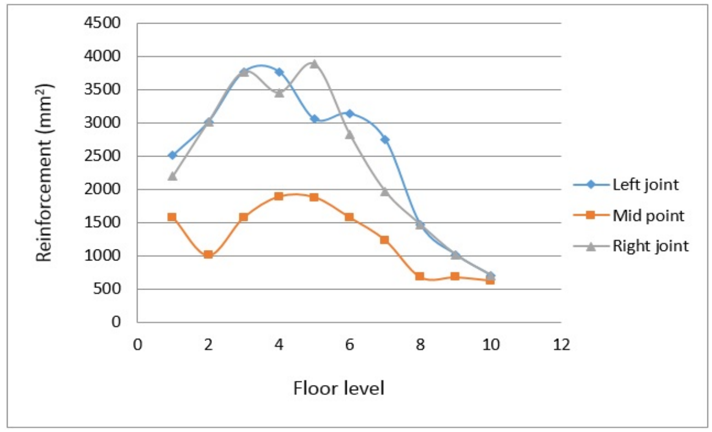

Fig. 6. Graphical representation of required Ast of beam in Zone V

Above table shows the reinforcement required for various floor levels at various seismic zones. From the above results it can be seen that amount of reinforcement in third floor is greater than all other floors in seismic zone II. One of the reason behind this behavior is the increase in base shear in third floor as compared to other floors.

6 COMPARISON OF COLUMNS AT DIFFERENT LEVELS AT DIFFERENT SEISMIC ZONES

TABLE 6
COMPARISON OF BEAMS AT DIFFERENT LEVEL IN DIFFERENT ZONES

FLOOR LEVEL	COLUMN NO:	ZONE II	ZONE III	ZONE IV	ZONE V
9th FLOOR	1841-1910	417.46	637.06	950.26	1429.06
8th FLOOR	1650-1719	2880	2880	2880	2880
7th FLOOR	1459-1528	2880	2880	2880	3456
6th FLOOR	1268-1337	2880	2880	2880	3744
5th FLOOR	1077-1146	2880	2880	2880	4032
4th FLOOR	886-955	2880	2880	2880	4032
3rd FLOOR	695-764	2880	2880	2880	3744
2nd FLOOR	504-573	2880	2880	2880	4320
1st FLOOR	313-382	2880	2880	3744	5760
G.F	122-191	2880	3744.8	5472	8640

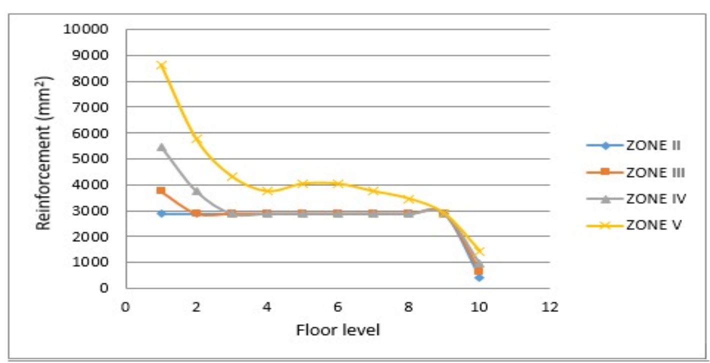

Fig. 6. Graphical representation of required Ast of beam in Zone V

When taking the results, it shows that amount of reinforcement changes only in ground floor and all other floors have same reinforcement in seismic zones II to IV. In seismic zone V, the reinforcement in gound floor column is found to be highest as compares to all other floors. This is beaause of the large base shear acting on the ground floor column.

4 CONCLUSION

In the present Research, an attempt has been made to analyses the seismic behavior of an L shaped multi-storied building with complexities, and the following are the conclusions are drawn.

This study focused on the seismic performances of reinforced concrete irregular building, which are most commonly used all over the world, the reinforcement required on various levels of the buildings are estimated using software analysis.

- Maximum reinforcement required in first floor beams is found to be 0.25 to 2.44 times the reinforcement required at the topmost storey.
- Maximum moment in third floor beams.
- Maximum reinforcement required in ground floor columns shows an increment of 30.02%, 90%, 200% for Zone III, Zone V and Zone V Respectively with respect to Zone II
- Variation in reinforcement in left joint and right joint is higher than mid joint.
- The moments in building increases gradually according to seismic zones, but in some cases certain variation in values has been noticed.
- Reinforced increases from Zone IV to V.
- Maximum amount of reinforcement required for an irregular building is in Zone IV and Zone V.
- The variation of percentage steel in an unsymmetrical structure is greater compared to a symmetrical structure.

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