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EARTHQUAKE ANALYSIS AND DESIGN OF MULTI-STORIED BUILDING FOR DIFFERENT ZONES IN INDIA

Tiriveedhi Saikrishna[1], V.Srinivasarao[2]
[1]M.Tech student, [2]Associate professor,
Department of civil engineering, USHARAMA COLLEGE OF ENGINEERING & TECHNOLOGY
TELAPROLU -521109, AP

Abstract: One of the most frightening and destructive phenomena of a nature is a severe earth quake and it's terrible after effects. Earthquake strike suddenly, violently and without warning at any time of the day or night. If an earthquake occurs in a populated area, it may cause many deaths and injuries and extensive property damage. Although there are no guarantees of safety during an earthquake, identifying potential hazards a head of time and advance planning to save lives and significantly reduce injuries and property damage. Hence it is mandatory to do the seismic analysis and design to structural against collapse. It is highly impossible to prevent an earthquake from occurring, but the damage to the buildings can be controlled through proper design and detailing. Designing a structure in such a way that reducing damage during an earthquake makes the structure quite uneconomical, as the earthquake might or might not occur in its lifetime and is a rare phenomenon. This study addresses the performance and variation of steel quantity of R.C framed structure in seismic zones (II,III,IV,V) . The present IScode1893:2002 doesn't provide information about the variation of steel quantity from zone to zone. This project report gives the STAAD Pro. Design of Multistoried building without considering the earthquake effect and gives how to calculate the seismic weights and base shear for a multistoried structure manually and also gives the STAAD Pro analysis and design of multistoried building in considering different seismic zones(II,III,IV,V) in India (as per IS1893(part-1):2002)in the point of steel quantity for all design load combinations. Ductile detailing has been done in conformation with IS: 13920. All drawings have been prepared using AutoCAD

I. INTRODUCTION

1.1 Earthquakes:

Vibrations of the earth's surface caused by waves coming from a source of disturbances inside the earth are described as earthquake. By far the most important earthquake from an engineering standpoint is of tectonic origin, that is, those associated with large scale strains in the crust of the earth. One of the theories describing this phenomenon is termed "elastic rebound theory". It explains that the strain energy that accumulates due to deformation in earth mass gets released through rupture when it exceeds the resilience of the storing materials. The energy thus released is propagated in the form of wave which impact energy to the media through which they pass and vibrate the structure standing on the earth's surface.

A major tectonic earthquake is generally preceded by small, fore shocks caused either by small rupture or plastic deformation and followed by, aftershocks, due to the fresh rupture or the readjustments of the fractured mass. A major's hock may result from a rapture of the rock over a length of 100 to 400 km and several kilometers wide and thick. Small earthquakes may also be caused by volcanic eruptions, subsidence in mines, blasts, impounding of reservoirs, pumping of oil etc. They may cause considerable damage in the small areas, but vast areas are shaken only by tectonic movements across active faults. Recently, geologists have proposed a theory termed plate tectonics. It offers an elegant comprehensive explanation for continent drift and mountain buildings. It holds that the surface earth consists of about a dozen giant plates of rock, 100km thick, which float on the earth's semi molten mantel and propelled by an undetermined force. The plates are in constant motion, and where the meet, friction temporarily locks them in place cause stress to build up near their edges. Eventually, the rock fractures allowing the plates to resume their motion. The energy released causes earthquakes.

II. EARTHQUAKE ANALYSIS

2.1. General introduction:

Seismic analysis or earthquake analysis is a subset of structural analysis and is the calculation of the response of a structure to the earthquakes. A structure has the potential to wave back and forth during an earthquake this is called the fundamental mode and is the lowest frequency of the structure response. However, buildings also have higher modes of response, which are uniquely activated during an earthquake. Once the structural model had been selected, it is possible to perform analysis to determine the seismically induced forces in the structure. They are different methods of analysis which provide different degrees of accuracy. The analysis process can be categorized on the basis of three factors, the type of externally applied loads, the behavior of the structure or the structural material and the type of structural modal selected. Based on the type of external action and behavior of structure, the analysis can be further classified as linear static analysis, linear dynamic analysis and nonlinear dynamic analysis.

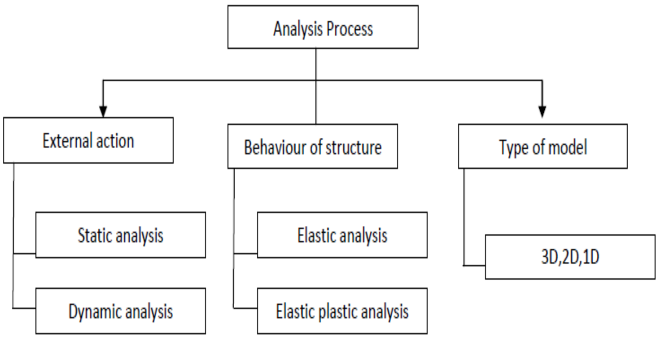
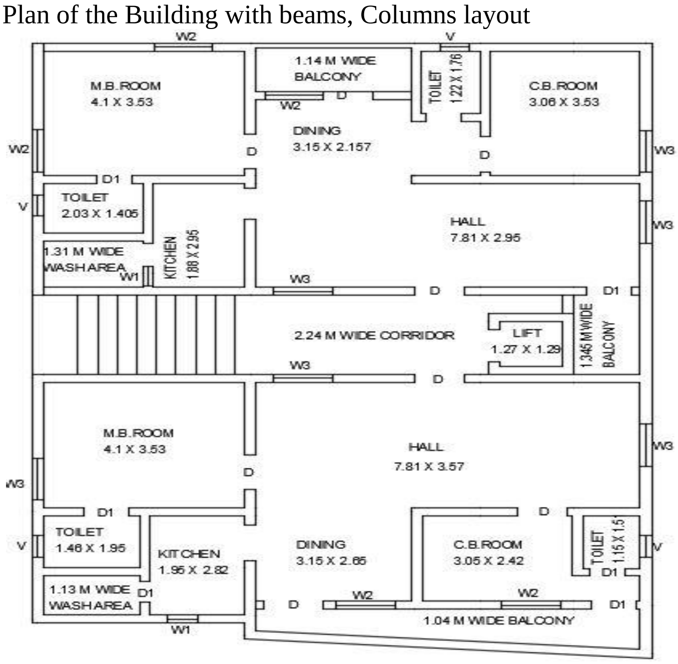


Fig. 1 Methods of analysis process

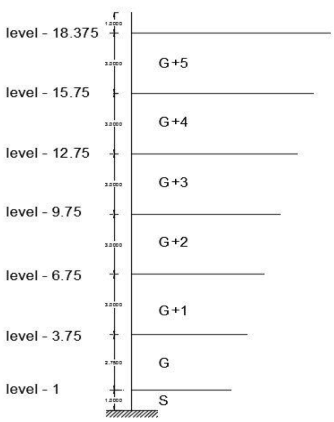
III. DETAILS OF PROPOSED STRUCTURE

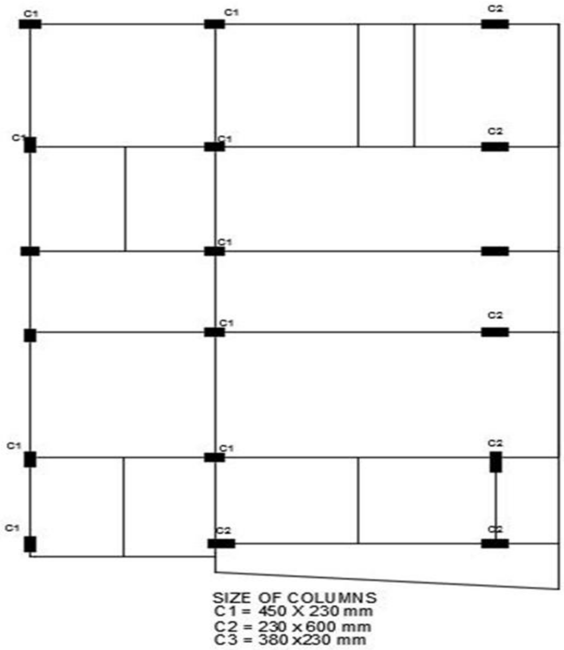
Live load= 2 KN/m^2 [IS 875 part-2, table-1]
Floor finish= 1.47 KN/m^2[IS 875 part-1,table-2]
Water proofing= 8.34*10^{-3} KN/m^2 [IS 875 part-2, table-1]
Terrace flooring = 8.34*10^{-3} KN/m^2 [IS 875 part-2, table-1]
Location = zone-II, zone-III, zone-IV, zone-V
Type of the soil = soft soil

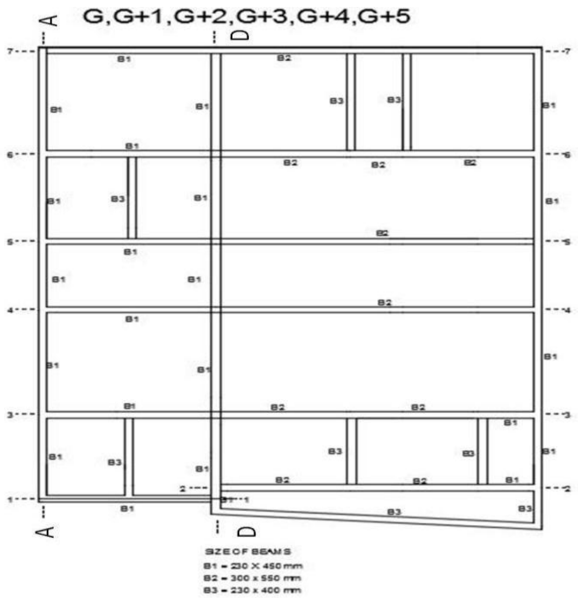
Plan of the Building with beams, Columns layout



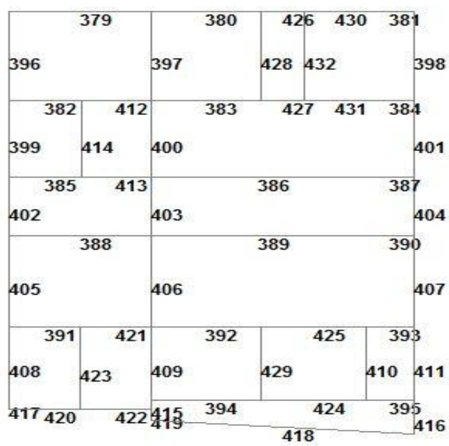
Storey heights:

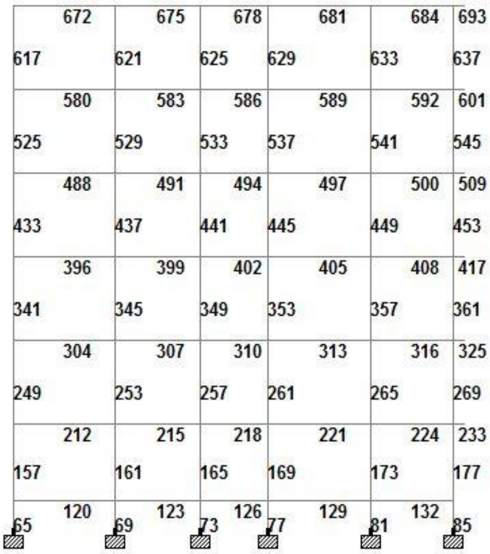






Beam Numbering and Column Numbering

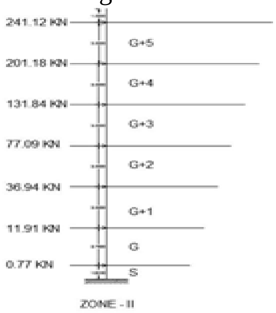


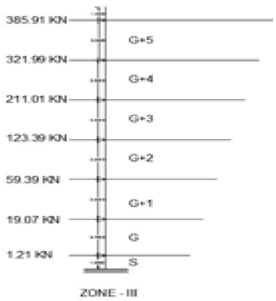


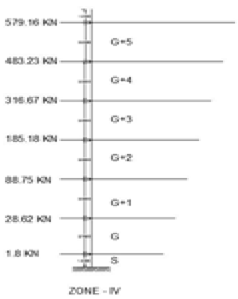
Base shears calculation for Zone-II:
$V_B = A_h * W$
where [$A_h = (Z/2)*(I/R)*(S_a/g)$ from IS1893]
W = seismic weight of building as per clause- 7.4.2

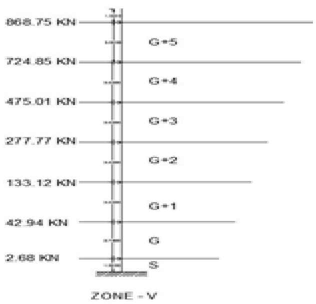
Storey	W_i (KN)	h_i (m)	$W_i * h_i^2 * 10^{-3}$	$Q_i = ((W_i*h_i^2)/(W_i*h_i^2))*V_B$	V_i (KN)
7	2110.7	18.75	742.04	241.12	241.12
6	2495.87	15.75	619.13	201.18	442.30
5	2495.87	12.75	405.73	131.84	574.14
4	2495.87	9.75	237.26	77.09	651.23
3	2495.87	6.75	113.71	36.94	688.17
2	2608.61	3.75	36.68	11.91	700.08
1	2267.15	1.00	2.26	0.77	700.85

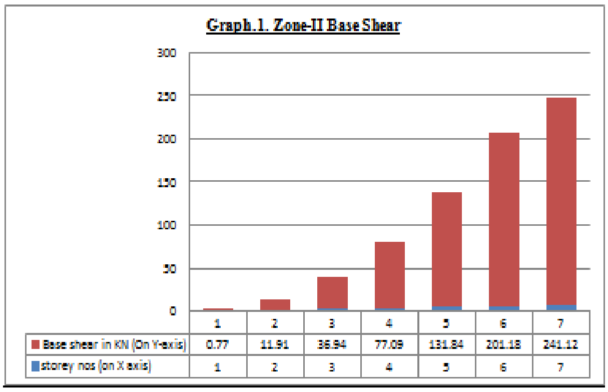
Base Shear Diagrams for different zones:

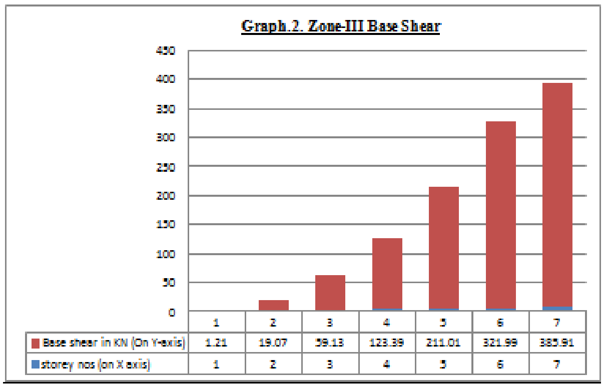


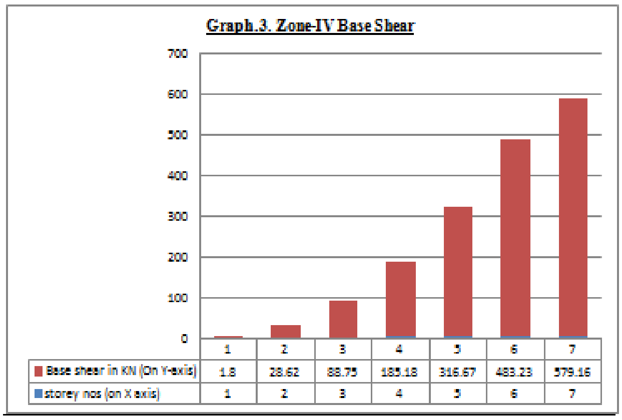


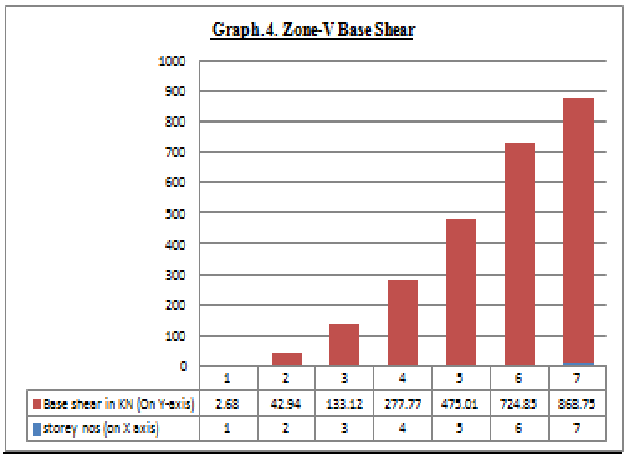




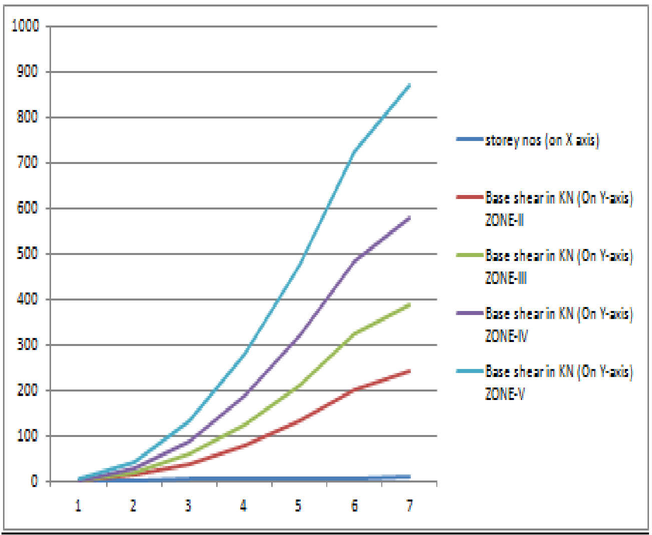








VARIATION OF BASE SHEAR



Column Details

	Column No.	Without Earthquake	Zone-II	Zone-III	Zone-IV	Zone-V
	157	418.71	17.03	27.25	40.88	88.01
	161	588.60	17.24	27.59	41.39	856.84
	165	502.87	16.94	27.10	40.66	734.82
	169	518.07	17.70	28.32	42.49	804.66
	173	561.91	21.02	33.63	50.44	764.86
	177	477.21	7.52	12.04	18.06	27.09
	158	814.91	1393.67	1393.67	1393.67	84.73
	162	854.31	1571.39	1571.39	1571.39	1272.99
	166	848.77	1525.42	1525.42	1525.42	1236.26
	170	858.41	1560.87	1560.87	1560.87	1326.39
	174	776.21	1451.54	1451.54	1451.54	1041.49
	178	951.82	1649.16	1649.16	1649.16	1656.99
	159	900.92	1507.3	1507.3	1507.3	55.6
	163	1028.56	1817.82	1817.82	1817.82	1605.57
Ground Floor	167	915.90	1610.63	1610.63	1610.63	1371.67
	171	951.10	1676.53	1676.53	1676.53	1414.19
	175	989.65	1749.27	1749.27	1749.27	156.57
	179	1108.05	1893.66	1893.66	1893.66	1896.36
	249	348.21	12.9	20.64	30.97	46.45
	253	483.31	13.02	20.82	31.24	711.28
	257	417.23	12.63	20.2	30.3	621.06
	261	427.43	13.31	21.3	31.94	14.9
	265	462.32	15.4	24.64	36.96	648.28
	269	395.82	6.02	9.63	14.44	21.67
	250	668.95	1144.43	1144.43	1144.43	64.95
	254	702.91	1287.22	1287.22	1287.22	1053.58
	258	696.23	1250.83	1250.83	1250.83	1029.04
	262	702.30	1274.7	1274.7	1274.7	1083.15
	266	644.89	1198.51	1198.51	1198.51	893.25
	270	776.97	1346.82	1346.82	1346.82	1334.93
	251	738.36	11.38	18.21	27.31	40.97
G+1 Floor	255	845.79	1493.18	1493.18	1493.18	44.54
	259	756.06	1329.02	1329.02	1329.02	51029
	263	782.57	1379.01	1379.01	1379.01	47.93
	267	814.45	1438.27	1438.27	1438.27	62.09
	271	913.25	1560.7	1560.7	1560.7	1558.94
	341	269.21	9.37	15	22.5	33.75
	345	373.63	9.25	14.81	22.21	33.31
	349	324.49	8.82	14.11	21.17	486.29
Floor	353	331.20	9.39	15.02	22.53	7.54
	357	358.33	10.42	16.68	25.02	512.64
	361	307.21	4.64	7.42	11.13	16.7
	342	521.33	1.91	3.06	4.59	44.94
	346	549.44	1002.92	1002.92	1002.92	821.64
	350	540.19	0.83	1.33	2.00	804.17
	354	544.27	0.64	1.02	1.52	830.68
	358	508.23	0.06	0.10	0.15	719.22
	362	601.78	1043.89	1043.89	1043.89	1017.33
	343	569.27	7.72	12.36	18.53	27.80
	347	657.20	8.66	13.85	20.78	31.17
	351	588.84	10.05	16.08	24.11	36.17
	355	608.00	9.56	15.30	22.94	34.42
	359	633.08	11.98	19.16	28.74	43.12
	363	711.71	8.12	12.99	19.48	1195.93
	433	190.49	6.00	9.60	14.40	21.6
	437	264.29	5.84	9.35	14.02	21.03
	441	230.87	5.46	8.73	13.09	348.79
	445	234.79	5.87	9.39	14.09	21.14
	449	254.18	6.06	9.7	14.55	372.38
	453	217.53	3.22	5.15	7.73	11.59
	434	372.76	1.69	2.71	4.07	6.1
	438	397.36	0.07	0.11	0.16	592.7
	442	384.94	0.53	0.86	1.28	578.05
	446	388.06	0.39	0.62	0.93	1.65
	450	370.68	0.45	0.72	1.08	12.00
	454	428.88	2.55	4.07	6.11	9.16
	435	399.81	4.52	7.23	10.84	16.27
G+3 Floor	439	469.04	5.34	8.54	12.81	19.22
	443	420.17	6.25	10.00	15.00	22.51
	447	432.99	6.14	9.83	14.74	22.11
	451	451.43	7.29	11.66	17.49	26.24
	455	509.43	5.20	11.27	12.49	18.73
	525	113.07	2.90	4.63	6.95	10.42
	529	155.25	2.98	4.77	7.16	10.74
	533	136.29	2.72	4.35	6.53	208.33
	537	138.09	2.98	4.77	7.16	10.74
	541	149.90	2.61	4.18	6.26	226.2
	545	127.12	1.88	3.00	4.51	6.76
	526	219.57	0.71	1.14	1.71	2.56
	530	246.35	0.01	0.02	0.03	0.04
	534	230.40	0.24	0.38	0.57	0.86
	538	233.19	0.16	0.26	0.39	0.58
	542	232.76	0.75	1.20	1.80	2.70
	546	257.37	1.02	1.64	2.45	3.68
	527	235.42	2.31	3.70	5.55	8.33
	531	281.18	2.68	4.29	6.44	9.66
G+4 Floor	535	250.46	3.06	4.89	7.33	11.00
	59	257.78	3.27	5.24	7.85	11.78
	543	269.77	3.50	5.60	8.39	12.59
	547	306.56	2.72	4.35	6.53	9.79
	617	34.51	0.88	1.40	2.10	3.16
	621	45.45	0.98	1.57	2.35	3.53
	625	41.35	0.83	1.33	2.00	6.587
	629	40.94	0.98	1.57	2.35	3.52
	633	44.50	0.58	0.93	1.39	2.09
	637	36.76	0.74	1.18	1.77	2.65
	618	67.31	0.22	0.35	0.53	0.80
	622	96.32	0.08	0.13	0.20	0.30
	626	75.61	0.01	0.02	0.03	0.04
	630	78.73	0.03	0.05	0.08	0.12
	634	95.93	0.52	0.83	1.24	1.86
	638	86.11	0.10	0.15	0.23	0.34
	619	70.80	120.91	120.91	120.91	100.69
G+5 Floor	623	93.63	0.78	1.25	1.87	143.90
	627	80.95	0.85	1.36	2.03	3.05
	631	82.51	1.12	1.79	2.68	4.02
	635	88.35	0.93	1.49	2.24	3.35
	639	103.46	0.88	1.41	2.11	3.16

Secondary story beams details

S.NO	BEAM NO	BENDING MOMENT (KN.M)				
		WITH OUT ERD	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
1	379	37.792	62.881	62.881	62.881	69.637
2	380	64.129	110.853	110.853	110.853	86.861
3	382	23.552	43.866	43.866	43.866	33.442
4	389	117.300	214.242	214.242	214.242	172.020
5	392	46.078	91.849	91.849	91.849	59.810
6	393	26.577	45.018	45.018	45.018	45.018
7	381	20.139	33.235	33.235	33.235	26.572
8	412	44.381	78.325	78.325	78.325	71.169
9	425	99.304	180.383	180.383	180.383	139.493
10	426	43.343	75.080	75.080	75.080	51.542
11	430	121.194	205.805	205.805	205.805	186.647
12	396	20.887	34.154	34.154	34.154	64.572
13	398	19.196	33.245	33.245	33.245	29.346
14	408	22.861	39.448	39.448	39.448	103.060
15	411	26.500	46.224	46.224	46.224	50.690

Third storey beams details

S.NO	BEAM NO	BENDING MOMENT (KN.M)				
		WITH OUT ERD	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
1	563	40.096	67.196	67.196	67.196	68.896
2	564	70.043	121.463	121.463	121.463	100.042
3	566	23.862	44.354	44.354	44.354	34.558
4	573	116.491	212.800	212.800	212.800	172.258
5	576	45.351	90.055	90.055	90.055	63.064
6	577	25.787	43.216	43.216	43.216	39.992
7	565	21.340	35.310	35.310	35.310	29.835
8	596	41.955	74.029	74.029	74.029	65.568
9	609	103.083	189.673	189.673	189.673	151.445
10	610	51.521	89.552	89.552	89.552	70.325
11	614	105.514	178.604	178.604	178.604	157.282
12	580	19.279	31.116	31.116	31.116	46.491
13	582	20.527	35.621	35.621	35.621	32.259
14	592	22.987	39.896	39.896	39.896	66.770
15	595	26.802	46.946	46.946	46.946	46.070

Fourth storey beams details

S.NO	BEAM NO	BENDING MOMENT (KN.M)				
		WITH OUT ERD	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
1	471	41.871	70.068	70.068	70.068	75.134
2	472	70.253	121.702	121.702	121.702	98.860
3	474	23.608	44.018	44.018	44.018	33.762
4	481	118.160	216.017	216.017	216.017	173.997
5	484	46.324	92.332	92.332	92.332	61.815
6	485	26.624	45.118	45.118	45.118	40.649
7	473	21.417	35.524	35.524	35.524	29.289
8	504	43.795	76.636	76.636	76.636	69.519
9	517	99.920	181.633	181.633	181.633	143.872
10	518	51.878	90.123	90.123	90.123	68.575
11	522	104.661	176.912	176.912	176.912	155.986
12	488	19.940	32.365	32.365	32.365	56.791
13	490	20.288	35.261	35.261	35.261	31.874
14	500	23.177	40.116	40.116	40.116	88.973
15	503	26.618	46.445	46.445	46.445	48.716

Comparisons for zones in view of steel quantity

S.NO	LOAD COMBINATION	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
1	1.5(D.L+L.L)	120597	120616	120843	123680
2	1.2(D.L+L.L)	111424	111445	111688	115163
3	1.2(D.L+L.L+EQ X+VE)	110839	111351	112500	116980
4	1.2(D.L+L.L+EQ X-VE)	112428	111932	112814	117993
5	1.2(D.L+L.L+EQ Z+VE)	111449	113050	113724	119308
6	1.2(D.L+L.L+EQ Z-VE)	110137	110271	111631	117314
7	1.2(D.L+L.L-EQ X+VE)	112428	111932	112814	117993
8	1.2(D.L+L.L-EQ X-VE)	110839	111351	112500	116980
9	1.2(D.L+L.L-EQ Z+VE)	110137	110271	111631	117314
10	1.2(D.L+L.L-EQ Z-VE)	111449	113050	113724	119308
11	1.5(D.L)	112322	112342	112579	115802
12	1.5(D.L+EQ X +VE)	112430	113481	115706	122619
13	1.5(D.L+EQ X -VE)	112469	114095	116002	121081
14	1.5(D.L+EQ Z +VE)	112430	115094	118332	124271
15	1.5(D.L+EQ Z -VE)	112141	112376	114727	121011
16	1.5(D.L-EQ x +VE)	112469	114095	116002	121081
17	1.5(D.L-EQ x -VE)	112430	113481	115706	122619
18	1.5(D.L-EQ Z +VE)	112141	112376	114727	121011
19	1.5(D.L-EQ Z -VE)	114805	115094	118332	124271
20	0.9D.L+1.5 EQ X +VE	105661	107113	108708	113413
21	0.9D.L+1.5 EQ X -VE	105432	105607	106890	111130
22	0.9D.L+1.5 EQ Z +VE	105478	106137	107177	113364
23	0.9D.L+1.5 EQ Z -VE	105226	105380	106571	112434
24	0.9D.L-1.5 EQ X+VE	105432	105607	106890	111130
25	0.9D.L-1.5 EQ X-VE	105661	107113	108708	113413
26	0.9D.L-1.5 EQ Z+VE	105226	105380	106571	112434
27	0.9D.L-1.5 EQ Z-VE	105478	106137	107177	113364

Highest Combination of Steel Quantity in zone wise

S.NO	ZONE	LOAD COMBINATION	QUANTITY OF STEEL IN (NEWTONS)	STEEL QUANTITY IN (Kg)
1	II	1.5(D.L+L.L)	120597	12297.47
2	III	1.5(D.L+L.L)	120616	12299.40
3	IV	1.5(D.L+L.L)	120843	12322.55
4	V	1.5(D.L+EQ Z +VE)	124271	12672.11

IV. CONCLUSIONS

The analysis of multistoried buildings is explained in two ways in this project With earth quake and without earthquake. In this Report I have Analyze base shears for structure in manually in all seismic zones by calculating the

gravity loads using IS 1893-2002. This study addresses the performance and the variation of steel quantity for the whole structure of multi-storied structure in seismic zones by using STAAD Pro. Software, we calculated B.M. and S.F. in the beams, axial loads in columns and compared the axial loads in different seismic zones. In the analysis the axial load of the zone-v is high and it is seen as different from the other zones
The variations in all the zones has shown through graphs
It has to be properly designed to withstand the seismic effects while sustaining an acceptable level of damage.
The variation in percentage in zone-II steel quantity in a building as compared with the building which is not considering the earthquake steel quantity is 22.39%
The variation in percentage in zone-II steel quantity in a building as compared with the building which is not considering the earthquake steel quantity is 22.41%
The variation in percentage in zone-II steel quantity in a building as compared with the building which is not considering the earthquake steel quantity is 22.64%
The variation in percentage in zone-II steel quantity in a building as compared with the building which is not considering the earthquake steel quantity is 26.12%

APPLICATIONS

By increasing percentage of reinforcement and orientation of reinforcement in the beam. Column joint process we can at least reduce the danger for human beings from the earthquake. In this project in zone-II, if at all we want to estimate the steel quantity of structure to identify the existence of soil conditions in the other zones by analyzing this process.

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