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Analysis and Design of G+30 High-rise buildings by using ETABS for various frame sections in seismic zones

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Abstract: We have known since the beginning of time that earthquakes can cause disasters. In modern times, buildings are getting smaller and more prone to sway, which makes them dangerous during an earthquake. To make buildings more earthquake resistant, scientists and engineers have experimented in the past. The use of lateral load resisting techniques in the building configuration has significantly improved the performance of the structure in earthquakes, according to numerous practical reports. The work has been done for various situations using shear walls and bracings for unusual heights, and the highest height considered for the reward gain knowledge is 93.5m.The modelling is performed to investigate at how seismic characteristics like base shear, lateral displacements, and lateral drifts will change under unique conditions and at particular heights. As outlined in IS 1893-2002, the implementation of the knowledge has been made for Zones II, III, IV, and V in all types of soils. In this study the behavior of a G+30 Buildings are designed as per IS: 456 and later subjected to earthquake loads & Wind loads. ETABS (Extended Three dimensional Analysis of Building Systems) tool have been used to analyze the high-rise buildings. Further performance analysis has been carried out and comparison is done for various zones.

Index Terms **–** Analysis, G+30 Buildings, ETABS**,** seismic zone, seismic analysis, storey drift, storey acceleration

I. INTRODUCTION

From the perspective of a structural engineer, a tall building or high-rising building (HRB) can be defined as one that, by virtue of its top, is affected by lateral forces such as wind or earthquake, or both, to the extent that they each play an extremely significant role within the structural type. Since the dawn of civilisation, grouping has been a part of tall structures[1]. Amongst such ancient tall constructions are the Egyptian Pyramids, one of the important Seven Wonders of the World. Such constructions were designed for safety and to convey enjoyment. In developing countries like India, the urbanisation process that started with the industrial period is still going strong. Wherever there are important work possibilities, industrialization drives relocation of contributors to metropolitan centres[2]. Tall structures' dynamic reactivity can be controlled by improving their structural design. A tall building is defined as a structure whose design is influenced by lateral pressures caused by earthquake and wind. In terms of what aspect ten encounters, the lateral flow initially dominates the seam, and the stiffness rather than the force becomes the main issue[3][4]. Tall structures with completely unique structural forms may also be used to increase lateral stiffness and lower waft index. Given that the column axial deformations as well as the diagonal and beam deformations, respectively, and the shear and flexural mode contributions, glide in the construction of frames would be a result. There are numerous Lateral resistive techniques that can be used to withstand the Constitution's Lateral Plenty Functioning. For soil type three (i.e., the smooth soil form), all recommended 4 zones, this lesson aims to comprehend the numerous lateral strategies that have arisen and their associated structural behaviour. While other structural characteristics of the building, such as the size of the columns, beams, bracings, and slab thickness, remain constant, the various types of bracings field unit presented in RCC building model at regular locations to understand the suitability of the programmes with relevance to seismic motions. The ETABS application system has completed the analytical modeling[5]. The main goal is to evaluate the lateral displacements, flow, base shear, and stiffness that occur owing to the better than parameters utilizing the Response Spectrum method in accordance with IS 1893 (part I): 2002[5,6].
It is decided to overcome those high-rise structures due to the increase in population and the resulting land shortage. Natural disasters have an impact on these kinds of high-rise structures. Because they can't be controlled and inflict damage and mayhem to the structural components, natural disasters like earthquakes are the most harmful. These natural disasters disrupted the course of regular lifecycle development and caused property destruction. Given that it is a worldwide issue, extensive research must be done, and the findings must be

presented in order to prepare the framework and meet the deadline. In order to address this problem and prevent the development of slums, vertical living is being used in many major cities. Urban concentration is making it difficult for people to find a place to live in urban regions. For engineers, building these high-rise structures is a challenging endeavour because of the numerous requirements, including lateral pressures, soil conditions, structural strength, stiffness, and economics. There are several innovations used today in the construction of high-rise structures, with shear walls being one of the most recent.

It is a vertical component that can bear lateral shear and bending stresses. Shear walls are constructed in the form of shells, and because of their in-plane stiffness and bending resistance, they can withstand moments and forces coming from all directions. Shear walls are better able to withstand lateral stresses (such as those caused by wind and earthquakes). With the development of technology, man has attempted to resist these natural disasters in a number of ways, including by creating early warning systems for disasters, implementing fresh prevention strategies, and putting in place effective relief and rescue efforts. But regrettably, not all natural calamities fall within this category[5]. There are periodic revisions to the risk maps that identify seismic zones in seismic codes (IS 1893:2002), which increases the base shear requirement on existing structures. It is possible to use the phrases "earthquake" and "seismic" interchangeably.

Objectives of work

i. To study irregularities in structural analysis and design of G+30 building as per code (IS 1893:2002).
ii. To design G+30 building with shear walls using ETABS
iii. To analyse and compare storey drift, storey stiffness, displacement
iv. To investigate how well a structure will behave to a seismic load without masonry filling.
v. To determine the displacements subject to seismic loading from one zone to another.
vi. To find out the bending moment and shear force selecting any one section for various seismic zones
vii. To analyse time history subjected to intermediate frequency ground motion for the response of regular buildings and compared to the response spectrum analysis.

II. LITERATURE REVIEW

The various recent works carried in this field are presented as follows:

F. Zaker et al (2022) has been investigated the design of reinforced concrete G+7 building for frame with infill walls and soft storey using ETABS. They carried out the seismic performance analysis and estimation through the comparison between different responses with the use of response spectrum method. Also behaviour of building is studied for static and dynamic load [7].

Shobha R et al (2021) have been carried out the seismic analysis of multi storey building under different ground motions. This work gives the clear understanding about the impact of different ground motions on building structure over its life span. The new parameters and information are obtained to have improvement in design [8].

M. K. Ahamed et al (2020) has been investigated the seismic behavior and performance of multi storied building structure in zone 3 with ETABS. They have carried out the study on flow of forces and variations in column forces and safe position of floating column multi storey building under seismic response. Also they considered this study without floating columns [9].

M. A. Shariff et al (2019) has studied the behaviour of building structure under the lateral loads. Seismic resistant bracings are provided to RC structure and analysis has been carried out. The building performance has evaluated for zone 4 and medium soil as per IS codes [10].

K. Sallal (2018): proposed to design and analyse the storeyed building under effect of earthquake and wind pressure with the use of ETABS tool. The 18m x 18m and eight stories structure have been modelled. Ten stories are assumed to be 3 metres high, making the structure's overall height 31meters [11].

III. STRUCURAL LOADS CALCULATIONS

Loads Acting on G+30 Building are Dead loads, Live loads and Earthquake load. The various loads calculations are as follows:

Wind loads IS: 875 (part-3)-1987

Design wing speed, $\mathbf{V_z = V_b\, K_1\, .K_2.\, K_3}$

Where K_1 = probability facts [risk at any height z in m/sec], K_3 = topography factor **clause [5.3.3]**.

K_2 = terrain height and structure size factor **clause [5.3.2]**

Design wind speed is assumed to remain constant up to a height of 10 meters above mean ground level.

K_2 = Category 3, For k_1 = basic wind speed =44 m/sec

Table 1: Design wind speed and pressure for various heights

Height	Design wind speed V_z	Design wind pressure $P_z= 0.6x\ v_z^2$
12.5m	33.44m/sec	0.670 kN/m^2
21.5m	33.44m/sec	0.670kN/m^2
33.5m	41.844m/sec	1.050kN/m^2
33.5m	41.844m/sec	1.050kN/m2
42.5m	44.22m/sec	1.173kN/m2
51.5m	46.332m/sec	1.287kN/m2
12.5m	33.44m/sec	0.670kN/m2
60.5m	47.24m/sec	1.332kN/m2
72.5m	48.18m/sec	1.392kN/m^2
81.5m	48.972m/sec	1.438kN/m^2
93.5m	50.028m/sec	1.501kN/m$^{2.}$

Table 2: loads on members

Reinforced concrete cement	25 kN/m^3
Brick work	13 to 20 kN/m^3
Floors	1.5 kN/m^2
Balcony	3 kN/m^2
Corridors	3 kN/m^2
Staircase	3 to 5 kN/m^2

LOAD CALCULATIONS

***For analysis, the following loadings are used*:-**

Dead Loads:

Loads resulting from the slab:

Wall loads:-

Outer wall loads 230 mm:

D L = wall thickness× (floor height-beam depth) ×unit wt of brick = 0.23× (3-0.40)×20 = 11.96kN/m

Factored load= 11.96×1.5 = 17.94kN/m

Internal wall loads 115 mm: D.L = 0.115x (3-0.4) x20 = 5.98kN/m

Factored load=1.5x5.98 = 8.97 kN/m

Table 3: total load on members

Parameters	For all floors	For ground floor	For roof
Slab thickness	3	3	3
Floor finish	1.44	1.44	1.44
Ceiling plaster	0.12	0.12	0.12
False ceiling	0.5	0.5	0.5
Total load	5.81kN/m$^{2.}$	5.31 kN/m^2	5.69kN/m^2

Live Loads: Live Load on typical floors = 4 kN/m^2

Earthquake Loads:

According to IS: 1893 (2002), the earth quake loads are calculated given the following seismic parameters

- Earth Quake Zone-4, 5
- Response Reduction Factor: 5
- Soil Type: Medium

IV. Design of G+30 building in E-tabs

We have carried out the design of G+30 building in most severs zone for wind and earthquake forces is carried out. 3D model is prepared for G+30building is in ETABS 2016[6]. Further, we have analyzed the high rise building of 30 floors (G+30) by considering seismic, dead and live loads. The criteria considered while designing of building are strength, serviceability and stability[12,13]. We have determined the effects of lateral loads on moments, shear force, axial force, base shear, maximum displacement and tensile forces on structural system are subjected and also compared the results of seismic zones 2, 3, 4 and 5. Buildings will be subjected to lateral loads based on Indian specifications. According to IS 456 (Dead load, Live load), IS 1893:2002 (Earthquake load), and IS 875: 1987, the analysis is carried out for seismic zones 4 and 5. (Wind Load). A 24.14 m x 20.627 m plan with 16 m x 12 bays on each side is imagined. The high rise building (HRB) has 30 stories, with a ground-to-ground height of 3.5 metres for all models and a floor-to-floor height of 3 metres[14,15]**.**

In this lesson, a 30-story building with an identical plan in various types of zones (according to IS 1893 (part I): 2002) and unusual styles of soils is used. To understand the impact of lateral deflection, base shear, bending second, shear force, and axial force caused by lateral load, a tall building with various types of braces introduced in the principal region in two bays is used. The location of the building is thought to be in several zones with unusual types of soils. Maximizing version and maintaining significant distinction are key considerations when choosing a layout. The vertical axis of each item is represented by the Z-axis, while the planner axes are represented by the X-axis and Y-axis. Rectangular shape mannequin plan layouts were selected.

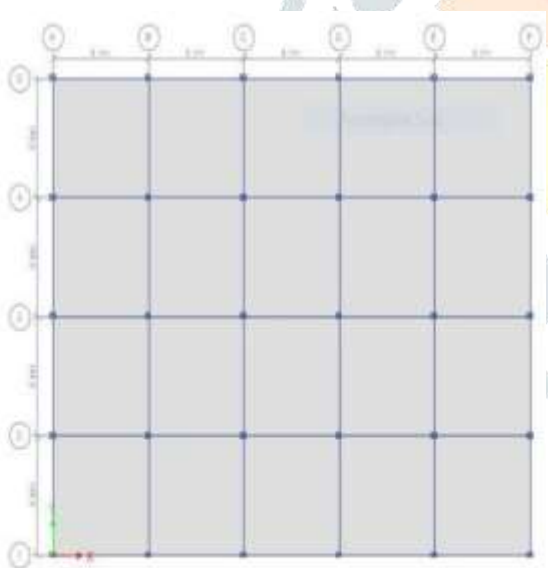

Figure 1 Plan of G+30 Building

Figure 2 Elevation of G+30 Building

- ETABS 2016 software was used to assess a high-rise structure with 30 storeys that was subject to seismic, wind, and live loads.
- All members were designed and inappropriate members have been obtained, and acceptable sections has suggested by the ETABS software.
- Reduced design time and better accuracy of the analysis have been obtained
- The high rise building's behaviour was vividly demonstrated using graphs and lateral displacements.
- When compared to zones 4, 3, and 2, zone 5 is shown to have higher lateral displacements or drifts.
- Additionally, it is observed that zone 5 has higher story shear than zone 2 based on the base responses of the structure that were acquired in zone 5.

V. RESULTS AND ANALYSIS

The proposed G+30 building structure have been designed using ETAB and analysis has been carried for five different zones. The results obtained are depicted in the table 4 to 11 and graph shown in figure 3 to figure 10.

Storey drift

Table 4 storey drift for various zones

Storey No.	Zone II	Zone III	Zone IV	Zone V
30	8.20E-05	0.00013	0.0002	0.00029
29	0.00013	0.0002	0.0003	0.00045
28	0.00017	0.00027	0.0004	0.0006
27	0.0002	0.00032	0.00048	0.00072
26	0.00023	0.00036	0.00055	0.00082
20	0.0001	0.00017	0.00025	0.00038
19	0.00011	0.00017	0.00025	0.00038
18	0.00011	0.00017	0.00026	0.00039
17	0.00011	0.00018	0.00027	0.0004
16	0.00012	0.00018	0.00028	0.00041
10	5.80E-05	9.30E-05	0.00014	0.00038
9	5.80E-05	9.20E-05	0.00014	0.00021
8	5.90E-05	9.40E-05	0.00014	0.00021
7	6.00E-05	9.60E-05	0.00014	0.00021
6	6.10E-05	9.80E-05	0.00015	0.00022

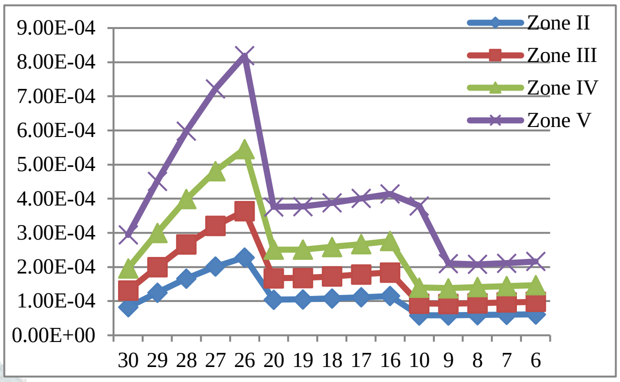

Figure 3 Comparison of storey drift for four zones

Storey acceleration

Table 5 storey acceleration for various zones

Storey No.	Zone II	Zone III	Zone IV	Zone V
30	290.21	464.34	696.5	1044.75
29	269.6	431.35	647.03	970.55
28	237.26	379.61	569.42	854.13
27	202.12	323.39	485.08	727.62
26	175.46	280.74	421.11	631.66
20	178.98	286.37	429.55	644.33
19	177	283.21	424.81	637.21
18	171.5	274.4	411.6	617.41
17	163.24	261.18	391.77	587.66
16	153.57	245.71	368.57	552.85
10	142.77	228.44	342.66	513.98
9	142.59	228.14	342.22	513.32
8	140.05	224.08	336.13	504.19
7	134.95	215.92	323.89	485.83
6	127.21	203.53	305.29	457.94

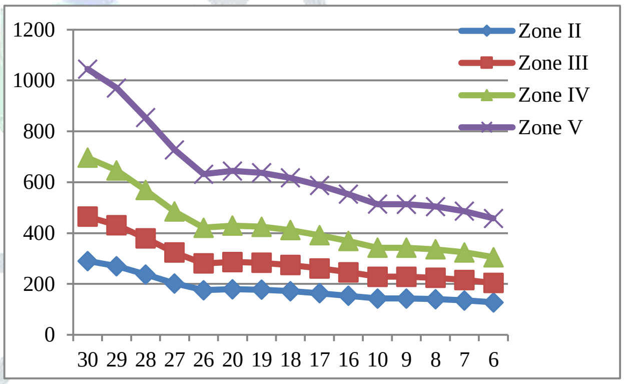

Figure 4 Comparison of storey acceleration

Time period

Table 6 time period for various zones

Mode No.	Zone II	Zone III	Zone IV	Zone V
1	1.619	1.619	1.619	1.619
2	1.619	1.619	1.619	1.619
3	1.378	1.378	1.378	1.378
4	0.714	0.714	0.714	0.714
5	0.714	0.714	0.714	0.714
6	0.662	0.662	0.662	0.662
7	0.418	0.418	0.418	0.418
8	0.418	0.418	0.418	0.418
9	0.393	0.393	0.393	0.393
10	0.305	0.305	0.305	0.305
11	0.305	0.305	0.305	0.305
12	0.286	0.286	0.286	0.286

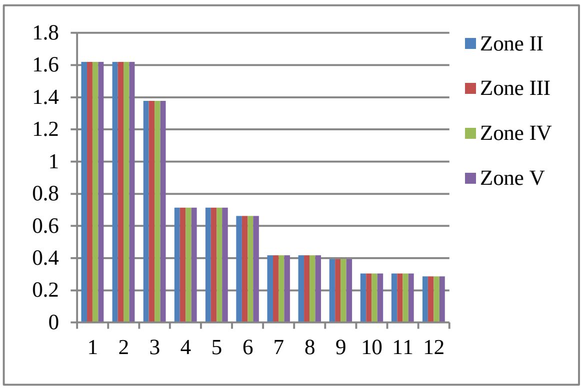

Figure 5 comparison of time period

Frequency

Table 7 frequency for various zones

Mode No.	Zone II	Zone III	Zone IV	Zone V
1	0.618	0.618	0.618	0.618
2	0.618	0.618	0.618	0.618
3	0.726	0.726	0.726	0.726
4	1.401	1.401	1.401	1.401
5	1.401	1.401	1.401	1.401
6	1.511	1.511	1.511	1.511
7	2.391	2.391	2.391	2.391
8	2.391	2.391	2.391	2.391
9	2.542	2.542	2.542	2.542
10	3.282	3.282	3.282	3.282
11	3.282	3.282	3.282	3.282
12	3.493	3.493	3.493	3.493

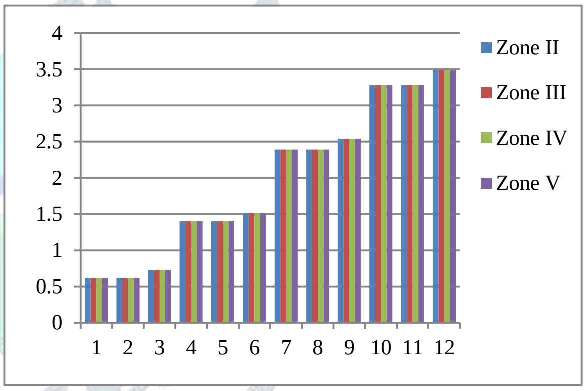

Figure 6 comparison of frequency

Base shear

Table 8 base shear for various zones

S. No	Zone II	Zone III	Zone IV	Zone V
1	1729.91	2767.859	4151.789	6227.683

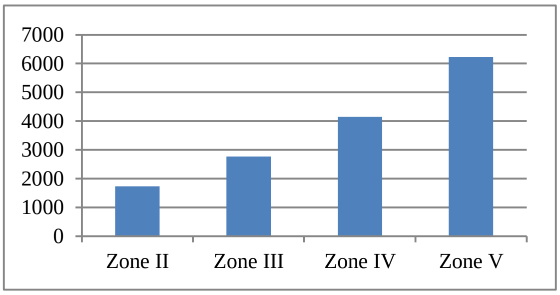

Figure 7 comparison of base shear

Shear

Table 9 shear for various zones

Storey No.	Zone II	Zone III	Zone IV	Zone V
30	121.4782	194.3651	291.5476	437.3214
29	246.8487	394.958	592.437	888.6555
28	356.269	570.0304	855.0455	1282.568
27	446.1326	713.8122	1070.718	1606.077
26	516.099	825.7584	1238.638	1857.956
20	677.088	1083.341	1625.011	2437.517
19	704.7114	1127.538	1691.307	2536.961
18	743.4039	1189.446	1784.17	2676.254
17	788.7173	1261.948	1892.922	2839.382
16	836.2316	1337.971	2006.956	3010.434
10	1074.027	1718.443	2577.665	3866.497
9	1136.807	1818.891	2728.336	4092.504
8	1209.998	1935.998	2903.996	4355.994
7	1289.937	2063.898	3095.848	4643.771
6	1372.543	2196.068	3294.102	4941.153

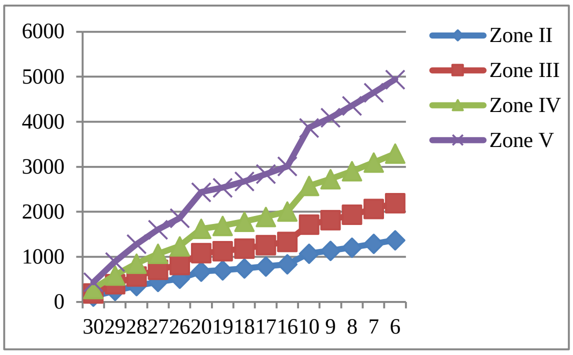

Figure 8 comparison of shear

Bending

Table 10 bending for various zones

Storey No.	Zone II	Zone III	Zone IV	Zone V
30	364.4345	583.0952	874.6429	1311.9643
29	1104.8618	1767.7789	2651.6684	3977.5026
28	2172.6663	3476.2661	5214.3991	7821.5986
27	3506.8624	5610.9798	8416.4697	12624.7046
26	5043.0756	8068.921	12103.3815	18155.0723
20	15769.384	25231.015	37846.522	56769.783
19	17532.679	28052.287	42078.4303	63117.6455
18	19299.552	30879.284	46318.9254	69478.3881
17	21100.675	33761.08	50641.6201	75962.4301
16	22962.987	36740.779	55111.1682	82666.7523
10	36039.703	57663.525	86495.2872	129742.931
9	38538.517	61661.626	92492.4395	138738.659
8	41161.247	65857.996	98786.9939	148180.491
7	43938.164	70301.063	105451.594	158177.391
6	46897.825	75036.52	112554.78	168832.17

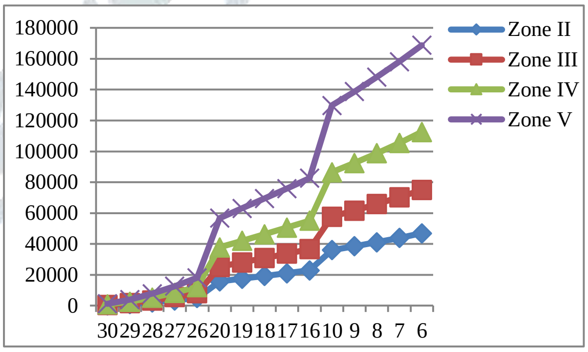

Figure 9 comparison of bending

Torsion

Table 11 torsion for various zones

Storey No.	Zone II	Zone III	Zone IV	Zone V
30	1639.9558	2623.9293	3935.8939	5903.8408
29	3332.4586	5331.9337	7997.9006	11996.8509
28	4809.631	7695.4096	11543.1145	17314.6717
27	6022.7896	9636.4633	14454.6949	21682.0424
26	6967.3357	11147.737	16721.6058	25082.4087
20	9140.6883	14625.101	21937.6519	32906.4779
19	9513.6041	15221.767	22832.6499	34248.9748
18	10035.953	16057.525	24086.287	36129.4304
17	10647.684	17036.294	25554.4412	38331.6618
16	11289.128	18062.605	27093.9075	40640.8613
10	14499.364	23198.982	34798.4727	52197.7091
9	15346.889	24555.022	36832.5329	55248.7994
8	16334.979	26135.966	39203.9494	58805.9241
7	17414.143	27862.628	41793.9424	62690.9135
6	18529.324	29646.919	44470.3781	66705.5672

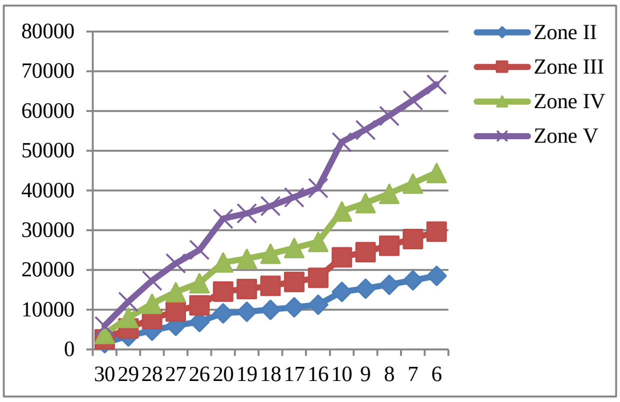

Figure 10 comparison of torsion

Findings:

The behavior of high rise structure for both the scheme has been investigated and results are obtained from mathematical modeling of proposed models. The figure 3 to figure 10 depicts the comparison result of storey drift, storey acceleration, time period, base shear, shear, bending and torsion. Additionally, it is noted that the results of the static analysis are more conservative than those of the dynamic method, leading to an uneconomical structure in both zone 4 and zone 5.

- When compared to other storeys, storey 31 exhibits the greatest amount of storey drift, which increases from top to bottom story in both zones 4 and 5.
- In comparison to zone 4, zone 5 has a higher drift value.
- When compared to forces in all floors, zone 4 and zone 5 experience the highest levels of storey shear. It is seen that zone5 has higher value of shear as compare to zone4.
- When compared to X direction and Y direction support reactions in zones 4 and 5, the Z direction force for support reactions has the highest value.
- When compared to the Y direction moment and the Z direction moment in zones 4 and 5, the X direction moment for support reactions has the highest value.
- For forces and times in support reactions, zone 5 has a higher maximum value than zone 4.
- The software will be able to retrieve the complete list of failed beams and will also provide a higher section.
- Details of each and every member have been obtained with the use of ETABS.
- Design time is reduce and accuracy is improved using ETABS

VI. CONCLUSIONS & FUTURE WORK

We have been successfully carried out design of G+30 building structure using ETAB software. The performance analysis of design has done for 4 zones. Additionally, it is noted that the results of the static analysis are more conservative than those of the dynamic method, leading to an uneconomical structure in both zone 4 and zone 5. Extensive investigations can be carried out with a variety of factors and traits as future work. Additionally, the inclusion of a soft storey in the model as well as various loadings on various building levels must be taken into account.

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