

Dynamic Seismic Analysis and Design of R.C.C Multi Purpose Building (G+15) By using E-Tabs

T.G.N.C. Vamsi Krishna, V. Amani, P.S. Sunil Kumar, CH. Naveen Kumar, M.Srinivas



Abstract: An earthquake is a sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface. Earthquakes are among the most powerful events on earth, and their results can be terrifying. In general for design of tall buildings both wind as well as earthquake loads need to be considered. Governing criteria for carrying out dynamic analyses for earthquake loads are different from wind loads. However many tall buildings are not so resistant in lateral loads due to earthquake. Reinforced concrete multi-storied buildings in India were for the first time subjected to a strong ground motion shaking in Bhuj earthquake. It has been concluded that the principal reasons of failure may be attributed to soft stories, floating columns, mass irregularities, poor quality of construction materials faulty construction methods, unstable earthquake response, soil and infrastructure, which were determined to cause damage to the attached structure. High-rise buildings are in high demand due to global urbanization and population growth, and high-rise buildings are likely to suffer the most damage from earthquakes. Since earthquake forces are irregular and unnatural in nature, engineering tools need to be sharpened to analyze the structure in the work of these forces. In this study, to understand the behaviour of structure located in seismic zones III for G+15 Multi-Purpose storey building model is considered for study. Performance of frame is studied through Response Spectrum analysis and comparison is made on shear force, storey drift, storey displacement and storey stiffness.

Keywords: Earthquake, analysis, structures, urbanization

I. INTRODUCTION

An earthquake is a sudden tremble or movement of the earth's crust which originates naturally at or below the surface. The word regular is vital here, since it prohibits stun waves caused by atomic tests, man-made blasts and so forth. The whole world is comprised of plates.

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The intersection between the two plates is called as fault. This fault in the Indian Context is the main boundary, fault extending through the terrain region all the way from west along Himachal Pradesh through Uttaranchal, Bihar, Assam to Burma. That plate descends through Andaman-Nicobar Islands and Bay of Bengal and into Indonesia. As the plate moves the rocks are subjected to stress, suddenly a fracture develops and this fracture is called as an earthquake.

In The present study we are using E-tabs software to design the Building in seismic zone III and to different the property and its results.

1.1 Affect of Earthquakes on Reinforced Concrete Buildings

A common RC building is made up of members of the floor (beam and slab) and floor members (floor and wall) and is supported by the foundation on the ground. The system consists of an RC frames The RC frame participates in resting the earthquake forces. Earthquake shaking generates inertia forces in the building, which are proportional to the building mass. Since most of the building mass are present at the ground level, the energy generated by the earthquake is mainly developed at the ground level. These energies go down - through the slabs and beams to the pillars and walls, and then from the foundation to the ground. As the inactive energy accumulates from the top of the building, the pillars and walls of the ground floor experience more earthquake power and are therefore designed to be more powerful than the people on the upper floor.

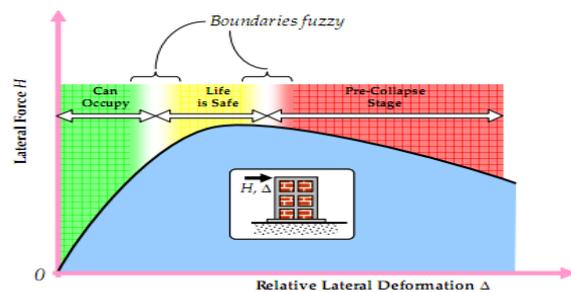


Figure 1. Seismic Performance of the building.

1.2 Seismic Zone Map of India & Recent Earthquakes

Earthquakes have been occurring in the Indian sub-continent from the time immemorial but reliable historical records are available for the last 200 years (Oldham,1883). From the beginning of the 20th century, more than 700 earthquakes of magnitude 5 or more have been recorded and felt in India. The seismicity of India is divided into four groups, namely Himalayan region, Andaman Nicobar, Kutch Region, and Peninsular India.



The goal of seismic zoning is to delineate regions of probable intensity of ground motion in a country, for providing a guideline for provision of an adequate earthquake resistance in constructed facilities. The first comprehensive seismic zoning map was developed by the Bureau of Indian Standards in 1962. Later in the subsequent years it was reviewed many times and thus a four zone seismic zoning map was adopted in IS 1893:2002. The map is based on expected intensity of ground shaking but does not consider the frequency of the occurrence. Current seismic zoning map as per IS 1893-2002 says that around 60% (Zone V= 12%, Zone IV=18%, Zone III = 26% and Zone II 44%) of India is prone to moderate to major earthquakes. Accordingly, zone factors (z) are defined for each zone to arrive at the design seismic force acting on the structure. Zone II corresponds to intensity VI or lower and zone V corresponds to intensity IX or higher. Zone II has lowest danger or risk while Zone - V has highest hazards. Since damage controlled limit state has been accepted, the zone factor, z has been reduced to half (z/2) of Maximum Considered Earthquake (MCE) for Design Basis Earthquake (DBE). Structures are explicitly designed for DBE and maximum considered earthquake is taken care of through over strength and ductility provisions.

Table 1: Showing the number of zones in different years.

Year of Release of Zone Maps			
1962	1966	1984	2002
0	0	I	II
I	I		
II	II	II	III
III	III		
IV	IV	VI	IV
V	V	V	V
VI	VI		

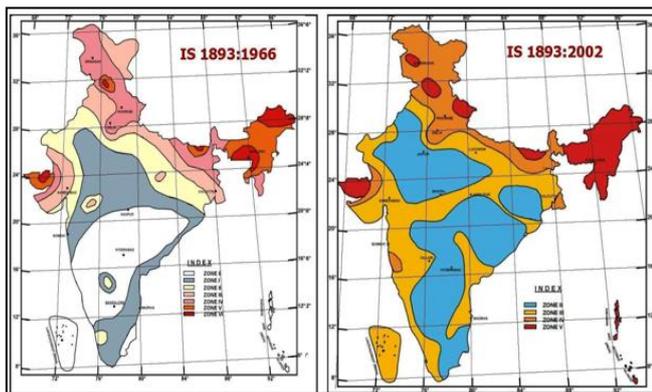


Figure 2: Seismic zoning maps of India I.S. 1893:1966 and IS1893:2002

II. LITERATURE REVIEW

Balaji U & Selvarasan in 2012 studied the G + 13 storey residential building. The building was analyzed for earthquake load using ETABS. The properties of the material were assumed to be simple and stable and dynamic analysis was performed. These non-linear analyzes were carried out with a second type of soil condition in view of the severe earthquake area and behavioural assessment. Different reactions such as displacement and base shear

were calculated and it was found that displacement increases with building height.

Mahesh N. Patil, Yogesh N. Sonawane studied the seismic analysis of an 8-story building in 1998. 22.5 m x 22.5-m, multi-storey common structure considered for study. Floor to floor height is considered as 3 m. Modelling and analysis of the structure is done in ETABS software The structure is analyzed and the results generated by the software are compared with the manual analysis of the structure using IS 1893: 2002.

The. Mahesh, B. Pandurangarao and others studied residential buildings of normal and irregular structures (G + 11) for earthquakes and wind loads using 2008 ETABS and staad pro V8i. Material property is considered to be static, dynamic and dynamic analysis for different seismic zones and for each zone; Behaviour was assessed using three different types of soils, namely hard, medium and soft. The authors have compared the general and irregular structures to the following theories,,

- The base shear standards and story drift values were more in regular configuration than irregular configuration.
- Base shear value was more in the zone 5 and that in the soft soil in regular configuration.
- Story drift value was more in the story 13 in the regular configuration.

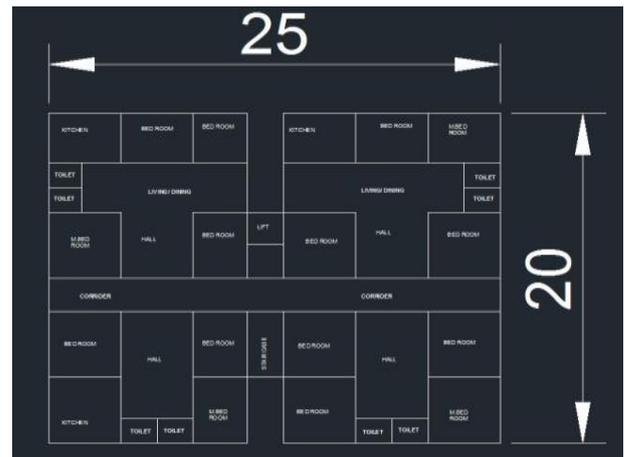


Figure 3. Residential floor plan for second to 15th floor

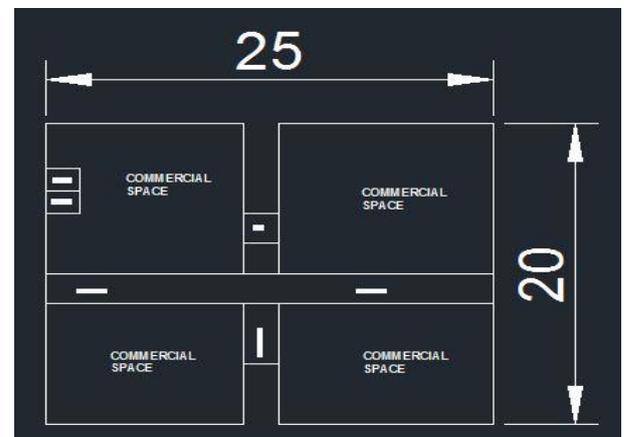


Figure 4. commercial floor plan for ground and 1st floor

III. MODELING

3.1 Structural Modelling Of G+15 Floor Rcc Building

Table 2: Showing the properties taken into consideration for modelling the structure

Type	Residential	Commercial
Live Load	2 KN/m ²	3 KN/m ²
Floor finish and ceiling load	2 KN/m ²	2 KN/m ²
Density of RCC considered:	25kN/m ³	25kN/m ³
Height of the structure	55.65 m	55.65 m
Thickness of slab	125mm	150 mm
Grade of Concrete	M25	M25
Depth of beam	480mm	480mm
Width of beam	300 mm	300 mm
Dimension of column	900* 600 mm, 1400 * 600 mm	900* 600 mm, 1400* 600 mm
Height of each floor	3.05 m	3.05 m
Depth of foundation	3 m	3 m
Earthquake Zone	III	III
Damping Ratio	5%	5%
Importance factor	1	1
Type of Soil	Medium soil	Medium soil
Type of structure	Special Moment Resisting Frame	Special Moment Resisting Frame
Response reduction Factor	5	5

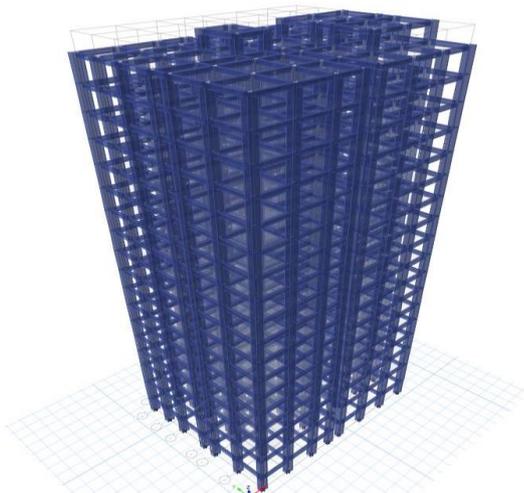


Figure 5. 3D View of structure

IV. ANALYSIS AND RESULTS

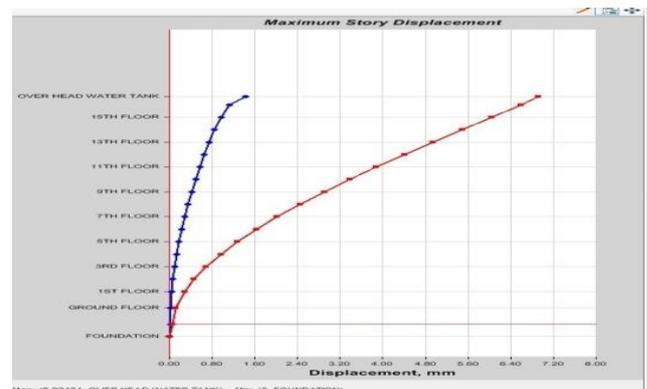
4.1 Storey Displacement

The lateral displacement of each story due to the lateral forces from base of the building or structures is known as story displacement. Story displacement results for the structures with various cases for all the models as tabulated below.

Table 3: Storey Displacement of the structure

Story	Elevation	Location	X-Dir	Y-Dir
	m		mm	mm
OVER HEAD WATER TANK	55.65	Top	1.424	6.925
TERRACE FLOOR	53.65	Top	1.121	6.598
15TH FLOOR	50.6	Top	0.963	6.048
14TH FLOOR	47.55	Top	0.839	5.494
13TH FLOOR	44.5	Top	0.736	4.945
12TH FLOOR	41.45	Top	0.645	4.406
11TH FLOOR	38.4	Top	0.562	3.883
10TH FLOOR	35.4	Top	0.486	3.387
9TH FLOOR	32.35	Top	0.414	2.905
8TH FLOOR	29.3	Top	0.346	2.449
7TH FLOOR	26.25	Top	0.284	2.024
6TH FLOOR	23.2	Top	0.227	1.631
5TH FLOOR	20.15	Top	0.176	1.276
4TH FLOOR	17.1	Top	0.131	0.961
3RD FLOOR	14.05	Top	0.092	0.689
2ND FLOOR	11	Top	0.061	0.463
1ST FLOOR	7.95	Top	0.037	0.284
GROUND FLOOR	3.95	Top	0.015	0.118
STILT	-0.05	Top	0.022	0.048
FOUNDATION	-3	Top	0	0

Result : from the table it is seen that the maximum displacement is occurring at top of the structure at over head tank which is 6.925mm.



Graph 1: The graph showing the maximum displacement value of the structure.

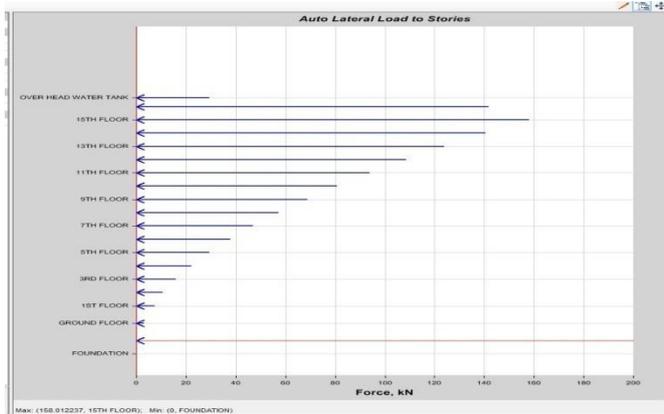
4.2 Lateral loads

Lateral loads are important when facing side loads such as earthquakes and wind loads. The lateral displacement structure depends on the height of the structure and the slenderness of the structure because the lateral load becomes more flexible and the height of the structure becomes weaker and the structure becomes weaker.

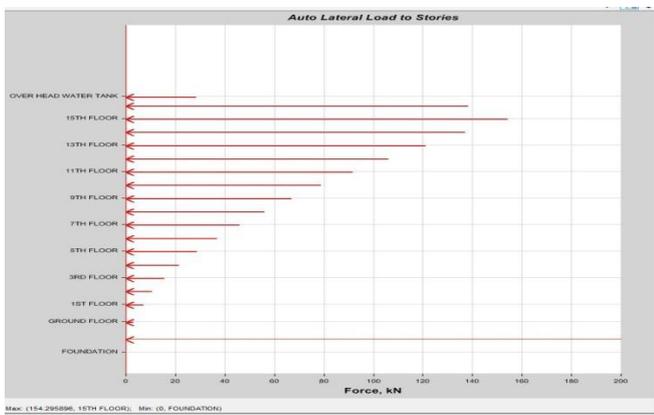
Table 4: Seismic loading of the structure

Story	X-Dir kN	Y-Dir kN
OVER HEAD WATER TANK	29.2898	28.6009
TERRACE FLOOR	141.7423	138.4086
15TH FLOOR	158.0122	154.2959
14TH FLOOR	140.5411	137.2357
13TH FLOOR	124.0933	121.1747
12TH FLOOR	108.6688	106.1129
11TH FLOOR	93.9311	91.7219
10TH FLOOR	80.8111	78.9105
9TH FLOOR	68.729	67.1125
8TH FLOOR	57.3807	56.0312
7TH FLOOR	47.0558	45.949
6TH FLOOR	37.7541	36.8661
5TH FLOOR	29.4756	28.7824
4TH FLOOR	22.2205	21.6979
3RD FLOOR	15.9886	15.6125
2ND FLOOR	10.78	10.5264
1ST FLOOR	7.4912	7.315
GROUND FLOOR	3.2337	3.1576
STILT	0.3281	0.3204
FOUNDATION	0	0

Result : from the table it is seen that the maximum lateral load is occurring at 15th floor which is 154.2959 KN for x-direction and 158.0122 KN for y-direction



Graph 2: The graph showing the maximum lateral load occurring at x- direction.

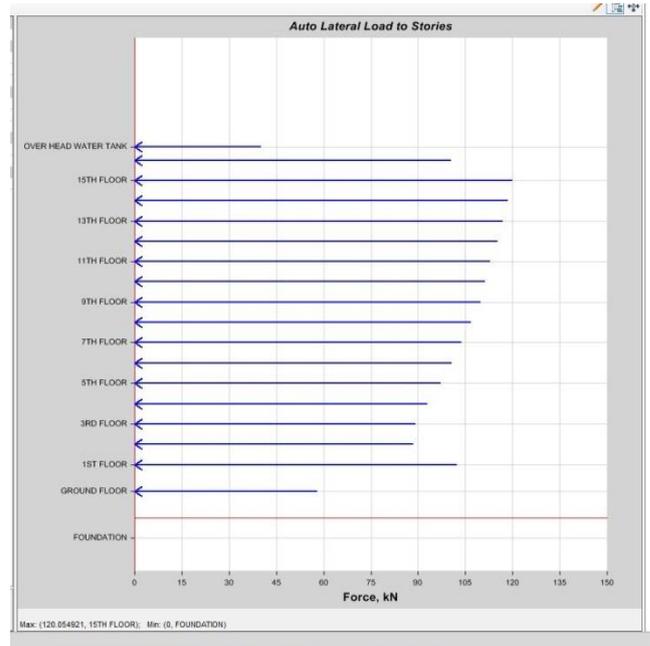


Graph 3: The graph showing the maximum lateral load occurring at y- direction.

Table 5: Wind load on structure

Story	X-Dir kN
OVER HEAD WATER TANK	40.0989
TERRACE FLOOR	100.5367
15TH FLOOR	120.0549
14TH FLOOR	118.4566
13TH FLOOR	116.8689
12TH FLOOR	115.292
11TH FLOOR	112.8021
10TH FLOOR	111.2307
9TH FLOOR	109.8196
8TH FLOOR	106.8007
7TH FLOOR	103.7955
6TH FLOOR	100.6507
5TH FLOOR	97.1567
4TH FLOOR	93.0727
3RD FLOOR	89.2814
2ND FLOOR	88.4672
1ST FLOOR	102.2448
GROUND FLOOR	58.0112
STILT	0
FOUNDATION	0

Result : from the table it is seen that the maximum lateral load is occurring at 15th floor which is 120.0549 KN for x-direction



Graph 4: The graph showing the maximum lateral load occurring at x- direction

4.3 Overturning Moment

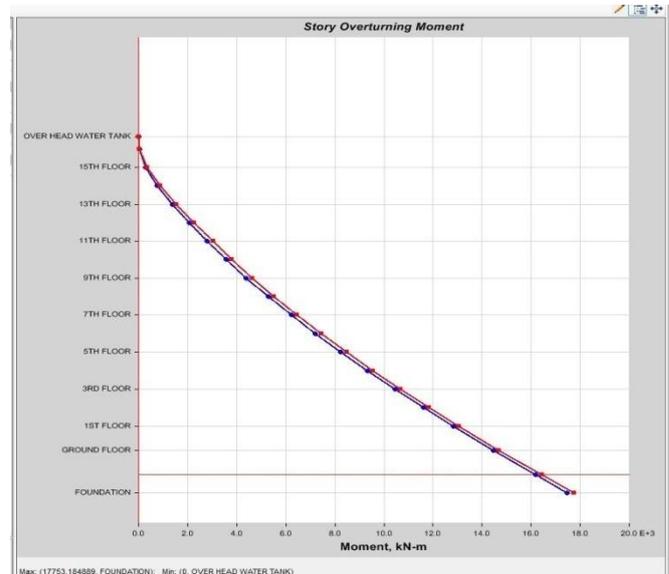
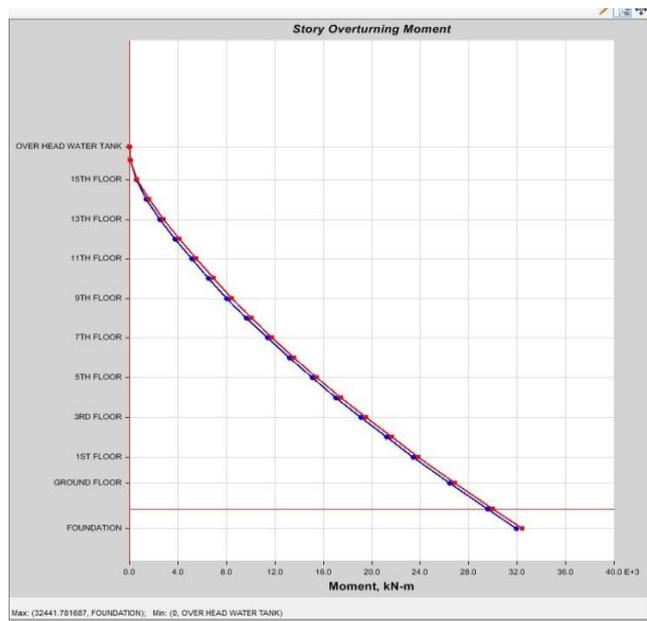
The "overturning moment" at any horizontal plane is the moment on the structure as a whole resulting from the dynamic earthquake forces above the plane, giving due regard to signs of the modal forces.



Table 6: overturning moment of the structure

Story	RS-X		RS-Y	
	X-Dir	Y-Dir	X-Dir	Y-Dir
	kN-m	kN-m	kN-m	kN-m
OVER HEAD WATER TANK	0	0	0	0
TERRACE FLOOR	55.9053	69.4934	30.5932	38.029
15TH FLOOR	533.9396	641.2355	292.1889	350.9046
14TH FLOOR	1390.5539	1616.7875	760.9557	884.7581
13TH FLOOR	2500.7158	2826.7116	1368.472	1546.867
12TH FLOOR	3758.7967	4146.2733	2056.934	2268.974
11TH FLOOR	5106.9736	5521.6853	2794.7	3021.644
10TH FLOOR	6511.8768	6935.0117	3563.508	3795.061
9TH FLOOR	8034.4758	8460.0719	4396.723	4629.623
8TH FLOOR	9658.9213	10084.2554	5285.672	5518.428
7TH FLOOR	11377.6761	11798.8587	6226.23	6456.714
6TH FLOOR	13180.7623	13595.6118	7212.936	7439.955
5TH FLOOR	15066.6029	15477.7448	8244.929	8469.919
4TH FLOOR	17038.5877	17451.0962	9324.063	9549.8
3RD FLOOR	19094.6614	19510.9082	10449.21	10677
2ND FLOOR	21225.2421	21643.7782	11615.13	11844.17
1ST FLOOR	23422.9297	23843.3131	12817.78	13047.83
GROUND FLOOR	26415.566	26848.3418	14455.45	14692.28
STILT	29547.3185	30015.0122	16169.24	16425.18
FOUNDATION	31934.3626	32441.7817	17475.51	17753.18

Result: from the table it is seen that the maximum overturning moment is occurring at foundation level which is the 31934.3626 KN-m at y-direction



Graph 5 & 6: The graph showing the maximum overturning moment occurring at x-y direction

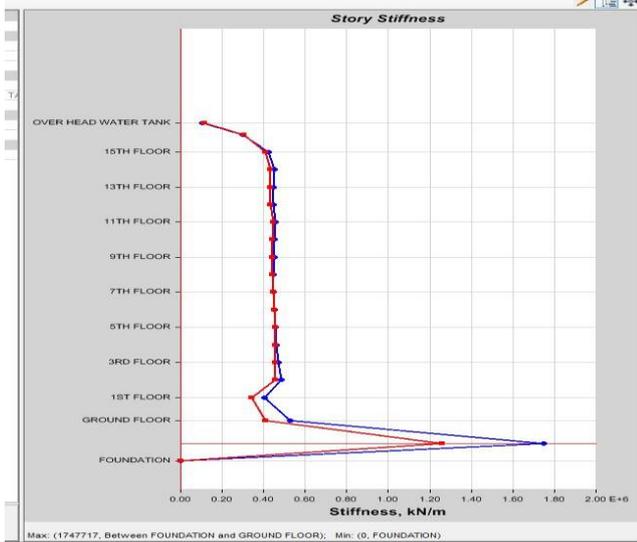
4.4 Storey Stiffness

Stiffness is the rigidity of any object or material. Objects with a high stiffness will resist changes in shape when being acted on by a physical force

Table 7. Storey Stiffness of the structure

Story	X-Dir	Y-Dir
	kN/m	kN/m
OVER HEAD WATER TANK	102516.98	115128.213
TERRACE FLOOR	299660.196	303318.685
15TH FLOOR	423752.263	409718.143
14TH FLOOR	452933.653	433864.257
13TH FLOOR	448888.275	434221.306
12TH FLOOR	444187.12	433093.293
11TH FLOOR	454792.674	444670.255
10TH FLOOR	450646.801	440986.123
9TH FLOOR	449719.042	443098.129
8TH FLOOR	446472.788	443463.46
7TH FLOOR	446307.73	444875.305
6TH FLOOR	450977.913	449046.733
5TH FLOOR	456967.787	454185.19
4TH FLOOR	461505.658	457470.301
3RD FLOOR	467988.432	458314.251
2ND FLOOR	485210.613	457718.673
1ST FLOOR	402761.589	342880.242
GROUND FLOOR	528667.468	407112.232
STILT	1747716.785	1257035.574
FOUNDATION	0	0

Result: from the table it is seen that the maximum stiffness is seen at between foundation and ground floor at stilt level which is the 1747716.785 KN-m.



Graph 7: The graph showing the maximum stiffness occurring at stilt floor

4.5 storey shear

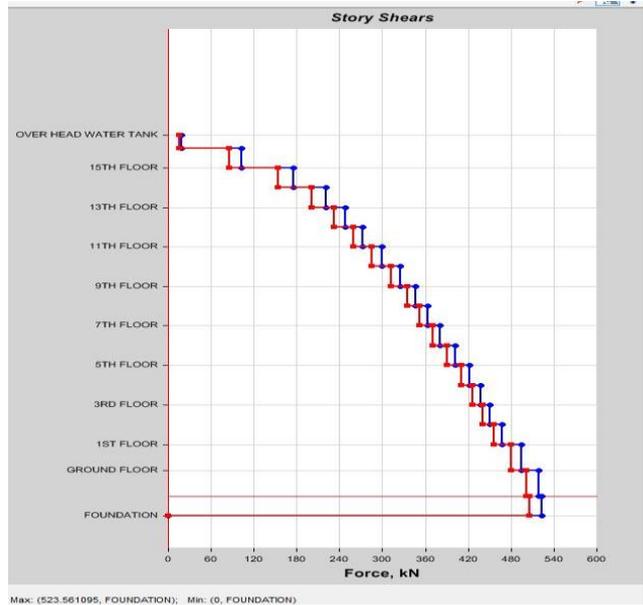
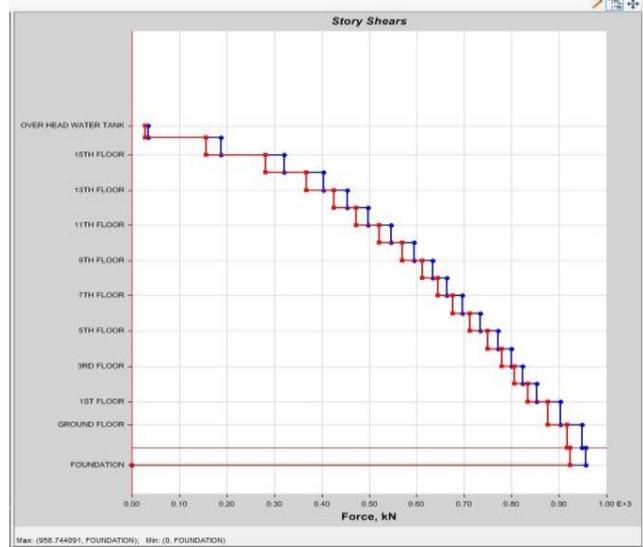
It is defined as the lateral force acting on each story in horizontal direction during earthquake, and the maximum lateral shear should always maximum at the base of the building which is termed as the Base shear. Maximum Story Shear for RS along X & Y Axis The Shear force at the base of the structure so obtained is been plotted for X and Y direction.

Table 8. Storey shear of the structure

Story	RS	
	X-Dir kN	Y-Dir kN
OVER HEAD WATER TANK	34.7467	19.0145
	34.7467	19.0145
TERRACE FLOOR	187.5282	102.6215
	187.5282	102.6215
15TH FLOOR	321.1261	175.7305
	321.1261	175.7305
14TH FLOOR	403.0815	220.5791
	403.0815	220.5791
13TH FLOOR	453.1093	247.9559
	453.1093	247.9559
12TH FLOOR	496.8741	271.9055
	496.8741	271.9055
11TH FLOOR	546.2329	298.9162
	546.2329	298.9162
10TH FLOOR	595.0718	325.6424
	595.0718	325.6424
9TH FLOOR	633.7858	346.828
	633.7858	346.828
8TH FLOOR	664.2049	363.4743
	664.2049	363.4743
7TH FLOOR	696.3322	381.0553
	696.3322	381.0553
6TH FLOOR	734.2589	401.81
	734.2589	401.81
5TH FLOOR	770.9456	421.8862
	770.9456	421.8862
4TH FLOOR	799.0286	437.2541
	799.0286	437.2541
3RD FLOOR	822.4837	450.0895
	822.4837	450.0895
2ND FLOOR	853.4781	467.0506
	853.4781	467.0506

1ST FLOOR	903.5893	494.4731
	903.5893	494.4731
GROUND FLOOR	949.1208	519.3894
	949.1208	519.3894
STILT	956.7441	523.5611
	956.7441	523.5611
FOUNDATION	0	0
	0	0

Result: from the table it is seen that the maximum storey shear is observed at bottom of the structure which is the structure which is 956.74 KN in x-direction and 523.56 in y-direction.



Graph 8&9 : The graph showing the maximum storey shear at bottom of the structure

4.6 Storey Drift

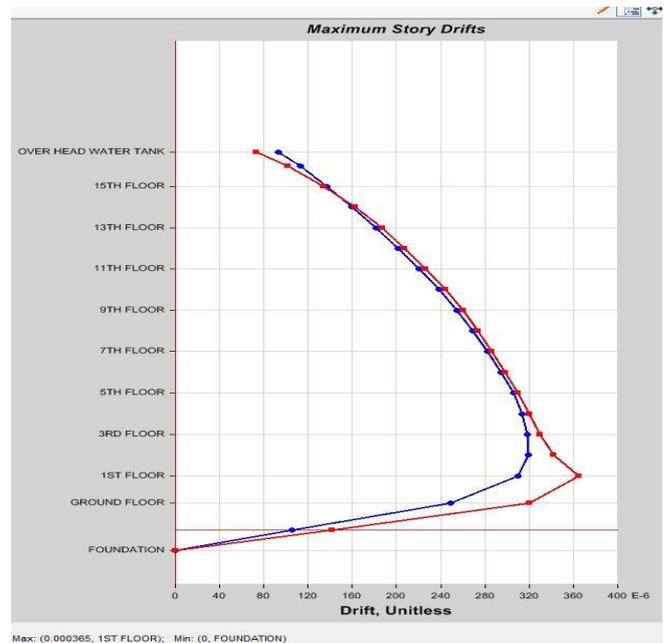
story drift is the lateral displacement of one level relation to the level above or below



Table 9: storey drift of the structure

Story	X-Dir	Y-Dir
OVER HEAD WATER TANK	0.00017	0.000093
TERRACE FLOOR	0.000207	0.000113
15TH FLOOR	0.00025	0.000137
14TH FLOOR	0.000292	0.00016
13TH FLOOR	0.000332	0.000182
12TH FLOOR	0.000368	0.000202
11TH FLOOR	0.000403	0.00022
10TH FLOOR	0.000436	0.000239
9TH FLOOR	0.000465	0.000255
8TH FLOOR	0.000492	0.000269
7TH FLOOR	0.000516	0.000282
6TH FLOOR	0.000539	0.000295
5TH FLOOR	0.000558	0.000306
4TH FLOOR	0.000573	0.000314
3RD FLOOR	0.000582	0.000319
2ND FLOOR	0.000583	0.000319
1ST FLOOR	0.000567	0.00031
GROUND FLOOR	0.000455	0.000249
STILT	0.000192	0.000105
FOUNDATION	0	0

Result: from the table it is seen that the maximum Storey drift is observed at first floor of the structure which is the 0.00066 For X-Direction

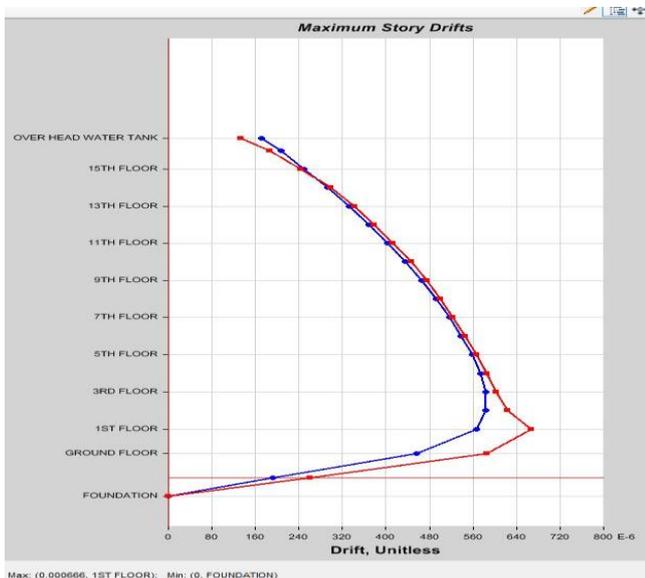


Graph 10 & 11: The graph showing the maximum storey drift

V. CONCLUSIONS

In the project report a structural model is considered where in a model is subjected to wind and seismic loads along with their corresponding behaviours and results are extracted and interpreted. Various parameters such as displacements, storey drifts, storey force, storey Stiffness, and base shear have been considered. Hence from the obtained results the following conclusions are drawn,

1. Maximum lateral storey displacement occurs at terrace floor level of the structure model.
2. Maximum Storey drift usually occurs at mid height level and goes on decreasing from mid height towards roof level.
3. As the height of the building increases storey acceleration also increases and is also directly proportional to the seismic intensity.
4. The seismic forces are more concentrated at the base of the building hence the resistive Storey force by the building will be more at the lower storey.
5. As the seismic intensity increases the base shear of the building also increases correspondingly.
6. It is clear that as the seismic intensity increases the response of the building varies accordingly.
7. The seismicity/ the resistive force of the building against the seismic force is directly proportional to the intensity of the earthquake as the intensity increases seismicity of the building increases proportionally.
8. As the seismicity of the building increases care should be engaged by the structural engineers to oppose the seismic energy and to safe guard the building.
9. The maximum displacement is occurring at top of the structure at over head tank which is 6.925mm
10. The maximum lateral load is occurring at 15th floor which is 154.2959 KN for x-direction and 158.0122 KN for y-direction



11. The maximum overturning moment is occurring at foundation level which is the 31934.3626 KN-m at y-direction
12. The maximum stiffness is seen at between foundation and ground floor at stilt level which is the 1747716.785 KN-m
13. The maximum storey shear is observed at bottom of the structure which is the structure which is 956.74 KN in x-direction and 523.56 in y-direction.
14. That the maximum Storey drift is observed at first floor of the structure which is the 0.00066 For X-Direction.

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