Study on seismic analysis of high-rise building by using software

Seismic Analysis in software of STAAD pro v8i (Ground +3 Basements + 50 storeys)

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***ABSTRACT*: This paper addresses the Case study on seismic analysis of high rise building system (Ground+ 3Basements+50) storey RCC by STAAD pro v8i with application of Indian standard provisions. One of the most frightening and destructive phenomena of a nature is a severe earthquake and it terrible after effect. It is highly impossible to prevent an earth quake from occurring, but the damage to the buildings can be controlled through proper design and detailing. Hence it is mandatory to do the seismic analysis and design to structures against collapse. Designing a structure in such a way that reducing damage during an earthquake makes the structure quite uneconomical, as the earth quake might or might not occur in its life time and is a rare phenomenon. This study mainly on to understanding the results from STAAD Pro v8i software under gravity loads provision made in IS 456:2000, Results shall satisfy the general criteria from being a failure after analysis Results to improve The accuracy as per IS code 1893 : 2002.**

I INTRODUCTION

High-rise buildings are constructed everywhere in the world. The height and Size of high-rise buildings gets larger and larger. The structural design of high-rise buildings depends on dynamic analysis for winds and earthquakes. Since today performance of computer progresses remarkably, almost structural designers use the software of computer for the structural design of high-rise buildings. Hence, after that the structural plane and outline of high-rise buildings are determined, the structural design of high-rise buildings which checks structural safety for the individual structural members is not necessary outstanding structural ability by the use of structural software on the market. However, it is not exaggeration to say that the performance of high-rise buildings is almost determined in the preliminary design stages which work on multifaceted examinations of the structural form and outline.

Traditionally, seismic design approaches are stated, as the structure should be able to ensure the minor and frequent shaking intensity without sustaining any damage, thus leaving the structure serviceable after the event. The structure should withstand moderate level of earthquake ground motion without structural damage, but possibly with some structural as well as non-structural damage. This limit state may correspond to earthquake intensity equal to the strongest either experienced or forecast at the site. In present study the effect of bare frame, brace frame and shear wall frame is studied under the earthquake loading. The results are studied for response spectrum method. The main parameters considered in this study to compare the seismic performance of different models are storey drift, base shear, story deflection and time period.

II OBJECTIVE OF THE WORK

- The main objective of high rise structure:
- To analyze the building as per code IS 1893-2002 part I criteria for earthquake resistant structure.
- Dynamic analysis of the building using response spectrum method.
- Building with different lateral stiffness systems.
- To get economical and efficient lateral stiffness system.
- To control the future population.
- To deal with energy and environmental challenges.
- Development of a city.

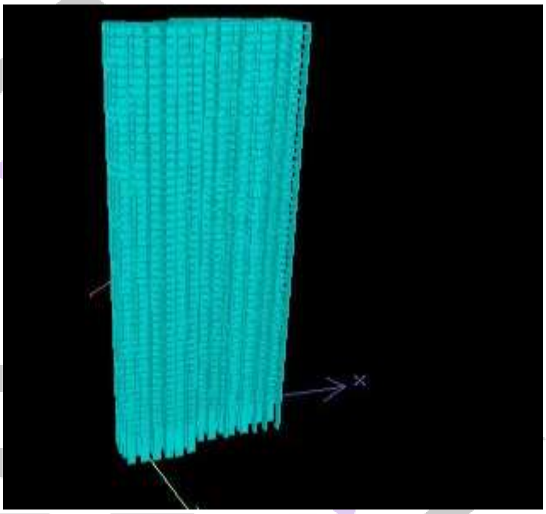
III SCOPE OF THE WORK

- Recently there has been a considerable increase in the number of tall buildings, both residential and commercial, and the modern trend is towards taller structures. Thus the effects of lateral loads like winds loads, earthquake forces are attaining increasing importance and almost every designer is faced with the problem of providing adequate strength and stability against lateral loads. For this reason to estimate wind load and earthquake loading on high-rise building design.

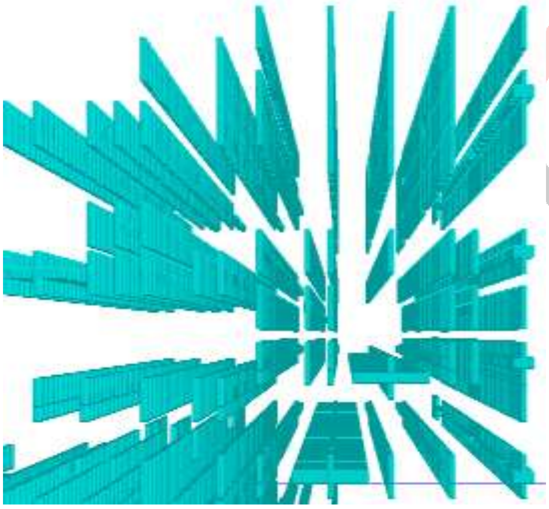
- Considering the ever increasing population as well as limited space, horizontal expansion is no more a viable solution especially in metropolitan cities. There is enough technology to build super-tall buildings today, but in India we are yet to catch up with the technology which is already established in other parts of the world.
- Many times, wind engineering is being misunderstood as wind energy in India. On the other hand, wind engineering is unique part of engineering where the impact of wind on structures and its environment being studied. More specifically related to buildings, wind loads on claddings are required for the selection of the cladding systems and wind loads on the structural frames are required for the design of beams, columns, lateral bracing and foundations. Wind in general governs the design

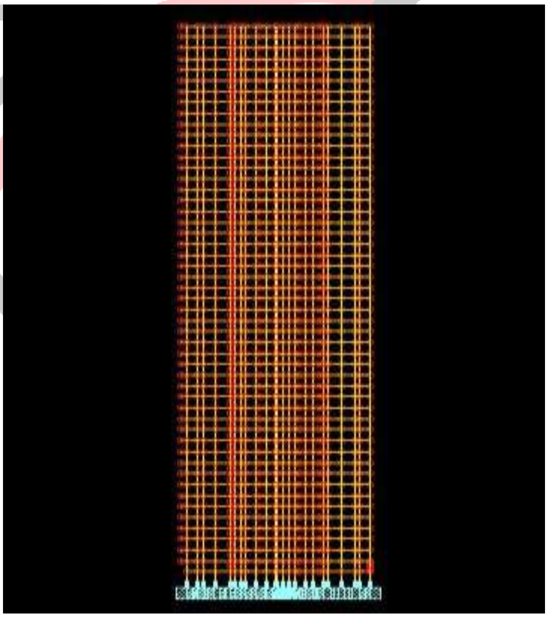
III METHODOLOGY

A. **Framing of plan**:- Plan that will require in order to analyse the respective structure as for understanding the result properly as height goes above further practices create complications for that proper biferfication is necessary with proper practices



KEY PLAN **MODEL**





LONG WALLS **SKELETAL STRUCTURE**

B. **Input loading:-**

Dead load and live loads (AS PER IS 875 PART II , IS 1893:2002)

Load description	value/units
Superimposed load on each floor	
• Live load	2 KN /M^2
• 230 mm thickness external wall	13.12KN/M
• 115 mm thickness internal wall	6.6 KN/M
Additional service load over roof top	
• Water proofing load	3 KN /M^2
• Live load	2 KN/M^2
• Service load	5 KN/M^2

Material properties

Concrete: - M40 N/MM^2 , Steel:- 500 N/MM^2

Concrete density: - 25, **KN/ M^3**: brick work - 22 **KN/ M^3**

Load combination will be as per IS 1893:2002 PART 1

For general RCC purpose will be as per IS 456:2000

Site details

Seismic zone: - 4 (as per IS 1893:2002 fifth revision)

City: - Mumbai, Maharashtra region

Floor height = 3m

Load combinations that been considered As per IS 1893:2002 PART 1

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

Reaction will be consider for worse load combination in analysis while designing vertical structural member (column / shear wall)

C. **Calculations:-** As per clause 7.8.1 Dynamic analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral load resisting elements, for the following buildings:

In this study, G+3B+50 storied RC Building has been analyzed using the response spectra method in STAAD-Pro. The plan and elevation of the building taken for analysis is shown in above images . In the earthquake analysis along with earthquake loads, vertical loads are also applied. For the earthquake analysis, IS 1893-2002 code was used .The total design seismic base shear (Vb) along any principal direction shall be determined by multiplying the design horizontal acceleration in the considered direction of vibration (Ah) and the seismic weight of the building.

The Design base shear
(Vb) = **Ah** x **W** [IS 1893(Part I):2002, clause **7.5.3**]

Ah = design horizontal acceleration in the considered direction of vibration =

(Z/2) x **(I/R)** x **(Sa /g)** [IS 1893(Part I):2002, clause **6.4.2**]

W = total seismic value of the building
The design base shear (Vb) computed shall be distributed along the height of the building as per the following expression (BIS1893: 2000)

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

[IS 1893(Part I):2002, clause **7.1.1**]

Where,
Qi is the design lateral forces at floor i,
Wi is the seismic weights of the floor i, and

Hi is the height of the floor i, measured from base

Design seismic load

The approximate fundamental natural period of vibration (Ta), in seconds, of all other buildings,
Including moment-resisting frame buildings with brick infill panels, may be estimated by empirical expression:

Ta = **0.09 h /√d**
[IS 1893(Part I):2002, clause **7.6.2**]

Calculating value

In X direction for, Ta (d= 53.09 meter)

Ta = 0.09 x 150 / √53.09 = 1.852 seconds

In Z direction for, Ta (d= 20.65 meter)

Ta = 0.09 x 150 / √20.65 = 2.970 seconds

NOW ,

Zone factor, Z = **0.24** for seismic zone IV
[IS 1893(Part):2002, table 2]

Importance factor, I = **1.0** table 6

Response reduction factor, R = **5.0** (SMRF – special moment resisting frame)

Soil type = medium soil

Damping % ratio = **5** % (assume)

For Sa / g value,

1.36 / Ta(X direction)= 1.36 /1.852 = **0.734** seconds

1.36 / Ta(X direction)= 1.36 /2.970 = **0.457** seconds

Value of Ah from above expression could we get,

Ah = 0.0176 (In x direction) ; Ah = 0.0109 (In z direction)

Therefore,

W = 100 % DL + 25 % LL .... Seismic weight of building

W = 680245.43 **KN**

Then,

Vb = Ah x W .... base shear

Vb = (Z/2) x (I/R) x (Sa /g) x W

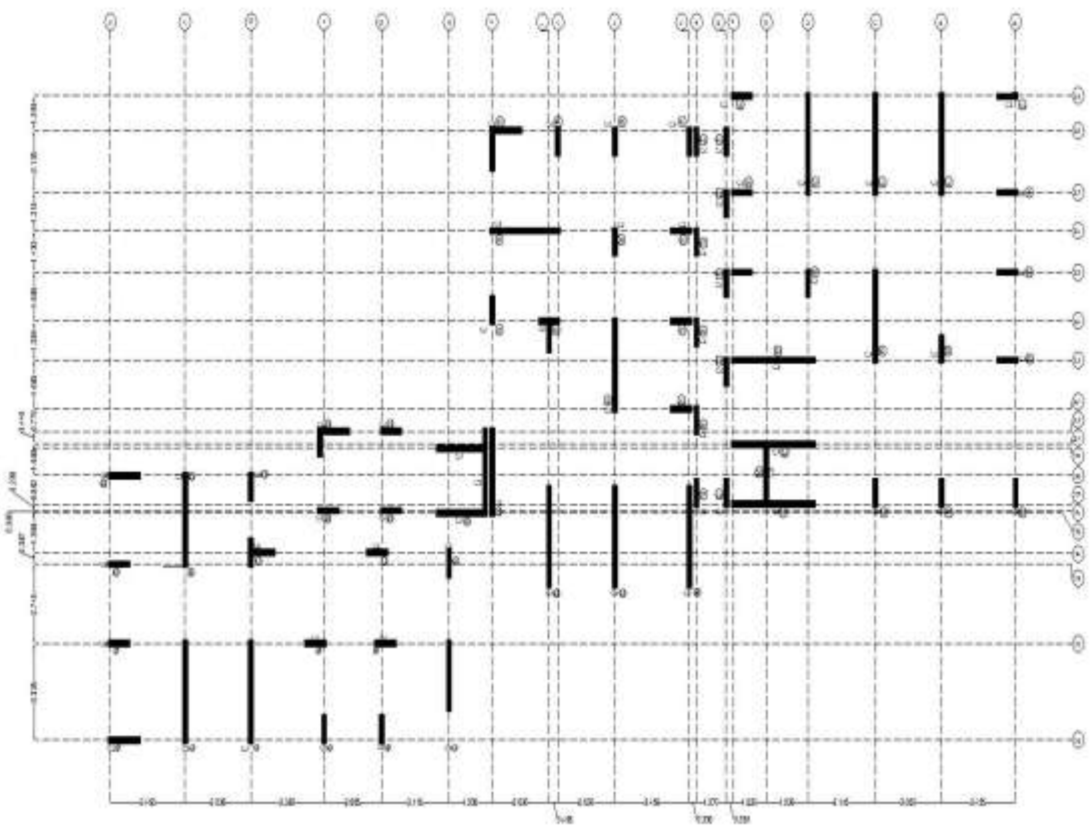
= 0.0176 x 680245.43

= 11972.31 KN (x direction)

&

Vb = (Z/2) x (I/R) x (Sa /g) x W

= 0.0109 x 680245.4 = 7414.67 KN (z direction)



CENTRE LINE PLAN

IV. Results

Table 1.1 (per story shear**)**

Storey	level In meter	peak storey
	X	Z (KN)
50	135.00	2641.02
49	132.00	3022.15
48	129.00	3384.17
47	126.00	3726.52
46	126.00	4048.79
45	120.00	4350.69
44	117.00	4632.07
43	114.00	4892.92
42	111.00	5133.41
41	108.00	5353.86
40	105.00	555.78
39	102.00	5728.22
38	99.00	5877.05
37	96.00	6008.20
36	93.00	6127.74
35	90.00	6241.24
34	87.00	6342.33
33	84.00	6432.74
32	81.00	6514.33
31	78.00	6589.09
30	75.00	6659.11
29	72.00	6726.52
28	69.00	6793.46
27	66.00	6862.03
26	63.00	6934.25
25	60.00	7011.99
24	57.00	7096.92
23	54.00	7190.49
22	51.00	7293.82
21	48.00	7407.75
20	45.00	7532.77
19	42.00	7669.01
18	39.00	7816.30
17	36.00	7971.29
16	33.00	8124.29
15	30.00	82889.90
14	27.00	8459.73
13	24.00	8631.56
12	21.00	8805.92
11	18.00	8988.71
10	15.00	9204.20
9	12.00	9445.12
8	9.00	9660.52
7	6.00	9848.16
6	3.00	10004.57
5	0.00	10176.66
4	-2.80	10242.28
3	-5.20	10288.33
2	-8.40	10316.23
1	--11.20	10326.39
Base	-14.20	10326.45

Calculated frequency for first 6 modes that software just calculated as below

Table 1.2

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)	ACCURACY
1	0.137	7.31097	1.052E-15
2	0.176	5.67043	4.919E-14
3	0.192	5.20709	7.145E-13
4	0.252	3.96507	9.393E-12
5	0.475	2.10445	9.292E-08
6	0.536	1.86628	3.691E-07

Modal mass participation in % (after the iteration of 300)

MASS PARTICIPATION FACTORS IN PERCENT, BASE SHEAR IN **KN (table 1.3)**

MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z	X	Y	Z
1	19.51	0.00	47.34	20.511	0.001	47.343	2598.31	0.00	2160.26
2	48.24	0.00	23.18	70.747	0.002	70.521	8282.11	0.00	6890.74
3	8.49	0.00	0.14	79.237	0.005	70.656	1587.57	0.00	1319.7
4	0.04	0.00	0.12	79.275	0.005	70.777	9.330	0.00	0.00
5	0.05	0.00	0.16	86.324	0.006	70.940	22.70	0.00	0.00
6	10.28	0.00	2.27	90.606	0.007	73.215	5363.64	0.00	4882.47

As per clause **7.8.2** [IS 1893:2002] the base shear (VB) from response spectrum is less than the base shear (vb) calculated using empirical formula for fundamental time period multiplying factor are :-

(vb/VB) = 11973 / 5363.64 = 2.23 (X direction)

(vb/VB) = 7414 / 4882.47 = 1.51 (Z direction)

Seismic weight of general model in dynamic equilibrium is as follows

MODAL WEIGHT (MODAL MASS TIMES G) IN **KN (table:- 1.4)**

MODE	X	Y	Z	WEIGHT
1	2.7935557E+04	1.246851E+04	6.955578E+04	3.547164E+04
2	6.906343E+04	1.477191E+00	3.405194E+04	5.662841E+04
3	1.215680E+04	4.435340E+00	1.985320E+02	1.762951E+04
4	5.438716E+01	2.710154E-02	1.776414E+02	7.870725E+03
5	7.024110E+01	1.092947E+00	2.394500E+02	9.778552E+03
6	1.472071E+04	1.458399E+00	3.342232E+03	3.559350E+04

Reactions (for the worse condition):- (**Table 1.5**)

Node no.	Horizontal	Vertical	Horizontal		Moments	
	Fx (KN)	**Fy (KN)**	**Fz (KN)**	**Mx (KNm)**	**My (KNm)**	**Mz (KNm)**
2281	7.961	12304.34	-3.174	-4.583	-2.508	-109.305
2283	18.714	11577.60	-3.242	-4.649	-1.588	-98.865
2284	21.285	6311.45	7.722	9.179	-2.764	-28.69
2286	-18.622	24123.53	24.408	1627.67	-15.563	29.615
2288	17.532	5060.89	-53.261	-85.78	-1.852	-24.785
2289	-2.354	3538.27	3.953	6.163	2.429	-2.980
2290	-51.462	22469.22	133.69	1915.41	3.366	70.053
2292	-13.191	5296.45	-32.64	-48.644	-5.586	19.151
2293	-52.165	25333.32	156.109	2501.09	-0.206	72.573
2294	0.521	4261.33	5.543	8.340	-1.842	-5.756
2295	-140.58	6585.29	-15.231	-21.05	-6.280	148.623
2296	-67.65	6182.57	-16.105	-22.00	-2.109	60.226
2297	5.349	25926.83	1.203	573.703	-6.520	-19.232
2298	3.860	4250.38	0.227	0.573	-0.402	-10.310

2299	31.793	11349.34	-3.686	-5.101	-2.428	-96.835
2300	-52.947	9602.35	-4.357	-5.791	-3.005	84.220
2301	46.21	5741.500	-8.880	-7.262	5.227	-54.238
2302	25.276	26577.57	90.745	4164.70	12.417	-44.681
2303	-9.666	5417.820	-64.271	-95.598	-0.656	15.188
2304	-1.271	11082	-185.99	-219.350	1.027	-7.317
2305	4.686	5040.667	-0.450	2.526	-2.392	-12.208
2303	-9.666	5417.820	-64.271	-95.598	-0.656	15.188
2304	-1.271	11082.055	-185.992	-219.350	1.027	-7.317
2305	4.686	5040.66	-0.450	2.526	-2.392	-12.208
2306	8.773	24881.416	366.932	6866.805	-20.869	-29.261
2307	-12.859	5441.938	-47.312	-71.086	-7.198	15.667
2308	-17.823	6480.8	-41.063	-56.618	-12.406	9.386
2309	6.187	5261.869	-32.329	-48.198	-5.687	-13.777
2312	-7.919	7457.670	-1.2228	1.046	0.365	8.232
2313	218.138	31122.83	2.910	23.048	3.767	-2363.18
2314	-4.723	7731.80	2.892	5.637	0.596	5.470
2315	16.485	5121.85	3.599	5.817	-0.739	-2363.18
2316	13.255	7076.87	1.871	3.686	0.465	-23.658
2317	5.199	6708.70	0.475	2.277	0.505	-15.893
2318	7.588	5860.554	0.882	2.694	0.196	-21.385
2319	26.433	29246.20	58.826	2028.95	-2.131	-57.028
2322	11.811	7217.38	2.112	4.403	0.771	-20.280
2323	-7.993	7956.861	0.682	2.504	0.608	9.422
2324	-7.110	8202.004	0.223	2.017	2.841	10.32
2325	20.186	5543.79	2.537	4.462	0.240	-33.661
2327	15.851	4913.68	0.538	2.367	-0.095	-29.641

Node no.	Horizontal	Vertical	Horizontal		Moments	
	Fx (KN)	**Fy (KN)**	**Fz (KN)**	**Mx (KNm)**	**My (KNm)**	**Mz (KNm)**
2328	4.736	5334.75	1.682	3.600	-0.160	-17.755
2329	4.639	16874.02	42.218	1022.060	-0.733	-17.955
2330	12.425	16366.23	41.274	1578.47	-4.365	-28.332
2331	19.720	4057.91	1.600	3.518	-0.222	-32.776
2334	-2.849	4099.270	-15.525	-22.001	0.854	-1.538
2335	39.225	20338.994	-495.475	-791.29	-5.276	-2619.76
2336	9.629	5303.35	-15.513	-22.163	4.357	-28.854
2337	4.631	1856.959	-41.292	-63.902	-7.125	-8.509
2336	9.629	5303.35	-15.513	-22.163	4.357	-28.854
2337	4.631	1856.95	-41.292	-63.902	-7.125	-5.509
2339	0.000	92.774	0.000	0.000	0.000	0.000
2340	0.000	92.774	0.000	0.000	0.000	0.000
2341	88.542	6179.854	-124.893	-154.720	3.577	-105.563
2342	189.270	11110.483	-139.06	-163.40	7.797	-188.363
2343	64.331	7536.136	-27.630	-34.262	4.469	-45.606
2344	182.418	10841.271	-14.497	-21.245	20.689	-139.380
2347	9.543	17419.24	40.076	1587.234	3.830	-25.619
2350	-3.796	7190.52	53.098	254.632	3.378	8.239
2352	-564.47	47209.07	1201.091	8586.13	-88.975	695.097
2353	-53.966	4582.868	-32.169	-27.931	2.662	58.236
2356	-60.364	10509.024	41.164	246.077	4.185	94.784
2369	-11.887	2911.958	-17.027	-23.290	2.407	16.277
2370	-13.088	21980.48	-55.613	-82.650	3.727	17.487
2371	119.810	15306.870	-113.327	-178.619	17.730	-1551.12
2372	2.495	1818.812	-52.309	-79.131	6.333	-5.529

V. CONCLUSION:- In our Case study we found that in table no.1.3 due to unsymmetrical of building geometry modes are not resisting 90 % as its satisfying in X direction successfully after carried out 300 iteration of analysis in such case cut off mode must be add in it & need to check either stiffness of building shall be increase or not. In table no. 1.4 after carried results of 6 modes the building seismic weight was found to be as **3.559350 x 10^4 KN.** As we can see from table no. 1.1 the maximum story shear was found to be at the base as **10326.45 KN.**

Another important term clause like 7.8.2 from IS 1893:2002 (PART 1) The multiplying factor of static and dynamic equilibrium in X & Z direction was found to be **vb/VB) =** 11973 / 5363.64 = **2.23** (X direction) where as in z direction are , **(vb/VB) =** 7414 / 4882.47 = **1.51** (Z direction). Meaning of adopting tall building for Response spectra analysis is to study the results by using staad pro software with provision of IS 1893:2002 (PART 1) successfully and it is studied. Seismic analysis with Response Spectrum Method with CQC method are used for analysis of a 3Basement + Ground + 50 story RCC high rise building as per IS 1893(Part1):2002.

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