Effect of Seismic and Wind on Behavior of Multi-Story Buildings with Rectangular, Square and T-Shaped Plan

Pratik Patil[1], P. R. Barbude[2], S.A. Rasal[3]
[1]*Post Graduate Student, Dept. of Civil Engineering, Datta Meghe College of Engineering, Airoli, Navi Mumbai 400708, Maharashtra, India*
[2,3]*Assistant Professor, Dept. of Civil Engineering, Datta Meghe College of Engineering, Airoli, Navi Mumbai 400708, Maharashtra, India*

***Abstract*—The demand for high-rise buildings has grown significantly in modern construction. As structures become taller, they face increased vulnerability to seismic and wind loads, making structural protection essential. Consequently, comprehensive research into altering plan configurations is required to develop structurally robust and cost-effective designs. By varying parameters such as story drift, acceleration, and fundamental time period, engineers can better evaluate building performance. This study builds upon existing literature from various researchers to identify geometric shapes that minimize adverse response parameters. Therefore, plan configuration plays a pivotal role and must be carefully optimized within practical design constraints. Seismic activity remains a primary consideration in structural engineering, often evaluated through comparisons between regular and irregular plan shapes. Research indicates that irregular geometries exhibit distinct seismic responses, and variations in configuration produce substantial behavioral changes across different performance metrics. Ultimately, simpler plan layouts tend to deliver the most efficient structural outcomes.**

***Index Terms*—Seismic, High-raised Building, Structural Analysis.**

I. INTRODUCTION

Due to rapid population growth, land scarcity, and soaring real estate costs in global urban centers, multi-story buildings have become increasingly common. However, as structures grow taller, they become more vulnerable to lateral forces primarily wind and seismic loads. Consequently, advanced construction techniques and robust design methodologies are implemented to safeguard high-rises against these environmental pressures. Numerous studies have been conducted to enhance structural performance under such loads. Among various strategies, modifying the building's floor plan geometry is recognized as one of the most effective, straightforward, and cost-efficient approaches. While rectangular layouts were historically standard, a wide array of diverse plan configurations is utilized today. Consequently, it is essential to analyze and compare the behavior of buildings with different shapes across various structural parameters to determine the most optimal design layout.

II. CORRESPONDING LITERATURE

Md. Mahmud Sazzad et al. (2015) [1] carried out the seismic & wind analysis of 6 story building with three different plan shapes i.e. rectangular with hollow space, modified cross shaped& L-shaped by using computer aided analysis & Bangladesh National Building Code (BNBC),2006. The comparison has been done by considering the parameters such as base shear, displacement & story drift. It has been concluded that rectangular with hollow space model is safest considering all the conditions &shape of building has noticeable effect in minimizing the drift of building.

Albert Philip et al. (2017) [2] carried out seismic analysis of G+12 storied reinforced concrete building with regular and irregular plan shape using CSI ETABS software for earthquake zone III in India. The analysis was carried out by adopting response spectrum analysis method. The comparison has been done by considering the parameters such as story displacements, story drifts, story shear and stiffness. It has been concluded that story displacement increases linearly with height of building. Maximum story drift

occurred at second floor for irregular structure &at fourth floor for regular structure. Maximum story shear force was observed between ground floor and second floor for regular structure and at ground floor for irregular structure. Story stiffness varies non- linearly for both the structures.

Jalal Mushina Obeed et al. (2013) [3] carried out the seismic analysis & wind analysis of 50 story T shaped irregular building located in zone V and by using E-tabs software. Wind load analysis was done by gust factor method and seismic analysis was done by response spectrum method. The comparison has been done by considering the parameters such as shear force, base shear, torsion, bending moment &displacement. It has been concluded that shear force and torsional moment are higher in case of irregular building compared to regular building and bending moments in regular buildings are higher compared to irregular building. The displacement of irregular building is more as compared to regular building under wind loads. The displacement in irregular is less compared to regular building under seismic loads.

Anupam Rajmani et al. (2015) [4] carried out seismic analysis and wind analysis of15, 30 and 45 story's building with circular, rectangular, square and triangle plan shape using STAAD-PRO software. The comparison has been done by considering the parameters such as wind load, earthquake load, and node displacement. It has been concluded that circular shape and triangular shape is most stable for maximum earthquake and maximum wind load for 15 story structure respectively. In case of 30 storied building, rectangular shape is most stable for maximum earthquake and wind load. In case of 45 storied building circular shape &rectangular shape is most stable for maximum earthquake and wind load respectively.

Megha Kalra et al. (2016) [5] carried out wind analysis of50 storied building having different plan shapes such as rectangular, L, U, T, I, Plus, and non-uniform shape by using STAAD Pro software &IS 875-Part III. The comparison has been done by considering the parameters such as story drift, joint displacement, intensity & bending moment. It has been concluded that L-shape and U-shape.

T. Prasanthi et al. (2017) [6] performed seismic analysis of G+20 storied RC building to study the structural behaviour of building for different plan configurations like rectangular and C- shape. Seismic analysis has been carried by static and response spectrum analysis by using ETABS computer program. The comparison has been done by considering the parameters such as structural displacements, drifts, story shear, overturning moment and stiffness. It has been concluded that rectangular shape building have more stiffness than C shape building. The values of base shear and top story displacement are higher in response spectrum analysis than in static analysis.

Athulya Ullas et al. (2017) [7] performed wind analysis of buildings having various shapes such as Y, Plus and V. Buildings of plan shapes Y, Plus and V are modeled in ETABS 2016 and analyzed. It is observed that the story force is same for all the buildings, i.e. the story force does not change with the shape. The lateral displacement is found maximum for V shape building. The story drift is observed maximum for Y shape as compared to that of other shapes and the lateral displacement and the story drift are observed minimum for Plus shape building as compared to Y and V shape buildings and hence it is the most structurally stable shape among the selected shapes.

Alhamd Farqaleet et al. (2016) [8] carried out the dynamic analysis of ten story RCC building frame rectangular in plan using nonlinear time history analysis method in SAP2000.The comparison has been done by considering the parameters such as base shear, story drift, and story displacements. It has been concluded that story drift increases from base to top floor. The maximum drift obtained for a ten-story building was within the permissible limits.

Aniket A. Kale et al. (2017) [9] carried out the wind &seismic analysis 15, 30 & 45 storied buildings of four different shapes of same area by using advance software CSIETABS. Response spectrum method was used to find the dynamic effects. The comparison has been done by considering the parameters such as story displacement, story drift, base shear, overturning moments Mz, acceleration &time period. It has been concluded that for maximum earthquake structure of 15-story is most stable structure &for maximum wind effect triangular structure of 15-story is most stable. For 45-story circular & rectangular shape building is most stable for maximum earthquake & wind effect respectively. Wind effect is critical for 45 story's building &on the other hand seismic is critical at 15 story & 30 story building. Wind effect is more critical than earthquake.

III. OBJECTIVES OF THE STUDY

The primary objective of this study is to develop high-rise building models using the ETABS software environment. The structural performance of tall buildings under seismic and wind loading will be investigated along with examination of various building plan geometries while maintaining a constant floor area. The impact of wind and earthquake loads on various structural components within the building is assessed. Also, the most efficient high-rise building shape for lateral load resistance through comparative analysis shall be identified and distinct plan configurations influence on structural behavior when subjected to wind and earthquake actions is to be identified.

IV. METHOD OF ANALYSIS

1. Wind Analysis: Wind load effects will be evaluated using ETABS 2018 software.
2. Response Spectrum Analysis: This approach is more scientifically rigorous than the seismic coefficient method and is specifically recommended by IS codes for high-rise buildings. It offers a more accurate seismic evaluation technique by explicitly considering the dynamic characteristics of the structure. It is also widely known as the spectral method. Correction factors are applied to the spectra to account for varying soil conditions, as outlined in IS 1893.

V. STRUCTURAL MODELLING

The following factors are noted during the analysis: The story shear of the structure should be minimized. The natural time period of the building should be extended. The overall structural moment should be reduced. The inter-story drift should be kept low. The floor acceleration should be higher. The lateral stiffness across the stories should be increased. All three plan configurations individually in relation to these six parameters are examined.

A. Rectangular Shaped Building

This is the module describing rectangular shaped building with six discussed parameters

1. Base Shear in X & Y Direction

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure.

Table 1: Base Shear in X & Y Direction for Rectangular Shaped Building

Story Level	Maximum Vx	Maximum Vy
Terrace	230.1028	1691.3984
30th	345.1543	363.935
29th	477.6176	3085.7472
28th	637.8213	644.4832
27th	716.4264	3738.2955
26th	958.7223	775.3056
25th	1028.6523	1053.8578
24th	853.7961	3639.3126
23rd	1280.6941	1295.1505
22nd	1280.6941	3160.9613
21st	1538.3154	1556.3485
20th	1476.5903	2568.8135
19th	1798.4688	1820.3714
18th	1626.3054	1893.6659
17th	1162.8658	1643.3776
16th	2039.8317	2065.6364
15th	2502.0538	1726.0517
14th	2263.1312	2292.8657
13th	3675.4113	1830.6023
12th	2469.0941	2502.7798
11th	2029.4085	1939.0981
10th	4984.2732	2156.8788
9th	2658.4465	2696.0985
8th	5594.6274	1446.6389
7th	2831.9142	2873.5407
6th	5285.8965	2169.9584
5th	2990.2228	3035.8245
4th	4669.5112	2280.924
3rd	3134.0973	2546.9336
2nd	3134.0973	3183.667
1st	4570.8309	1851.2912
Ground	3264.2624	3317.7845

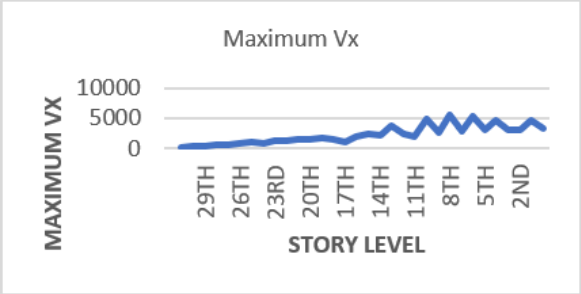


Fig 1(a): Graph of Story Level vs Maximum Vx (Rectangular Shaped Building)

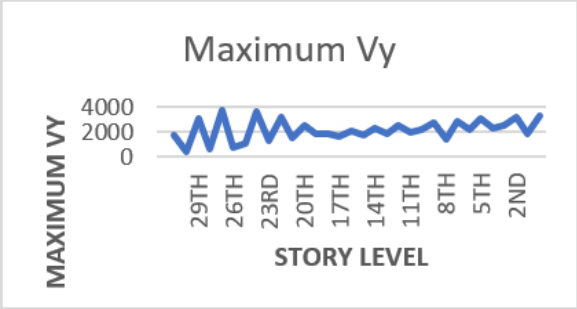


Fig 1(b): Graph of Story Level vs Maximum Vy (Circular Shaped Building)

2. Time Period

The approximate fundamental natural period of vibration (Ta), in seconds

Table 2: Time Period for Rectangular Shaped Building

Mode	Period (seconds)
1	4.475
2	3.787
3	1.348
4	1.17
5	0.715
6	0.637
7	0.454
8	0.412
9	0.3
10	0.276
11	0.155
12	0.143

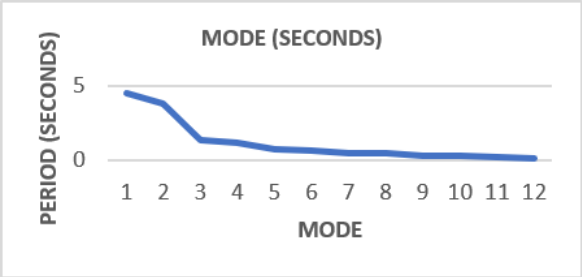


Fig 2: Graph of Mode vs Period (Rectangular Shaped Building)

3. Overall, Moment in X & Y Direction

It is the amount of overall bending moment in X & Y direction generated by the structure as per ETABS 2018 Software referring to IS:456 & IS 1893, etc.

Table 3: Overall, Moment for Rectangular Shaped Building

Story Level	Maximum Mx	Maximum My
Terrace	94116.96	690.3085
30th	85992.7649	-47250.864
29th	125892.48	2122.5063
28th	188838.7199	-123320.4332
27th	173729.9249	29.6694
26th	283560.4799	4176.5196
25th	262390.4431	0.000007718
24th	378282.2399	6727.1511
23rd	351759.6152	-271851.6366
22nd	473003.9998	9652.6298
21st	441639.7269	-345620.4252
20th	441639.7269	49.3013
19th	567725.7598	12844.909
18th	531867.1341	0.0218
17th	662447.5198	16218.6435
16th	623816.4573	-489520.4405
15th	757169.2797	19716.3286
14th	716200.8143	-560356.1294
13th	712950.4138	32.4543
12th	851891.0397	23308.1502
11th	803724.4361	24.9031
10th	946612.7997	26986.6822
9th	902808.9689	-700069.8216
8th	1041334.56	30758.3113
7th	996935.3509	-769049.6662
6th	985791.4963	34634.4358
5th	1136056.32	-837509.1075
4th	1077138.366	17653.7197
3rd	1230778.08	38625.3447
2nd	1168717.574	0
1st	1325499.84	42738.1522
Ground	1282064.459	-973046.515

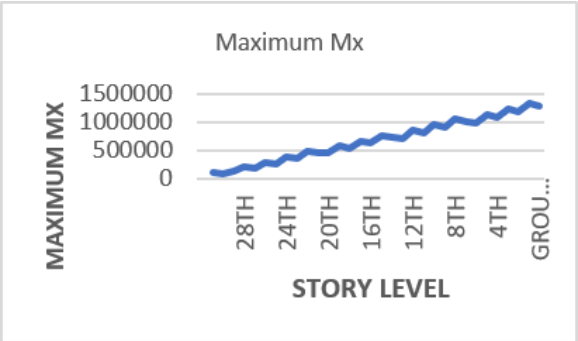


Fig 3(a): Graph of Story Level vs Maximum Mx (Rectangular Shaped Building)

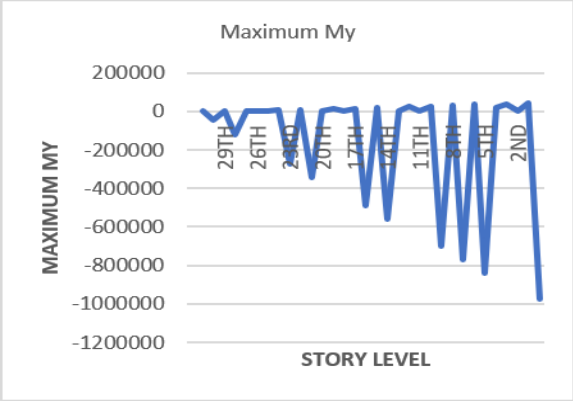


Fig 3(b): Graph of Story Level vs Maximum My (Rectangular Shaped Building)

4. Inter Story Drift

Inter-story drift of building structures is defined as the relative translational displacement difference between two consecutive floors.

Table 4: Inter Story Drift for Rectangular Shaped Building

Story Level	Maximum Drift
Terrace	0.002948
30th	0.001093
29th	0.000885
28th	0.001113
27th	0.001092
26th	0.001092
25th	0.000988
24th	0.001211
23rd	0.001065
22nd	0.001331
21st	0.001449
20th	0.001043
19th	0.001564
18th	0.001673
17th	0.001183
16th	0.001775
15th	0.001246
14th	0.00187
13th	0.001956
12th	0.001357
11th	0.002035
10th	0.002106
9th	0.002106
8th	0.002168
7th	0.001482
6th	0.002223
5th	0.00227
4th	0.001553
3rd	0.002309
2nd	0.001592
1st	0.00234
Ground	0.002362

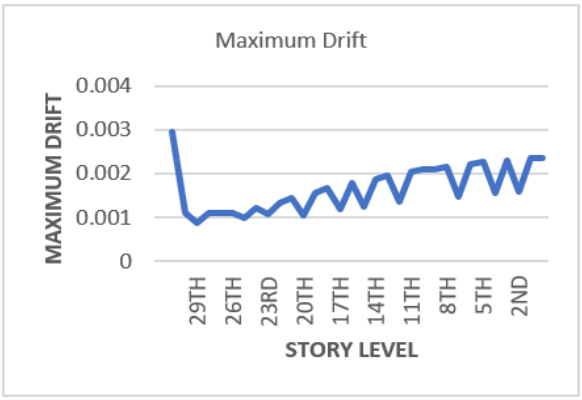


Fig 4: Graph of Story Level vs Story Drift (Rectangular Shaped Building)

5. Story Acceleration

Inter-story drift of building structures is defined as the relative translational displacement difference between two consecutive floors.

Table 5: Acceleration for Rectangular Shaped Building

Story Level	Maximum Ux	Maximum Uy	Maximum Uz
Terrace	405.73	432.7	20.2
30th	342.51	353.92	20.05
29th	281.96	280.8	19.75
28th	235	231.72	19.27
27th	215.15	222.72	18.63
26th	221.85	240.73	17.83
25th	238.95	262.39	16.93
24th	251.3	272.6	15.95
23rd	253.37	268.66	14.95
22nd	248.72	257.34	13.97
21st	245.86	252.44	14.07
20th	251.27	260.5	14.35
19th	262.78	274.12	13.52
18th	272.23	283.21	12.37
17th	272.75	281.39	12.05
16th	264.27	270.93	12.92
15th	254.78	262.92	14.1
14th	255.2	269.04	14.44
13th	267.91	285.65	13.64
12th	282.94	298.57	12.65
11th	288.82	297.76	13.41
10th	284.57	287.36	16.21
9th	283.61	286.94	18.84

8th	301.24	311.65	19.18
7th	330.74	345.87	16.92
6th	346.54	359.83	15.52
5th	333.71	343.86	20
4th	315.23	331.46	26.32
3rd	340.65	371.48	27
2nd	391.09	427.24	18.92
1st	375.96	402.13	15.41
Ground	324.24	248.56	33.31

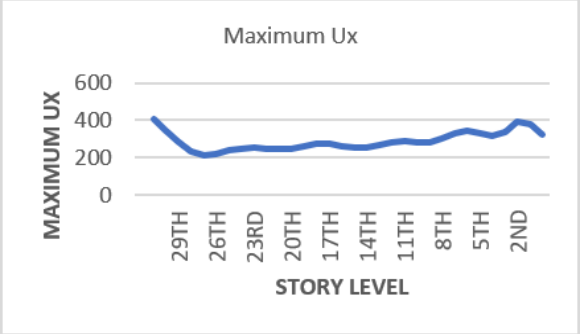


Fig 5(a): Graph of Story Level vs Maximum Ux (Rectangular Shaped Building)

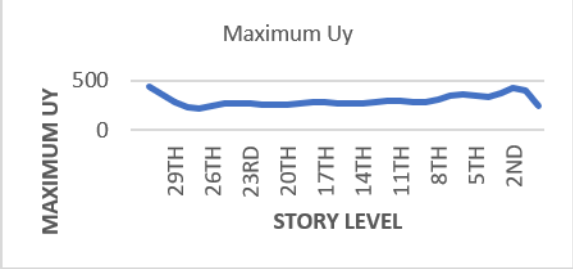


Fig 5(b): Graph of Story Level vs Maximum Uy (Rectangular Shaped Building)

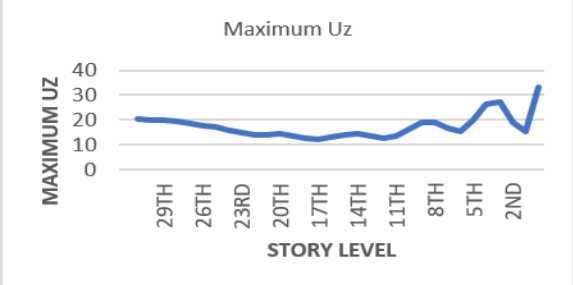


Fig 5(c): Graph of Story Level vs Maximum Uz (Rectangular Shaped Building)

6. Story Stiffness in X & Y Direction

Story stiffness of building structures is defined as the lateral force producing unit translational lateral deformation in that story, with the bottom of the story restrained from moving laterally, i.e., only translational motion of the bottom of the story is restrained while it is free to rotate.

Table 6: Story Stiffness for Rectangular Shaped Building

Story Level	Maximum Stiffness X	Maximum StiffnessY
Terrace	297737.396	196833.406
30th	550859.814	369870.251
29th	695620.794	474497.408
28th	768668.354	529675.908
27th	800197.271	553986.817
26th	809433.349	561367.68
25th	808518.125	561692.11
24th	805138.197	561301.045
23rd	803481.377	563154.572
22nd	804724.796	567350.674
21st	807964.668	572397.456
20th	811596.4	576712.339
19th	814546.363	579635.554
18th	816825.059	581642.058
17th	819289.98	583860.255
16th	822879.299	587255.407
15th	827838.656	591987.663
14th	833484.959	597376.783
13th	838720.09	602526.045
12th	842968.673	607149.714
11th	846886.559	612015.73
10th	852250.3	618617.587
9th	860939.048	628250.263
8th	873823.593	641342.828
7th	890993.389	658076.262
6th	913981.729	680410.166
5th	948677.778	714108.622
4th	1006336.063	768822.055
3rd	1102743.003	857366.752
2nd	1267734.874	1006070.117
1st	1614063.704	1320570.878
Ground	2600320.381	2202666.134



Fig 6(a): Story Level vs Stiffness X (Rectangular Shaped Building)

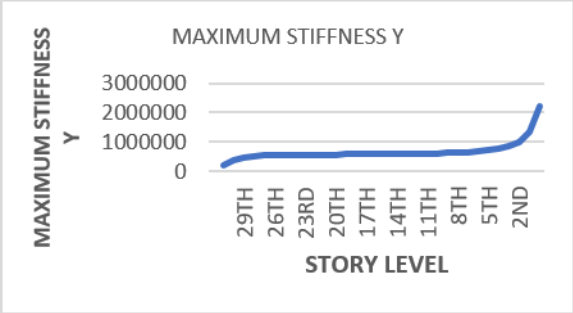


Fig 6(b): Story Level vs Stiffness Y (Rectangular Shaped Building)

B. Square Shaped Building

This is the module describing C shaped building with six discussed parameters

1. Base Shear in X & Y Direction

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure.

Table 7: Base Shear in X & Y Direction for Square Shaped Building

Story Level	Maximum Vx	Maximum Vy
Terrace	175.2099	1454.0557
30th	259.8347	259.8539
29th	355.4159	2785.0525
28th	531.208	531.208
27th	533.1239	3778.1119
26th	787.7343	630.1875
25th	787.7343	931.7093
24th	753.7708	4320.0491
23rd	1027.286	1027.286
22nd	991.4292	4356.6178
21st	1250.4537	1250.4537
20th	1169.8012	3880.2868
19th	1457.828	1457.828
18th	1315.4017	3084.3459
17th	1323.0796	2934.8188
16th	1649.9994	1649.9994
15th	1238.2163	2825.273
14th	1827.5583	1827.5583
13th	2410.2537	2385.9809
12th	1991.0953	1991.0953
11th	1614.9383	1792.631
10th	3820.21	1712.9608
9th	2141.201	2141.201
8th	4848.0904	1541.832
7th	2278.4662	2278.4662
6th	5173.8517	1767.9463
5th	2403.4817	2403.4817
4th	5156.5234	1841.4383
3rd	2516.8383	2013.4707
2nd	2516.8383	2516.8383
1st	5432.6443	1321.1093
Ground	2619.127	2619.127

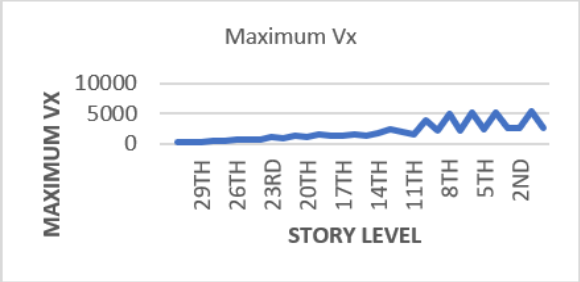


Fig 7(a): Story Level vs Maximum Vx (Square Shaped Building)

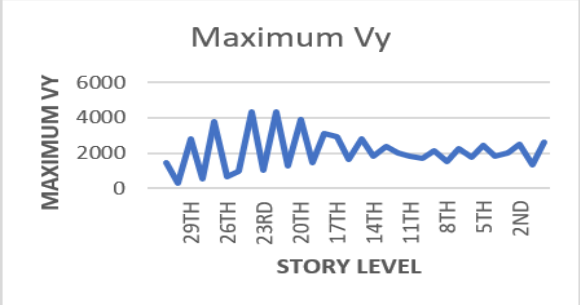


Fig 7(b): Story Level vs Maximum Vy (Square Shaped Building)

2. Time Period

The approximate fundamental natural period of vibration (Ta), in seconds

Table 8: Time Period for Square Shaped Building

Mode	Period (Seconds)
1	3.128
2	3.128
3	0.985
4	0.985
5	0.542
6	0.542
7	0.373
8	0.373
9	0.263
10	0.261
11	0.143
12	0.14

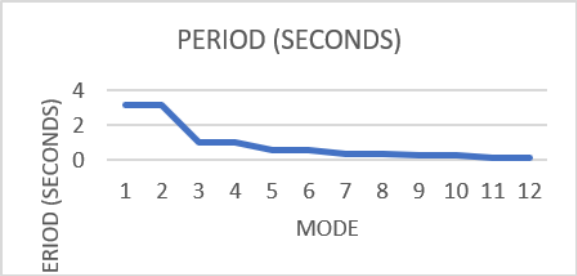


Fig 8: Mode vs Period (Square Shaped Building)

3. Overall, Moment in X & Y Direction

It is the amount of overall bending moment in X & Y direction generated by the structure as per ETABS 2018 Software referring to IS:456 & IS 1893, etc.

Table 9: Overall, Moment for Square Shaped Building

Story Level	Maximum Mx	Maximum My
Terrace	15041.4562	96258.393
30th	2769.7644	85743.6507
29th	28585.7128	127883.532
28th	5722.4056	191825.2979
27th	38380.6211	171615.482
26th	8485.6835	287392.2029
25th	9038.7061	258222.5431
24th	43905.3064	382959.1079
23rd	11065.977	345591.9235
22nd	44306.4092	478526.0128
21st	13469.6568	433615.8856
20th	39504.2353	433232.3957
19th	15703.091	574092.9178
18th	31493.6517	521418.3466
17th	29937.6108	669659.8228
16th	17772.6471	611484.5699
15th	28851.3857	765226.7277
14th	19684.6935	701239.8457
13th	24368.927	698669.6911
12th	21445.5991	860793.6327
11th	18312.9288	787594.343
10th	18454.9048	956360.5377
9th	23061.7337	882181.9363
8th	20264.3667	1051927.443
7th	24539.4681	973289.9359
6th	17325.4503	965843.801
5th	25885.174	1147494.348
4th	18046.1006	1055138.909
3rd	27105.2236	1243061.253
2nd	27105.2236	1144543.297
1st	25632.3089	1338628.158
Ground	28205.9897	1248726.08

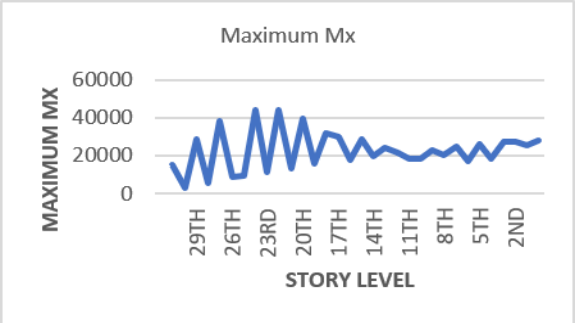


Fig 9(a): Story Level vs Maximum Mx (Square Shaped Building)

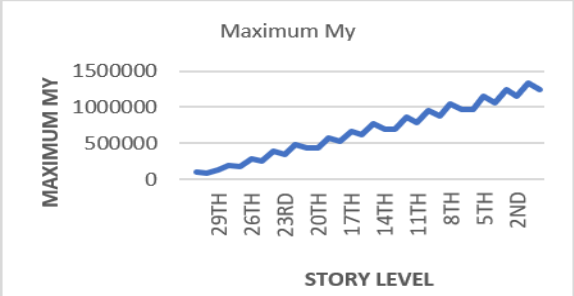


Fig 9(b): Story Level vs Maximum My (Square Shaped Building)

4. Inter Story Drift

Inter-story drift of building structures is defined as the relative translational displacement difference between two consecutive floors.

Table 10: Inter Story Drift for C Shaped Building

Story Level	Maximum Mx
Terrace	0.004193
30th	0.000779
29th	0.000494
28th	0.000961
27th	0.001064
26th	0.000615
25th	0.001062
24th	0.000948
23rd	0.000731
22nd	0.000803
21st	0.000782
20th	0.000829
19th	0.000872
18th	0.000872
17th	0.000911
16th	0.001005
15th	0.001058
14th	0.000975
13th	0.001105

12th	0.001162
11th	0.001023
10th	0.001084
9th	0.001042
8th	0.001059
7th	0.001095
6th	0.001272
5th	0.00113
4th	0.001485
3rd	0.001426
2nd	0.001194
1st	0.001224
Ground	0.001184

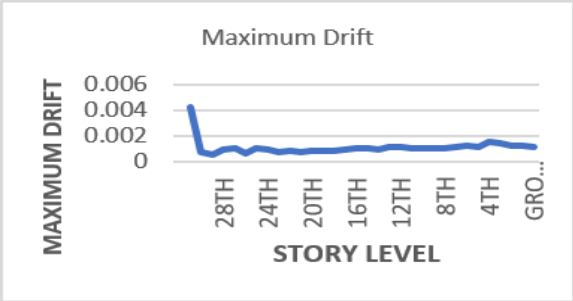


Fig 10: Story Level vs Story Drift (Square Shaped Building)

5. Story Acceleration

Inter-story drift of building structures is defined as the relative translational displacement difference between two consecutive floors.

Table 11: Acceleration for Square Shaped Building

Story Level	Maximum Ux	Maximum Uy	Maximum Uz
Terrace	335.36	344.8	29.3
30th	306.7	315.24	29.22
29th	272.29	279.01	29.05
28th	236.84	240.21	28.73
27th	209.27	215.72	28.26
26th	196.71	207.68	27.61
25th	198.8	211.98	26.8
24th	207.83	220.99	25.85
23rd	215.82	227.49	24.78
22nd	219.3	228.39	23.64
21st	219.6	224.97	22.46
20th	220.76	223.4	21.27
19th	225.94	232.62	20.11
18th	234.08	242.85	18.99
17th	241.09	250.23	17.94
16th	242.99	251.24	16.94
15th	239.11	245.51	15.98
14th	233.53	236.99	15.05
13th	233.11	234.91	14.12
12th	241.51	246.38	13.16
11th	254.6	260.25	12.16
10th	264.48	269.35	11.14
9th	267.34	270.7	10.12
8th	268.25	269.65	9.14
7th	276.97	278.32	8.2
6th	293.37	296.17	7.34
5th	301.48	303.32	6.56
4th	288.44	288.7	5.82
3rd	274.22	273.53	4.99
2nd	298.85	299.32	3.94
1st	319.06	318.26	2.65
Ground	229.81	228.33	1.37

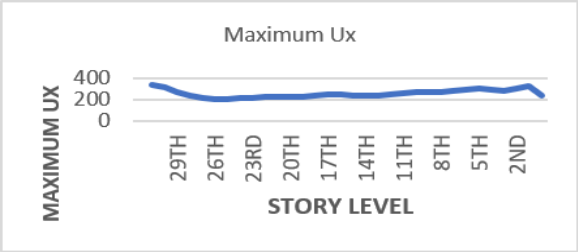


Fig 11(a): Story Level vs Max. Ux (Square Shaped Building)

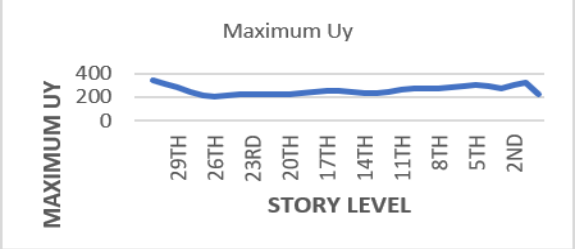


Fig 11(b): Story Level vs Maximum Uy (Square Shaped Building)

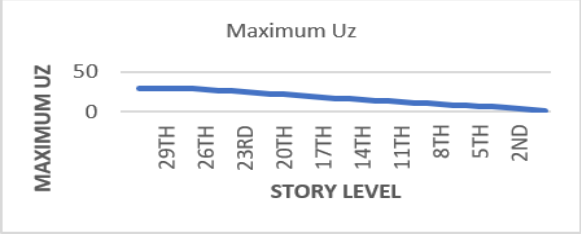


Fig 11(c): Story Level vs Maximum Uz (Square Shaped Building)

6. Story Stiffness in X & Y Direction

Story stiffness of building structures is defined as the lateral force producing unit translational lateral deformation in that story, with the bottom of the story

restrained from moving laterally, i.e., only translational motion of the bottom of the story is restrained while it is free to rotate.

Table 12: Story stiffness for Square Shaped Building

Story Level	Maximum Stiffness X	Maximum Stiffness Y
Terrace	277220.312	277240.768
30th	501789.553	501820.674
29th	643483.707	643509.805
28th	731335.355	731345.592
27th	785983.103	785979.79
26th	820193.241	820181.534
25th	842173.276	842160.921
24th	857574.341	857569.339
23rd	870327.023	870334.123
22nd	882881.614	882907.448
21st	896340.001	896372.717
20th	910782.6	910806.598
19th	925797.233	925798.923
18th	941009.64	940988.713
17th	956390.489	956357.545
16th	972240.218	972209.84
15th	988919.837	988905.119
14th	1006530.708	1006544.849
13th	1024779.175	1024810.292
12th	1043167.305	1043191.519
11th	1061413.492	1061413.166
10th	1079821.957	1079801.319
9th	1099267.31	1099246.982
8th	1120634.812	1120640.106
7th	1144047.115	1144082.587
6th	1168764.75	1168785.349
5th	1194597.12	1194577.005
4th	1224552.659	1224561.261
3rd	1267044.68	1267201.698
2nd	1337675.726	1337892.529
1st	1486991.713	1486910.146
Ground	1830880.662	1832000.17

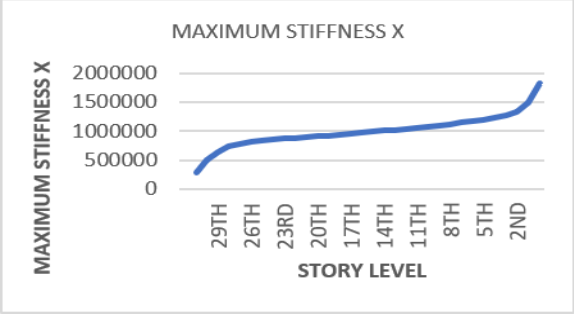


Fig 12(a): Story Level vs Stiffness X (Square Shaped Building)



Fig 12(b): Graph of Story Level vs Maximum X (Square Shaped Building)

C. T - Shaped Building

This is the module describing hollow rectangular shaped building with six discussed parameters

1. Base Shear in X & Y Direction

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure.

Table 13: Base Shear in X & Y Direction for T Shaped Building

Story Level	Maximum Vx	Maximum Vy
Terrace	294.6071	2105.9029
30th	328.1332	353.765
29th	411.2496	3988.698
28th	699.2959	697.8482
27th	616.8744	5085.2348
26th	1046.6433	833.555
25th	1046.6433	1078.0139
24th	1267.709	5380.8832
23rd	1370.9784	1368.1337
22nd	1195.5254	5335.4699
21st	1673.1028	1669.641
20th	1439.0613	4646.7958
19th	1953.8176	1946.0943
18th	1649.0107	1949.7929
17th	2222.5021	3536.5029
16th	2213.923	2209.39
15th	2029.3681	3212.7722
14th	2536.7101	2449.2324
13th	1967.5138	2682.2388
12th	2848.8915	2670.1201
11th	2080.4566	2180.6016
10th	3159.0459	2291.7458
9th	2878.5859	2872.853
8th	3467.1725	1799.2435
7th	3467.1725	3058.231

6th	2239.935	2395.302
5th	3773.2693	3227.0541
4th	2359.5199	2500.424
3rd	4077.3338	2695.883
2nd	3386.5691	3380.122
1st	4379.3621	1808.3432
Ground	4379.3621	3518.2344

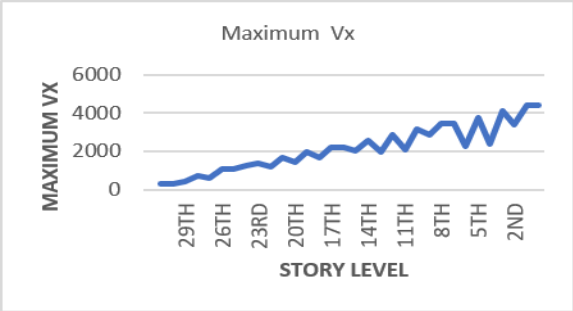


Fig 13(a): Story Level vs Maximum Vx (T Shaped Building)

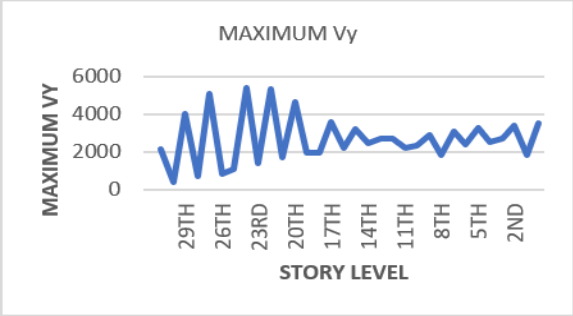


Fig 13(b): Story Level vs Maximum Vy (T Shaped Building)

2. Time Period

The approximate fundamental natural period of vibration (Ta), in seconds

Table 14: Time Period for T Shaped Building

Mode	Period (seconds)
1	3,18
2	3.168
3	2.503
4	0.994
5	0.968
6	0.797
7	0.546
8	0.5
9	0.365
10	0.256
11	0.25
12	0.131

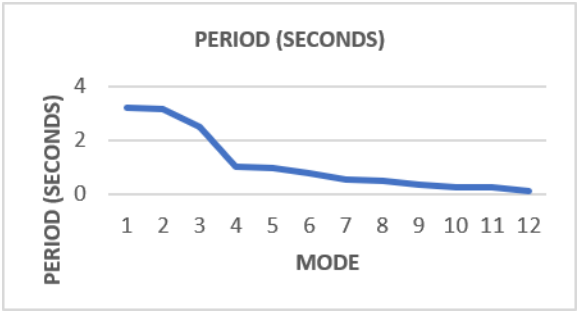


Fig 14: Mode vs Period (T Shaped Building)

3. Overall, Moment in X & Y Direction

It is the amount of overall bending moment in X & Y direction generated by the structure as per ETABS 2018 Software referring to IS:456 & IS 1893, etc.

Table 15: Overall, Moment for T Shaped Building

Story Level	Maximum Mx	Maximum My
Terrace	25270.8341	240622.6764
30th	6848.1423	218645.8374
29th	47864.3758	322619.586
28th	14403.69	483929.379
27th	61022.8172	441134.2445
26th	21450.6916	727241.6118
25th	21472.8446	664643.6812
24th	64570.5992	970559.2702
23rd	28072.033	889014.5778
22nd	64025.6388	1213882.245
21st	34217.6538	1114081.598
20th	61138.4807	1114081.598
19th	39926.0945	1457210.42
18th	42425.4992	1339687.333
17th	62752.5145	1700543.676
16th	45213.7384	1567122.133
15th	61078.4637	1943881.888
14th	50096.9676	1794784.555
13th	56059.8859	1791999.537
12th	54592.1641	2187224.924
11th	50603.7788	2018527.891
10th	50360.9437	2430572.648
9th	58715.7107	2252062.917
8th	55194.8402	2673924.919
7th	62483.9912	2481571.94
6th	50420.6496	2472120.139
5th	65913.3896	2917281.588
4th	48405.4145	2699167.228
3rd	68930.2538	3160642.502
2nd	69020.2905	2926386.999
1st	69815.4139	3404007.503
Ground	71821.0783	3172987.098

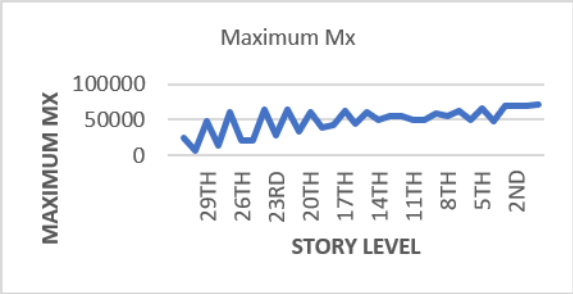


Fig 15(a): Story Level vs Maximum Mx (T Shaped Building)

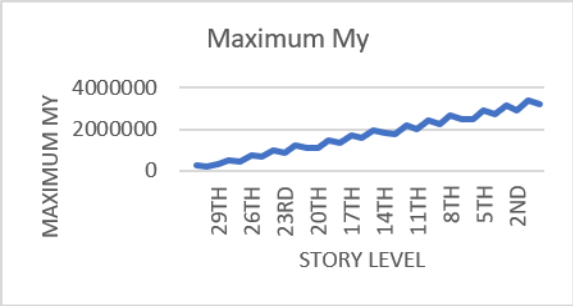


Fig 15(b): Story Level vs Maximum My (T Shaped Building)

4. Inter Story Drift

Inter-story drift of building structures is defined as the relative translational displacement difference between two consecutive floors.

Table 16: Inter Story Drift for T Shaped Building

Story Level	Maximum Drift
Terrace	0.00309
30th	0.001007
29th	0.001039
28th	0.001039
27th	0.000923
26th	0.001094
25th	0.000978
24th	0.001161
23rd	0.000943
22nd	0.001235
21st	0.000814
20th	0.001315
19th	0.000994
18th	0.001397
17th	0.001048
16th	0.00148
15th	0.00148
14th	0.001563
13th	0.001563
12th	0.001646
11th	0.001646
10th	0.001381
9th	0.001726
8th	0.001204
7th	0.001805
6th	0.001042
5th	0.001882
4th	0.001169
3rd	0.001957
2nd	0.001296
1st	0.002029
Ground	0.001312

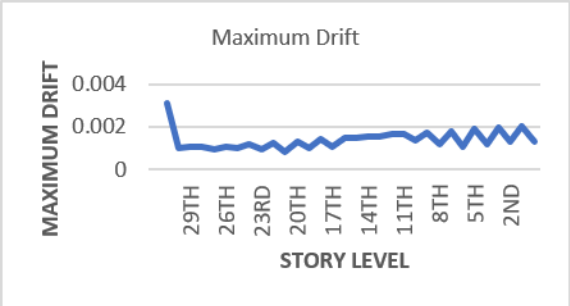


Fig 16: Story Level vs Story Drift (T Shaped Building)

5. Story Acceleration

Inter-story drift of building structures is defined as the relative translational displacement difference between two consecutive floors.

Table 17: Acceleration for T Shaped Building

Story Level	Maximum Ux	Maximum Uy	Maximum Uz
Terrace	468.16	365.65	34.76
30th	428.39	324.37	34.71
29th	385.91	280.37	34.59
28th	342.08	240.32	34.55
27th	300.39	214.39	34.35
26th	266.4	208.19	33.9
25th	246.34	216.1	33.18
24th	243.6	226.85	32.19
23rd	255.52	232.89	30.93
22nd	274.91	233.37	29.44
21st	294.28	232.5	27.77
20th	308.33	235.51	25.98
19th	314.37	243.74	24.15
18th	312.34	253.04	22.41
17th	304.73	257.42	20.83
16th	296.36	253.88	19.36
15th	293.3	245.35	18.04
14th	300.19	240	17.09
13th	317.22	245.02	17.21

12th	339.67	258.67	16.05
11th	360.38	271.44	15.24
10th	372.82	275.97	16.92
9th	373.36	275	20.4
8th	362.87	280.59	22.75
7th	347.63	299.5	21.88
6th	337.56	319.06	18.97
5th	339.2	318.37	20.85
4th	349.12	296.22	29.6
3rd	373.18	293.24	36
2nd	367.66	338.96	31.36
1st	308.67	357.41	20.02
Ground	443.79	284.7	48.06

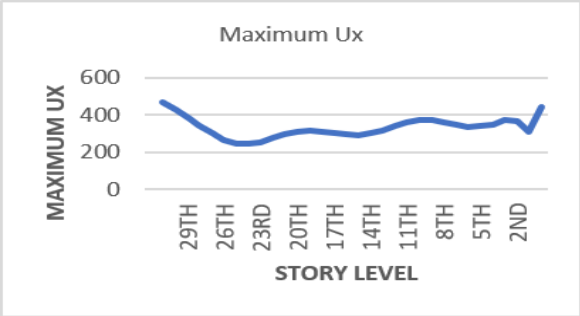


Fig 17(a): Story Level vs Maximum Ux (T Shaped Building)

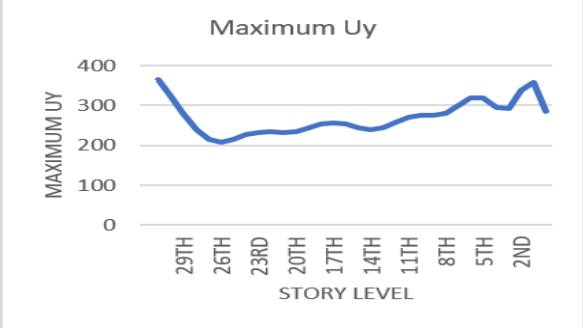


Fig 17(b): Story Level vs Maximum Uy (T Shaped Building)

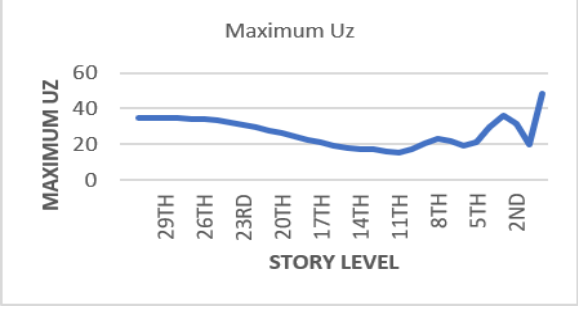


Fig 17(c): Graph of Story Level vs Maximum Uz (T Shaped Building)

6. Story Stiffness in X & Y Direction:

Story stiffness of building structures is defined as the lateral force producing unit translational lateral deformation in that story, with the bottom of the story restrained from moving laterally, i.e., only translational motion of the bottom of the story is restrained while it is free to rotate.

Table 18: Story stiffness for T Shaped Building

Story Level	Maximum Stiffness X	Maximum Stiffness Y
Terrace	233905.857	408445.491
30th	465720.553	754223.224
29th	637632.22	961870.956
28th	759953.405	1075878.828
27th	844998.11	1136459.735
26th	902988.367	1167085.241
25th	960401.101	1181833.631
24th	1012378.857	1189734.552
23rd	1056326.098	1196425.78
22nd	1094272.235	1204737.048
21st	1127689.337	1215225.007
20th	1157678.735	1227088.742
19th	1185091.924	1239263.302
18th	1210609.079	1251235.792
17th	1234791.632	1263268.776
16th	1258119.293	1276031.548
15th	1281017.97	1289944.229
14th	1303882.891	1304710.312
13th	1327100.37	1319419.746
12th	1351071.618	1333232.413
11th	1376242.912	1346225.579
10th	1403148.738	1359770.8
9th	1432479.806	1375966.663
8th	1465199.998	1396368.524
7th	1502756.909	1421301.65
6th	1547523.192	1451275.426
5th	1603678.044	1490378.346
4th	1679059.915	1550232.645
3rd	1795115.697	1649953.968
2nd	1991022.556	1828280.383
1st	2412270.011	2248362.345
Ground	3015260.633	2922087.819



Fig 18(a): Story Level vs Stiffness X (T Shaped Building)

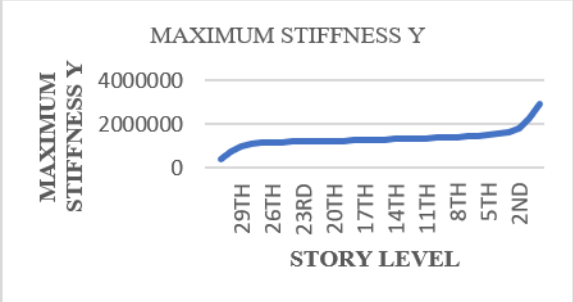


Fig 18(b): Story Level vs Maximum Y (T Shaped Building)

VI. CONCLUSION

As per the analysis of high-rise buildings with rectangular, square and T shaped plans, the conclusions are as follows:

- When the Base Shear is considered for the analysis (lesser value is good) the T Shaped building has lowest value followed by Square Shaped and Rectangular Shaped buildings.
- When the Time Period is considered for the analysis (higher value is good) the Rectangular Shaped building has higher value followed by T Shaped and Square Shaped buildings.
- When the Overall Moment is considered for the analysis (lesser value is good) the Square Shaped building has least value followed by Rectangular Shaped and T Shaped buildings.
- When the Story Drift is considered for the analysis (lesser value is good) the Rectangular Shaped building has least value followed by T Shaped and Square Shaped buildings.
- When the Story Acceleration is considered for the analysis (higher value is good) the T Shaped building has higher value followed by Rectangular Shaped and Square Shaped buildings.
- When the Story Stiffness is considered for the analysis (higher value is good) the T Shaped building has higher value followed by Rectangular Shaped and Square Shaped buildings.

So as per the whole analysis, the observation shows that if we are considering Base shear, Story Acceleration and Story Stiffness then the T-shaped building is best among all. If Time Period and Story Drift is considered then the Rectangular shaped building is best and for Overall Moment, the Square shaped building is best.

So, the selection of suitable plan shape for a multi-story building needs a thorough examination of its response to wind and earthquake loading. The Results can we verified with ETABS software and the concerned design Indian Standard Codes.

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