ANALYSIS OF UNDAMPED IRREGULAR RCC BUILDING USING SAP2000

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Abstract: *Structures these days are constructed with irregularities along the height for architectural views. The structure is said to be irregular when the distribution of its mass, stiffness and strength varies along its configuration. Seismic load is considered to be an important load that the structure must be analyzed. From the past earthquake records it can be observed that the structures with irregularity show poor seismic performance. This project work is concerned about analyzing and studying the behavior of irregular building and different models of vertically irregular building when subjected to seismic loads. For the study one model of vertical irregular structure of G+ 40 storeys is considered. The analysis is carried out by using Sap2000 software by time history method. The results of various parameters like time period, storey displacement, and storey stiffness are obtained and the graphs are plotted. From the results it can be observed that regular structure possess better seismic performance as compared to vertically irregular structure.*

INTRODUCTION

1. GENERAL

The primary purpose of all kinds of structural systems used in the building type of structures is to support gravity loads. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses, produce sway movement or cause vibration Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces.

1.2 SEISMIC ZONE MAP OF INDIA & RECENT EARTHQUAKES

Earthquakes have been happening in the Indian sub landmass from the time immemorial however dependable chronicled records are accessible throughout the previous 200 years (Oldham, 1883). From the earliest starting point of the twentieth century, more than 700 earthquakes of size at least 5 have been recorded and felt in India. The seismicity of India is separated into four gatherings, to be specific Himalayan locale, Andaman Nicobar, Kutch Region, and Peninsular India.

The objective of seismic zoning is to outline districts of plausible power of ground movement in a nation, for giving a rule to arrangement of a satisfactory tremor protection in developed offices. the main thorough seismic zoning map was produced by the Bureau of Indian Standards in 1962. Later in the ensuing years it was evaluated commonly and along these lines a four zone seismic zoning map was embraced in Is 1893:2002. The guide depends on expected force of ground shaking yet does not think about the recurrence of the event.

Current seismic zoning map according to IS 1893-2002 says that around 60% (Zone V= 12%, Zone IV=18%, Zone III = 26% and Zone II 44%) of India is inclined to direct to significant earthquakes. As needs be, zone factors (z) are characterized for each zone to touch base at the plan seismic power following up on the structure. Zone II relates to force VI or lower and zone V compares to power IX or higher. Zone II has most reduced threat or hazard while Zone - V has most astounding perils. Since harm controlled point of confinement state has been acknowledged, the zone factor, z has been decreased to half (z/2) of Maximum Considered Earthquake (MCE) for Design Basis Earthquake (DBE).

Structures are expressly intended for DBE and most extreme considered seismic tremor is dealt with through finished quality and pliability arrangements.

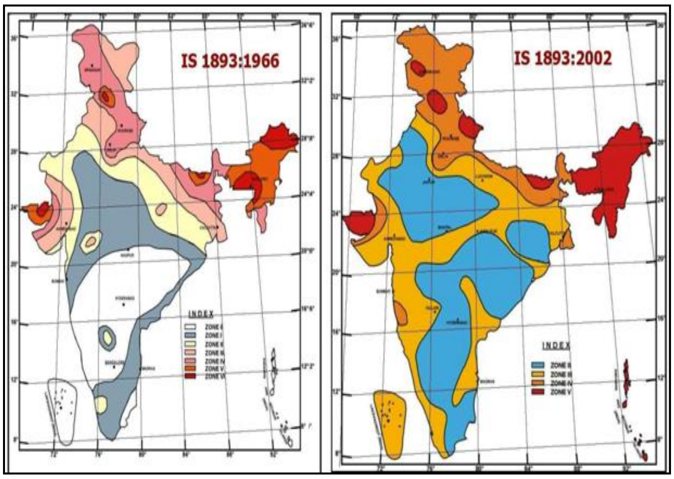


Fig: 1 Seismic zoning maps of India I.S. 1893:1966 and IS1893:2002

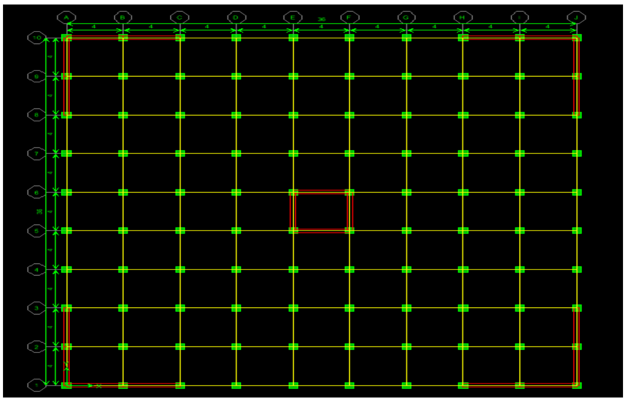
1.3 OBJECTIVE OF STUDY

- Time History Analysis of Buildings.
- To compare the following aspects of the buildings.

- Lateral Displacements at joints.
- Acceleration.
- Base shear-x direction
- Beam Line element
- Torsion
- Velocity

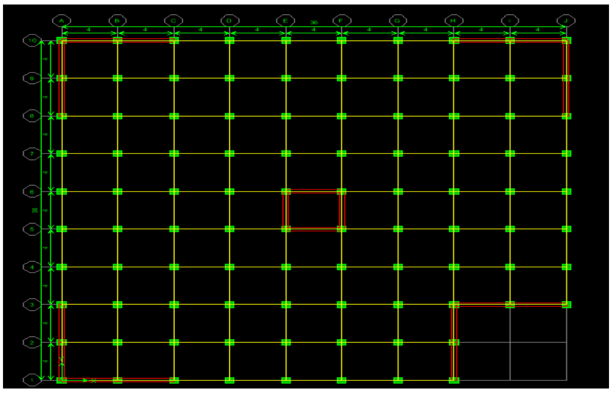
1.4 CASE STUDY

In the present work, a 40-storied reinforced concrete frame building situated in Hyderabad city which falls in Zone IV, is taken for the purpose of study. The plan area of building is 54x54m and 3.0m as height of typical storey. It consists of 9 bays in X-direction and 9 bays in Y-direction. The total height of the building is 120.2m along parapet wall. The building is considered as a Special Moment Resisting Frame. The plan of building is shown in fig. 4.1 and the front elevation along x-z axis is shown in Fig n the elevation along y-z axis is shown in Fig. 4.2. Also the isometric view of the building is shown in the Fig.41. As the structure is regular and relatively simple, the identification of the differences in results can be known in easy and can be discuss in depth.



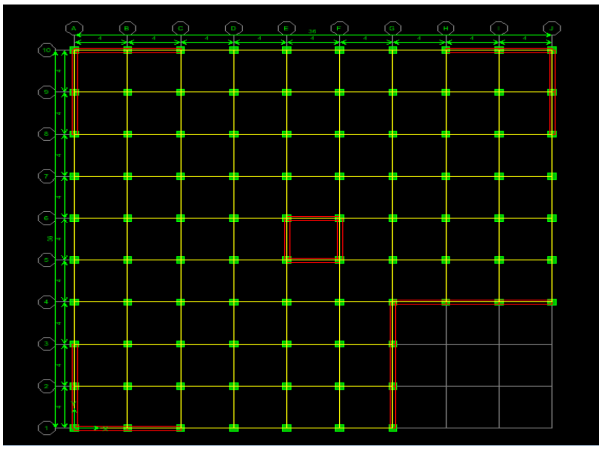
All dimensions are in meters

Fig 2: Plan of Model-1, Mass as-symmetric structure in regular shape as shown in figure.



All dimensions are in meters

Fig 3. Plan of Model-2, Mass as-symmetric structure in irregular shape as shown in figure



All dimensions are in meters

Fig 4.Plan of Model-3, Mass as-symmetric structure in irregular shape as shown in figure

2. GENERAL DATA COLLECTION OF MASS AS-SYMMETRIC STRUCTURE

Table 1: General data collection and condition assessment of the building.

S. No.	Description	MODEL - 1	MODEL - 2	MODEL - 3
1.	Plan size	54x54m	54X54m	54X54m
2.	Building height	120.2m	120.2m	120.2m
3.	Number of stories above ground	40	40	40
4.	Type of structure	RC frame	RC frame	RC frame
5.	Open ground storey	Yes	Yes	Yes
6.	Falling hazards	Parapet wall	Parapet wall	Parapet wall
7.	Type of building	Regular frame with open ground storey	Regular frame with open ground storey	Regular frame with open ground storey
8.	Beam sizes	450x600 mm	450x600 mm	450x600 mm
9.	Column sizes	600x600 mm 800x800 mm 1200x1200mm	600x600 mm 800x800 mm 1200x1200mm	600x600 mm 800x800 mm 1200x1200mm
10.	Mass load	Loads are	All loads are same	All loads are same

		different from span to span.	from floor to floor	from floor to floor
10.	Grade of concrete used	M40	M40	M40
11.	Software used	SAP2000 vs. 16	SAP2000 vs. 16	SAP2000 vs. 16

3. RESULTS AND DISCUSSION

The results of the analytical investigations are presented in the Tables. The results are also shown graphically in the Figures.

3.1. Displacement at point 1:

After modeling and analyzing the structure, the displacements at the joints in the structure were checked out. In this chapter, joints of the extreme columns of comparison of three buildings are checked for displacement and they are compared.

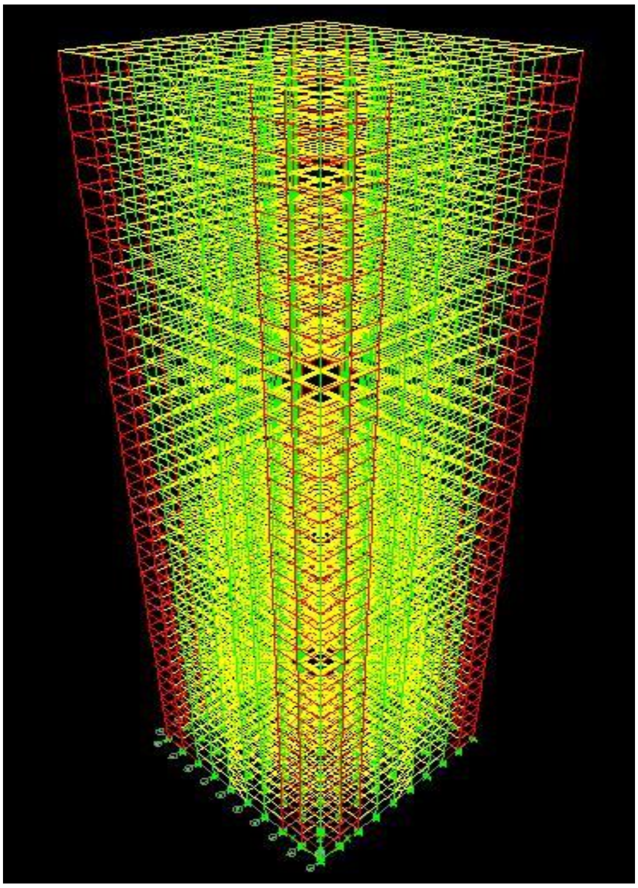


Fig 5: time vs. displacement at joint: 1 in the buildings

Table 2: Time vs. Displacement at joint 1 in the buildings.

The table below shows the Displacement values with respect to time for 25s at joint 1 in the buildings.

Mass as-symmetric		Mass as-symmetric		Mass as-symmetric	
Model-1		Model-2		Model-3	
Time (s)	Displacement(m)	Time (s)	Displacement(m)	Time (s)	Displacement(m)
16.5	-0.28713	16.5	-0.21947	16.5	-0.13536
17	0.16605	17	0.16616	17	0.01661
17.5	0.33371	17.5	0.26757	17.5	0.15462
18	0.03507	18	-6.25E-04	18	0.05936
18.5	-0.2915	18.5	-0.2449	18.5	-0.14259
19	-0.18109	19	-0.12151	19	-0.11491
19.5	0.16127	19.5	0.14665	19.5	0.07732
20	0.23794	20	0.17255	20	0.13173
20.5	-3.18E-04	20.5	-0.02002	20.5	0.01342
21	-0.2177	21	-0.1653	21	-0.122
21.5	-0.11862	21.5	-0.0724	21.5	-0.0829
22	0.13674	22	0.11128	22	0.08249
22.5	0.16454	22.5	0.10681	22.5	0.11146
23	-0.02284	23	-0.02959	23	-0.02139
23.5	-0.16965	23.5	-0.11766	23.5	-0.12391
24	-0.06714	24	-0.03313	24	-0.02816
24.5	0.10902	24.5	0.07718	24.5	0.09148
25	0.13281	25	0.08393	25	0.07962

Mass as-symmetric		Mass as-symmetric		Mass as-symmetric	
Model-1		Model-2		Model-3	
Time (s)	Displacement(m)	Time (s)	Displacement(m)	Time (s)	Displacement(m)
0	0	0	0	0	0
0.5	0.05649	0.5	0.05694	0.5	0.06234
1	0.23801	1	0.23835	1	0.20453
1.5	-0.44854	1.5	-0.4551	1.5	-0.52741
2	-0.80456	2	-0.81025	2	-0.61664
2.5	1.71084	2.5	1.71939	2.5	1.70457
3	1.57213	3	1.58278	3	1.14549
3.5	-0.89258	3.5	-0.92028	3.5	-1.12474
4	-1.51255	4	-1.51988	4	-1.13344
4.5	-0.31635	4.5	-0.26322	4.5	0.25161
5	1.26578	5	1.27211	5	1.00768
5.5	1.16505	5.5	1.11844	5.5	0.47629
6	-0.70882	6	-0.73018	6	-0.75162
6.5	-1.25662	6.5	-1.23454	6.5	-0.72998
7	-0.08748	7	-0.03804	7	0.33892
7.5	1.031	7.5	1.03099	7.5	0.76463
8	0.67772	8	0.61099	8	-0.03023
8.5	-0.52866	8.5	-0.54757	8.5	-0.53318
9	-0.91925	9	-0.86099	9	-0.17684
9.5	0.00324	9.5	0.04368	9.5	0.24891
10	0.79759	10	0.76903	10	0.2463
10.5	0.38925	10.5	0.32765	10.5	-0.03884
11	-0.4978	11	-0.5041	11	-0.21899
11.5	-0.62484	11.5	-0.55657	11.5	-0.12247
12	0.11958	12	0.15701	12	0.11908
12.5	0.60867	12.5	0.55586	12.5	0.17088
13	0.22944	13	0.16849	13	0.0098
13.5	-0.40913	13.5	-0.38862	13.5	-0.12122
14	-0.42545	14	-0.35477	14	-0.08991
14.5	0.16001	14.5	0.17756	14.5	0.05192
15	0.45959	15	0.39761	15	0.11459
15.5	0.09468	15.5	0.04453	15.5	0.04217
16	-0.35842	16	-0.3222	16	-0.08527

The above table shows the variation of displacement values at the interval of 0.5 second in the three different types of structures i.e., symmetric structure to asymmetric structure. It is observed that there is minor change in the displacement values.

GRAPH:

In the below figure shows the variation of displacement with time for all the three types of Mass as-symmetric buildings are:

1. Model-1 in regular shape
2. Model-2 in irregular shape
3. Model-3 in irregular shape

In this variation of stiffness as-symmetric is very high when compared to symmetric structure & mass as-symmetric but the values of symmetric structure is quite greater than the mass as-symmetric structure.(i.e., stiffness as-symmetric > symmetric structure > stiffness as-symmetric).

Table: 3. it shows the maximum displacement with respect to time for three types of the buildings:

STRUCTURES	MAXIMUM DISPLACEMENT At point IN (M)	TIME(S)
Model-1	1.7	2.5
Model-2	2.36	11
Model-3	0.54	2.5

The maximum displacement with respect to time when compared with 3 types of buildings is 2.36m at 11s in Model-2.

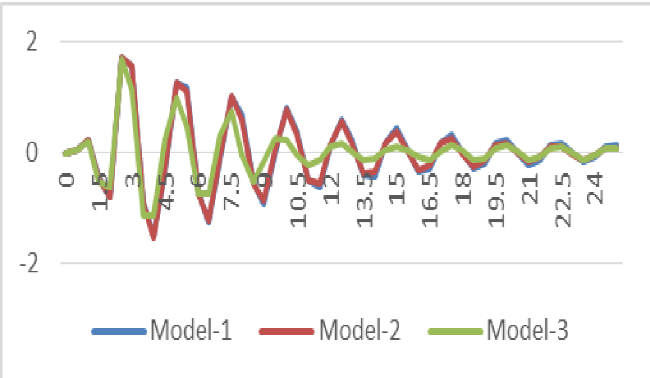


Fig 6: Graph showing Time vs. displacement at joint no.1 in the buildings.

The above graph shows the variation of displacement values at the interval of 0.5 second in the three different types of structures i.e., symmetric structure to asymmetric structure. It is observed that there is minor change in the displacement values.

3.2 ACCELERATION AT JOINT: 1:

And the values of these accelerations were compared with the values of corresponding columns of the buildings. The values of acceleration in UX direction are shown.

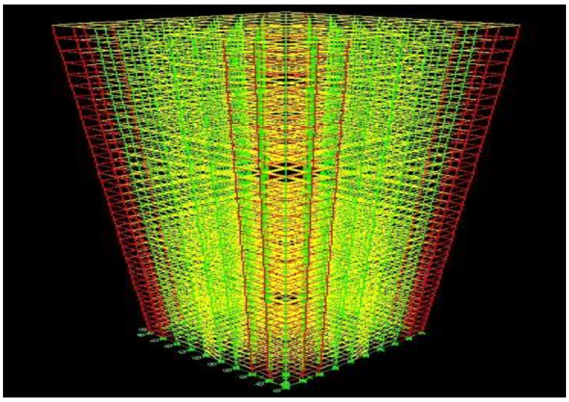


Fig.7: 3D Model of 40 storey building.

Table 4: Time vs. Acceleration in columns at joint-1 in buildings.

The table below shows the Acceleration values with respect to time for 25s at joint 1 in the buildings

Mass as-symmetric		Mass as-symmetric		Mass as-symmetric	
Model-1		Model-2		Model-3	
Time (s)	Accleration(m/s2)	Time (s)	Accleration(m/s2)	Time (s)	Accleration(m/s2)
16.5	2.12215	16.5	42.99773	16.5	-2.80761
17	-1.50018	17	32.83104	17	0.17273
17.5	-2.29715	17.5	19.33502	17.5	-9.75755
18	-0.03869	18	4.99021	18	0.99272
18.5	2.11171	18.5	-16.70024	18.5	0.38203
19	0.88794	19	-34.51867	19	-4.45442
19.5	-1.42028	19.5	-32.95577	19.5	-4.60961
20	-1.18749	20	-9.31765	20	1.28612
20.5	-0.35419	20.5	13.34427	20.5	7.03238
21	1.19625	21	31.60489	21	-11.45333
21.5	0.91192	21.5	16.20315	21.5	9.55744
22	-1.19451	22	-28.27639	22	7.41732
22.5	-0.71279	22.5	-19.45956	22.5	-10.30565
23	0.29669	23	7.96378	23	10.03806
23.5	1.24408	23.5	6.43104	23.5	8.23344
24	0.33174	24	23.77021	24	4.02813
24.5	-0.75536	24.5	16.80801	24.5	-9.81309
25	-0.69727	25	-15.43645	25	13.11701

Mass as-symmetric		Mass as-symmetric		Mass as-symmetric	
Model-1		Model-2		Model-3	
Time (s)	Accleration(m/s2)	Time (s)	Accleration(m/s2)	Time (s)	Accleration(m/s2)
0	-0.60353	0	-0.63758	0	0.39483
0.5	5.76148	0.5	6.49616	0.5	-0.73795
1	-9.69954	1	-13.50681	1	4.22332
1.5	21.85845	1.5	19.72561	1.5	9.07423
2	36.00791	2	69.44001	2	2.51489
2.5	-4.41076	2.5	32.03115	2.5	-1.26754
3	-9.42777	3	8.71732	3	-14.9657
3.5	20.52663	3.5	31.00656	3.5	5.9102
4	-0.76941	4	-52.31047	4	-1.11398
4.5	-0.06361	4.5	-66.69413	4.5	-3.87241
5	-1.45391	5	-17.36261	5	-0.68662
5.5	-11.64973	5.5	-8.29632	5.5	-10.92593
6	10.07795	6	60.67598	6	7.60243
6.5	8.39161	6.5	71.15247	6.5	5.35987
7	-2.21572	7	-4.65101	7	-5.01437
7.5	-4.56071	7.5	-37.32872	7.5	-4.62468
8	-4.32453	8	-60.85966	8	11.22615
8.5	2.26232	8.5	-39.34363	8.5	9.21496
9	7.78452	9	46.26	9	-17.7178
9.5	0.39422	9.5	45.66421	9.5	13.32068
10	-5.59977	10	24.37207	10	2.9182
10.5	-1.51554	10.5	40.49893	10.5	-2.85119
11	3.32832	11	-14.84965	11	4.73523
11.5	4.57908	11.5	-50.37595	11.5	-1.34672
12	-1.30325	12	-29.94057	12	2.23743
12.5	-4.04824	12.5	-34.51197	12.5	0.77234
13	-1.19134	13	6.38109	13	2.80946
13.5	3.2017	13.5	62.73983	13.5	-1.36691
14	2.16543	14	25.82331	14	-5.66917
14.5	-1.34122	14.5	-21.05245	14.5	9.57339
15	-2.99971	15	-36.26092	15	-12.46381
15.5	-0.58627	15.5	-36.34482	15.5	2.56931
16	2.22435	16	7.03296	16	-3.98679

The above table shows the variation of acceleration values at the interval of 0.5 second in the three different types of structures i.e., symmetric structure to asymmetric structure. It is observed that there is major change in the acceleration values.

GRAPH:

The below figure shows the variation of acceleration with time for all the three types of buildings are:

1. Model-1 in regular shape
2. Model-2 in irregular shape
3. Model-3 in irregular shape

In this, variation of stiffness as-symmetric is very high when compared to stiffness as-symmetric structure but the value of stiffness asymmetric structure is high than mass as-symmetric (i.e., stiffness as-symmetric > stiffness as-symmetric > mass as-symmetric structure.)

Table: 5: It shows the maximum Acceleration with respect to time for three types of the buildings:

STRUCTURE	MAX. ACCELERATION AT POINT 1 IN m/s^2	TIME(S)
Model-1	36	2
Model-2	71	6.5
Model-3	13.3	9.5

The maximum Acceleration with respect to time when compared with 3 types of buildings is 71m/s2 at 6.5s in Model-2.

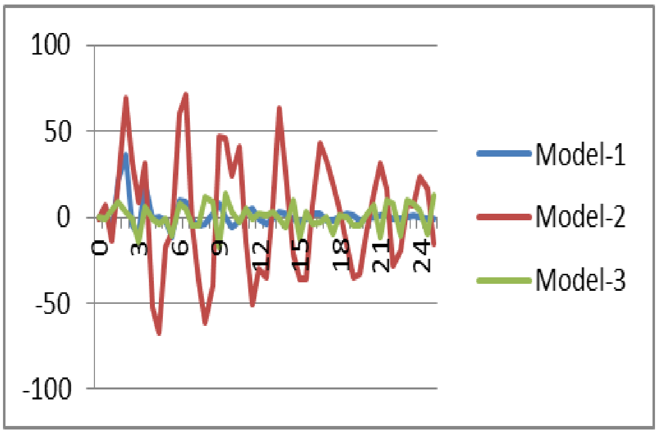


Fig 8: Graph showing Time vs. acceleration at joint1 in buildings.

The above graph shows the variation of acceleration values at the interval of 0.5 second in the three different types of structures i.e., symmetric structure to asymmetric structure. It is observed that there is major change in the acceleration values.

3.3 VELOCITY AT JOINT 1:

After modelling and analyzing the structure, the velocity at the joints: 4 in the structure were checked out. In this chapter, joints of the extreme columns of comparison of three buildings are checked for velocity and they are compared.

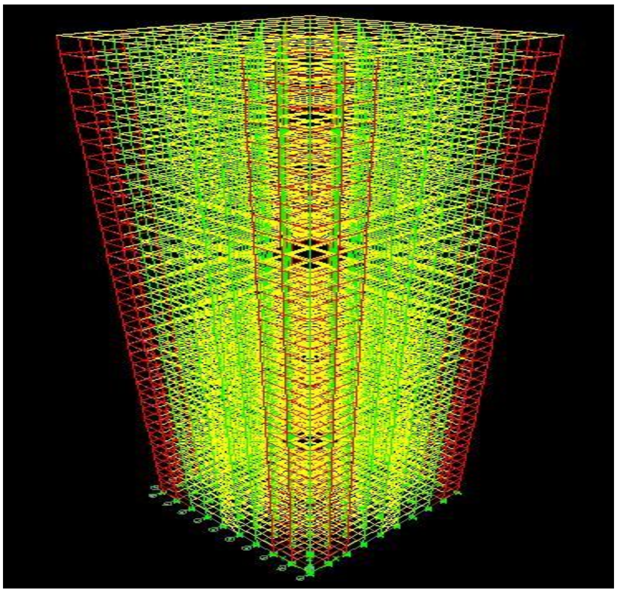


Figure 9 : 3D Model of 40 storey building.

Table 6: Time vs. velocity at joint: 1 in the buildings. The table below shows the Velocity values with respect to time for 25s at joint 1 in the buildings.

Mass as-symmetric		Mass as-symmetric		Mass as-symmetric	
Model-1		Model-2		Model-3	
Time (s)	Velocity(mph)	Time (s)	Velocity(mph)	Time (s)	Velocity(mph)
0	0	0	0	0	0
0.5	0.3448	0.5	0.38885	0.5	0.07342
1	-0.02998	1	-0.03179	1	0.26185
1.5	-4.0677	1.5	-5.15529	1.5	-0.83815
2	2.27725	2	1.47173	2	2.62043
2.5	1.66861	2.5	2.56981	2.5	-1.05194
3	-1.47035	3	0.84622	3	-0.94029
3.5	-4.64327	3.5	-4.53123	3.5	0.20375
4	-0.11068	4	0.69349	4	0.8466
4.5	5.22128	4.5	8.8808	4.5	1.63189
5	1.0675	5	-1.23104	5	-0.37763
5.5	-2.73807	5.5	-6.7954	5.5	-1.27787
6	-2.80071	6	-3.11601	6	0.55576
6.5	0.56696	6.5	-0.39405	6.5	1.56519
7	3.03475	7	7.20254	7	-0.4866
7.5	1.19574	7.5	6.07221	7.5	0.05798
8	-2.46736	8	-7.49426	8	-0.58705
8.5	-1.87468	8.5	-5.87586	8.5	0.18166
9	0.83061	9	2.18158	9	0.53437
9.5	2.06334	9.5	2.48016	9.5	0.15444
10	0.74934	10	2.76	10	-0.78791
10.5	-1.91397	10.5	-2.31259	10.5	-0.10255
11	-1.28931	11	-3.78746	11	0.03972
11.5	0.8805	11.5	4.66071	11.5	-0.4007
12	1.63657	12	4.71028	12	0.50141
12.5	0.14969	12.5	-2.9667	12.5	-0.26063
13	-1.39045	13	-5.25749	13	-1.42491
13.5	-0.80047	13.5	-3.13601	13.5	0.68439
14	0.74479	14	3.82505	14	0.3986
14.5	1.1718	14.5	7.54541	14.5	-1.18281
15	-0.08561	15	-0.49188	15	0.23696
15.5	-1.14401	15.5	-6.32723	15.5	0.43176
16	-0.45337	16	-2.6257	16	-0.82255

Mass as-symmetric		Mass as-symmetric		Mass as-symmetric	
Model-1		Model-2		Model-3	
Time (s)	Velocity(mph)	Time (s)	Velocity(mph)	Time (s)	Velocity(mph)
16.5	0.69356	16.5	2.22183	16.5	-0.38461
17	0.84565	17	3.66104	17	1.55026
17.5	-0.21815	17.5	-0.51143	17.5	-0.25749
18	-0.82614	18	-3.95806	18	-0.91364
18.5	-0.29302	18.5	-0.30196	18.5	0.36868
19	0.61519	19	4.18444	19	0.82401
19.5	0.58022	19.5	2.75825	19.5	0.65931
20	-0.25558	20	-3.02037	20	-0.01347
20.5	-0.62418	20.5	-4.8671	20.5	-0.88366
21	-0.11723	21	0.61804	21	0.45492
21.5	0.48381	21.5	4.60802	21.5	1.38341
22	0.33467	22	2.87084	22	0.58476
22.5	-0.19411	22.5	-1.90877	22.5	-1.45387
23	-0.47218	23	-5.45255	23	-0.09272
23.5	-0.01886	23.5	-0.3733	23.5	0.62124
24	0.37792	24	4.44072	24	0.82484
24.5	0.23102	24.5	0.37981	24.5	-0.20092
25	-0.12891	25	-1.58221	25	-1.54981

The above table shows the variation of velocity values at the interval of 0.5 second in the three different types of structures i.e., symmetric structure to asymmetric structure. It is observed that there is minor change in the velocity values.

GRAPH:

The below figure shows the variation of velocity with time for all the three types of buildings are:

1. Model-1 in regular shape
2. Model-2 in irregular shape
3. Model-3 in irregular shape

In this, variation of stiffness as-symmetric is very high when compared to symmetric structure & mass as-symmetric but the values of symmetric structure are quite greater than the mass as-symmetric structure.

Table 7. It shows the Maximum Velocity with respect to time for three types of the buildings.

STRUCTURE	MAXMUM VELOCITY(MPH)	TIME(S)
Model-1	5.2	4.5
Model-2	8.88	4.5
Model-3	2.62	2

4. CONCLUSIONS

The present practice in seismic design is to adopt Response spectrum method of structural analysis. The code leaves the application of method of dynamic analysis making use of Time History Analysis concept to the discretion of the designer. In this context in the present project, a 1- storey building has been analyzed Time History Analysis making use of Sap2000.

In brief, In the symmetric structure the centre of mass and centre of radius is coincides .In the mass as-symmetric structure, the centre of mass is at an eccentricity and In stiffness as-symmetric structure the centre of rigidity is at an eccentricity.

A comparison of the three sets of results demonstrates both the capabilities and limitations of the proposed procedure.

1. Single storey stiffness asymmetric buildings oscillate predominantly in the first mode than the mass asymmetric building and the symmetric building.
2. The comparison of results for the maximum displacement, velocity, acceleration, torsion obtains from the time history analysis of single storey asymmetric building; show that the proposed procedure can estimate the response of multi-storey building model satisfactory.
3. It has been observed that the lateral displacements, more in stiffness asymmetric structure. It has been noticed that the displacement values for building with symmetric structure is less by 30% and mass asymmetric structure is less by 77% when compared to building with stiffness asymmetric structure.
4. The maximum velocity, is more in stiffness asymmetric structure .It has been noticed that the maximum velocity values in symmetric structure is less by 23% and in mass asymmetric structure is less by 75% when compared to building with stiffness asymmetric structure.
5. The base shear is more in symmetric structure when compared to other two structures. It has been noticed that the base shear in stiffness asymmetric structure is less by 28% and in mass asymmetric structure is less by 47% when compared to building with symmetric structure.
6. The maximum torsion, is more in stiffness asymmetric structure .It has been noticed that the maximum torsion values in symmetric structure is less by 33% and in mass asymmetric structure is less by 77% when compared to building with stiffness asymmetric structure.

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