COMPARISON OF MULTISTOREY BUILDING USING RESPONSE SPECTRUM ANALYSIS IN DIFFERENT SEISMIC ZONES BY USING STAAD.PRO SOFTWARE

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Abstract

A multi-storey building is just a building that has multiple storeys above the ground. A multi storied building is either residential or commercial. Migration of individuals from rural to urban centres where job opportunities are significant. The land available for building to accommodate this migration is becoming scarce which ends in rapid increase within the cost of land. And this leads to construction of multi-storeyed buildings as they supply an outsized floor area in an exceedingly relatively small area of land in urban cities. A comparison of high-rise buildings by response spectrum analysis in different seismic zones of India. The main objective of this research paper is to compare regular and irregular buildings in seismic zone III & zone V by response spectrum analysis in STAAD. Pro. The soil type taken into consideration is medium soil type. The aim is to find base shear, storey drift and story displacement and eigen value and eigen vector by response spectrum analysis. Cost analysis has also been done. Analysis is done as per IS 456:2000 and IS 1893:2002. It focuses on dynamic analysis of buildings. Without increasing the area, we can extend only the building's floor to design a multi-storied building as this will save overall building cost.

Key Words: *Seismic Analysis, Response Spectrum Analysis, Base Shear, Storey Drift, Story Displacement, STAAD.Pro*

1. Introduction-

The designing of structures in seismic zones needs a lot of knowledge regarding the behaviours of structure. Experience and judgement for the entire process of a structural designing and planning not only requires calculations and imaginations but also the science knowledge of structural engineering that involves design codes as well as byelaws and sample experiences. There are some advantages in using the response spectrum analysis for the prediction of member forces & displacement within the structure systems. The codal provision as per IS: 1893 (part 1)-2002 code of response spectrum analysis of multi storied building is also considered. As high-rise buildings require a lot of time and more calculations. STAAD.Pro imposes a quick, efficient, accessible, accurate platform for studying a multi-storey building. The design of multi-storied buildings only increases the building's floor area without raising the area which will also save money to some extent. Nowadays the buildings are constructed to meet our basic detail and better Serviceability. It is not a problem of constructing buildings anyhow, rather it is important to construct an efficient building which is capable of serving for several years without any failure conditions.

Response spectrum analysis-

Response spectrum analysis is a method to estimate the structural response to short, nondeterministic, transient dynamic events. Some common examples of such events are earthquakes and shocks.

The response spectrum method is based on a special type of mode superposition. The idea is to provide an input that gives a limit to how much an eigenmode having a certain natural frequency and damping can be excited by an event of this type. A response spectrum is a function of frequency or period, showing the peak response of a simple harmonic oscillator that is subjected to a transient event. The response spectrum is a function of the natural frequency of the oscillator and of its damping. Response-spectrum analysis is useful for design decision-making because it relates structural type-selection to dynamic performance. In the response spectrum method of analysis, multiple mode of vibrations was used in the frequency domain.

Regular and irregular structure-

In a high seismic zone, it becomes a matter of concern that performance of a structure mainly depends on some certain factors such as its shape, size, structural configuration, ductility and strength. From a seismic safety point of view, the basic rule while designing buildings is 'Regularity', 'Symmetry' and 'Continuity'.

A structure is said to be irregular if it contains irregular distributions of mass, stiffness and strength or due to its geometrical irregular configurations.

Irregular structures constitute a larger part of the modern urban infrastructure. Structures are never perfectly regular and hence the designers routinely need to evaluate the likely degree of irregularity and the structure gets affected by earthquake due to the effect of this irregularity. When those buildings are located.

2. Model differences:

1. It contains a regular structure with a beam & column.

2. It contains irregular structure with beam & column.

3. It can be variate with height or any dimension of building

3. Design description:

The location data for the structure considered for evaluation study is as follows:

Type of structure: Concrete structure

Seismic zone: Zone III & Zone V

Zone factor: 0.16 & 0.36

Type of soil: Medium soil

No. of stories: G+5, G+7, G+9 and G+11

Material: M20, Steel Fe415

Size of beam: 650X450 mm

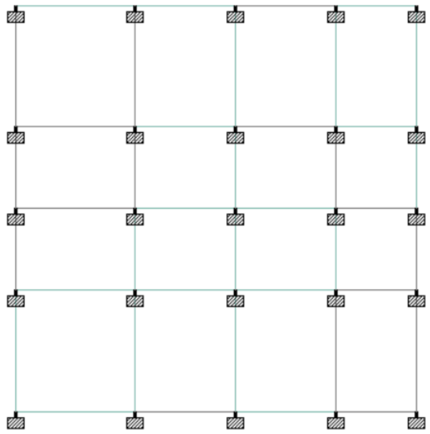
Size of column :500X500 mm

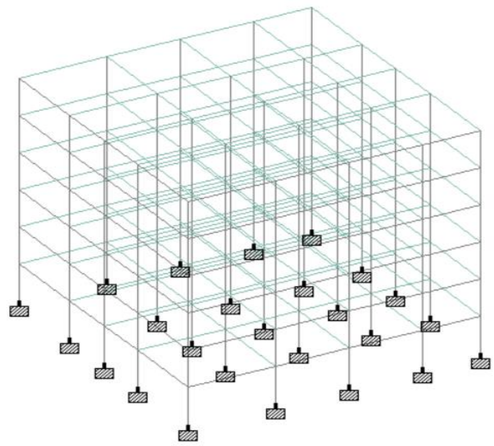
Imposed load: 2KN/m^2

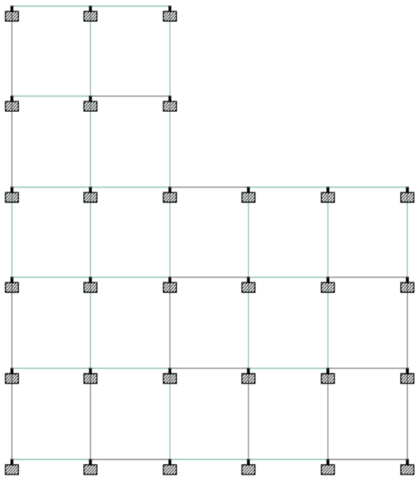
Response reduction factor: 3

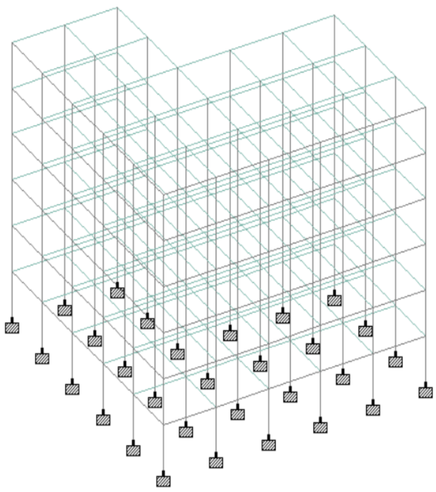
Modelling:

1. (G+5) REGULAR AND IRREGULAR BUILDING:

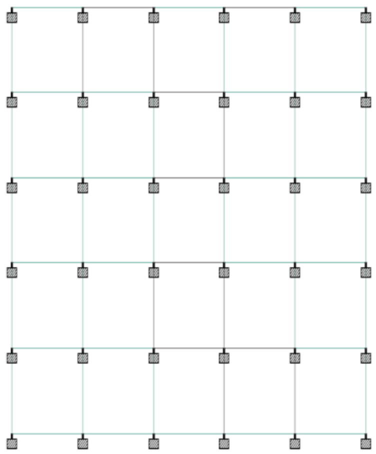


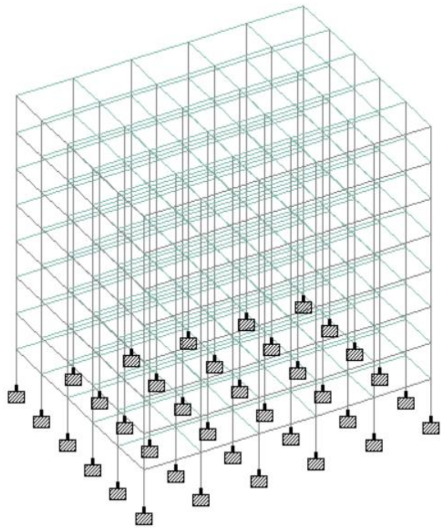


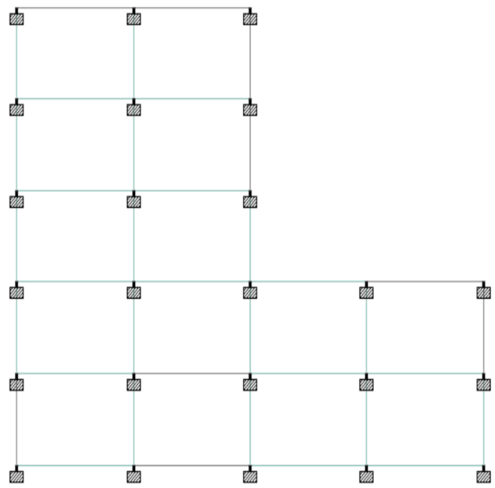


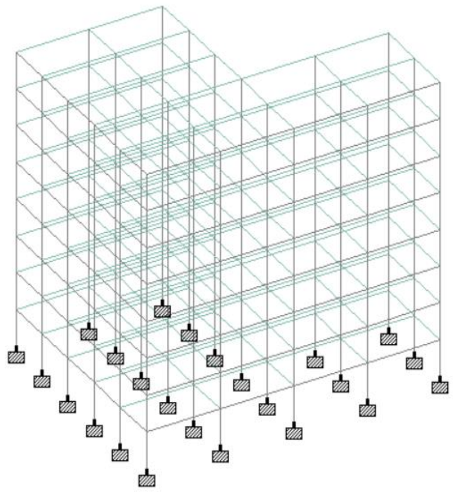


2. (G+7) REGULAR AND IRREGULAR BUILDING

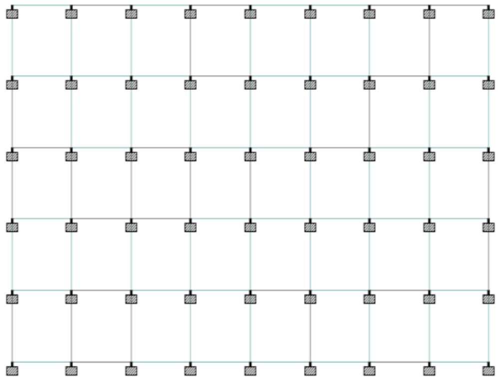
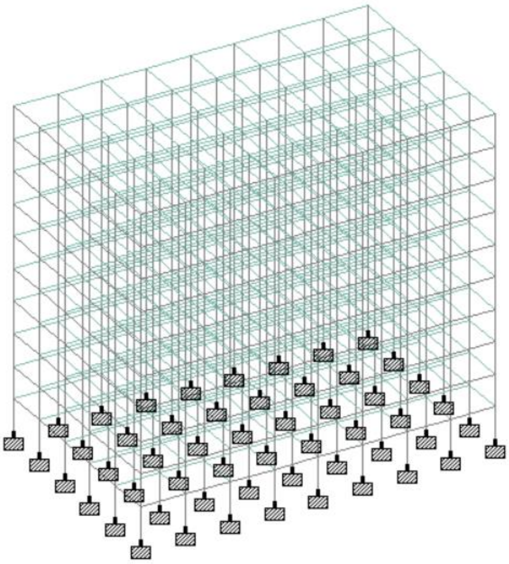


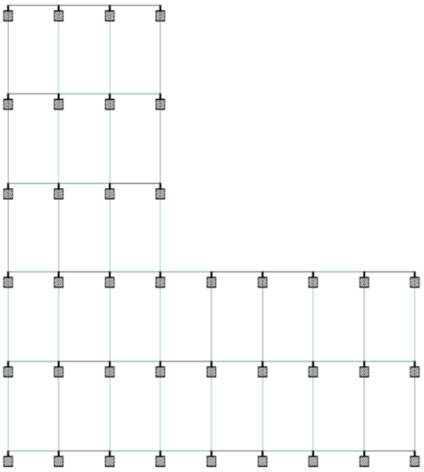
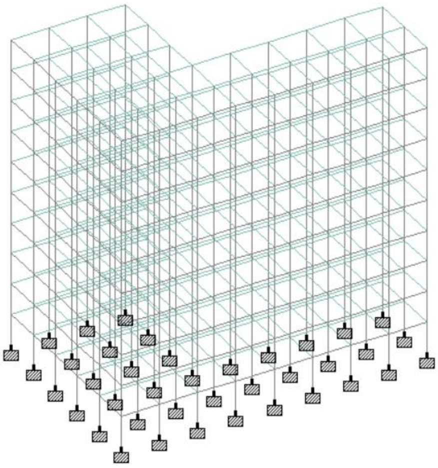




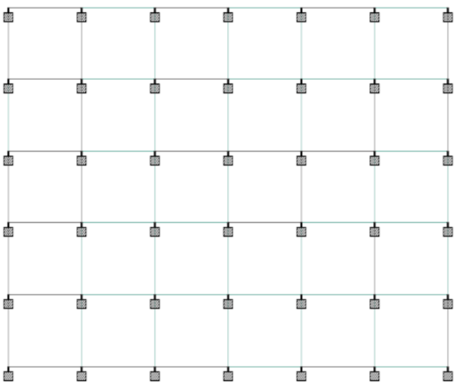
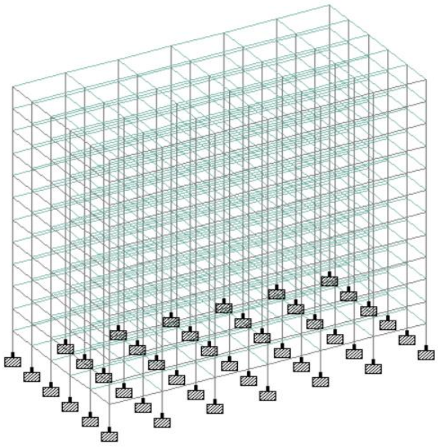


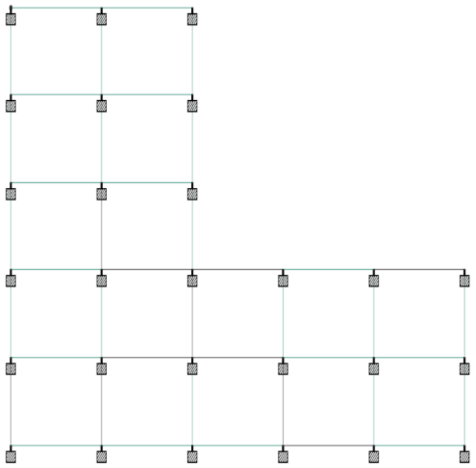
3. (G+9) REGULAR AND IRREGULAR BUILDING:

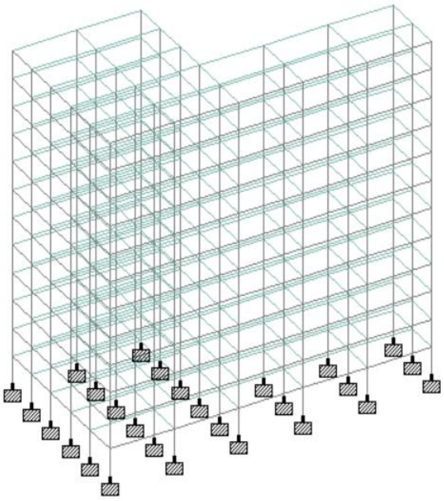



4. (G+11) REGULAR AND IRREGULAR BUILDING:





Results:

<u>Base shear:</u>

Base shear in zone III:

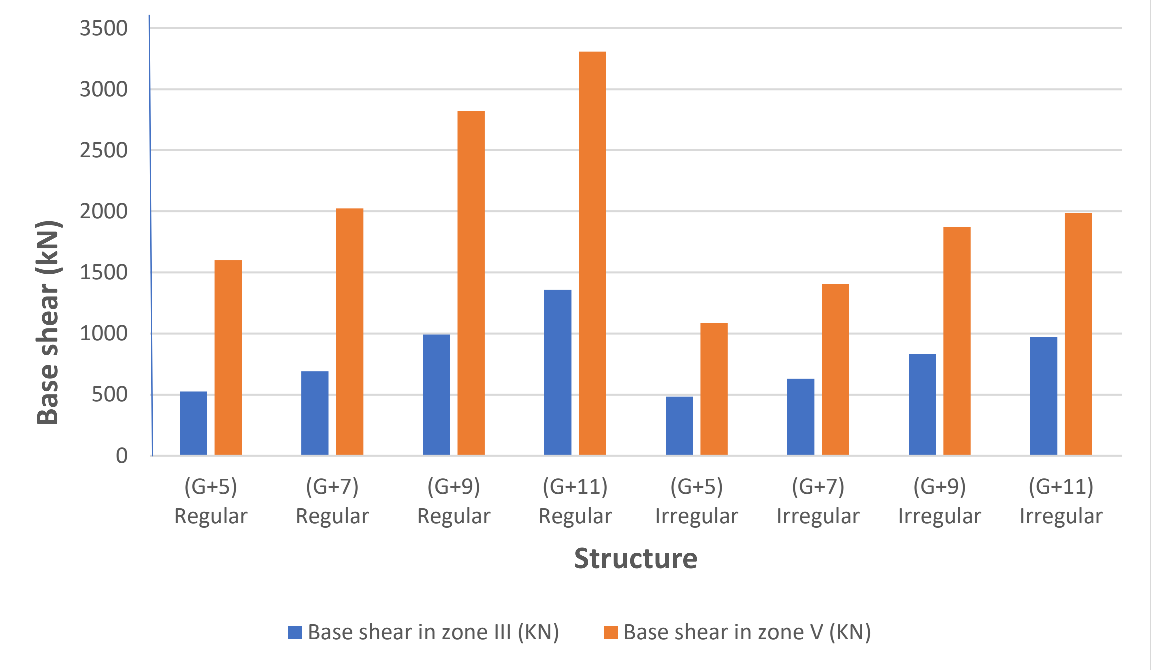
Structure	Base shear (KN)
(G+5) Regular	525.143
(G+7) Regular	691.13
(G+9) Regular	992.74
(G+11) Regular	1358.59
(G+5) Irregular	482.46
(G+7) Irregular	629.98
(G+9) Irregular	831.95
(G+11) Irregular	971.09

Base shear in zone V:

Structure	Base shear (KN)
(G+5) Regular	1601.207
(G+7) Regular	2023.27
(G+9) Regular	2824.102
(G+11) Regular	3307.18
(G+5) Irregular	1085.54
(G+7) Irregular	1405.926

(G+9) Irregular	1873.72
(G+11) Irregular	1988.17

Comparison of base shear in Zone III & Zone V:



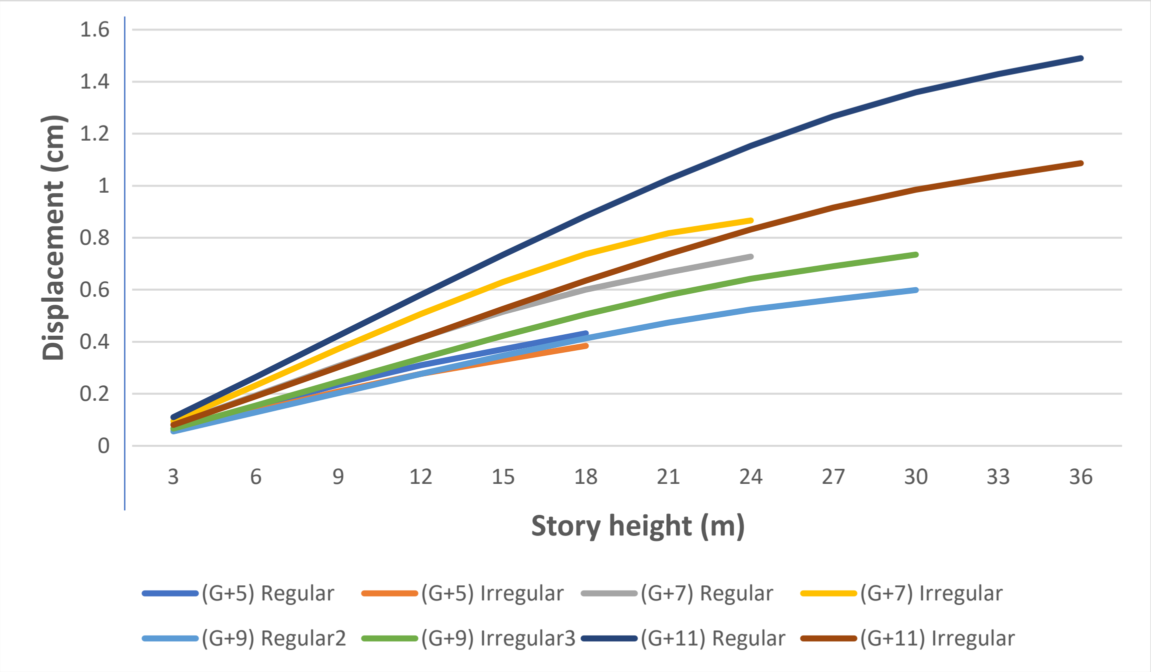
<u>Displacement:</u>

Displacement in zone III in x-direction:

Story height (m)	Displacement (cm)							
	(G+5) Regular	(G+5) Irregular	(G+7) Regular	(G+7) Irregular	(G+9) Regular	(G+9) Irregular	(G+11) Regular	(G+11) Irregular
3	0.065	0.057	0.0818	0.0949	0.0557	0.0663	0.1100	0.0803
6	0.1507	0.1336	0.1940	0.2324	0.1289	0.1551	0.2646	0.1901
9	0.2346	0.2089	0.3071	0.3723	0.2032	0.2458	0.4231	0.3030
12	0.3102	0.2769	0.4158	0.5069	0.2766	0.3359	0.5808	0.4159
15	0.3709	0.3312	0.5156	0.6307	0.3474	0.4232	0.7353	0.5272
18	0.4324	0.3843	0.6011	0.7369	0.4138	0.5052	0.8842	0.6351
21			0.6666	0.8178	0.4734	0.5792	1.0248	0.7375
24			0.7274	0.8664	0.5237	0.6418	1.1535	0.8318

27					0.5620	0.6899	1.2665	0.9153
30					0.5989	0.7352	1.3596	0.9850
33							1.4289	1.0380
36							1.4903	1.0866

Graph of displacement in zone III in x-direction:

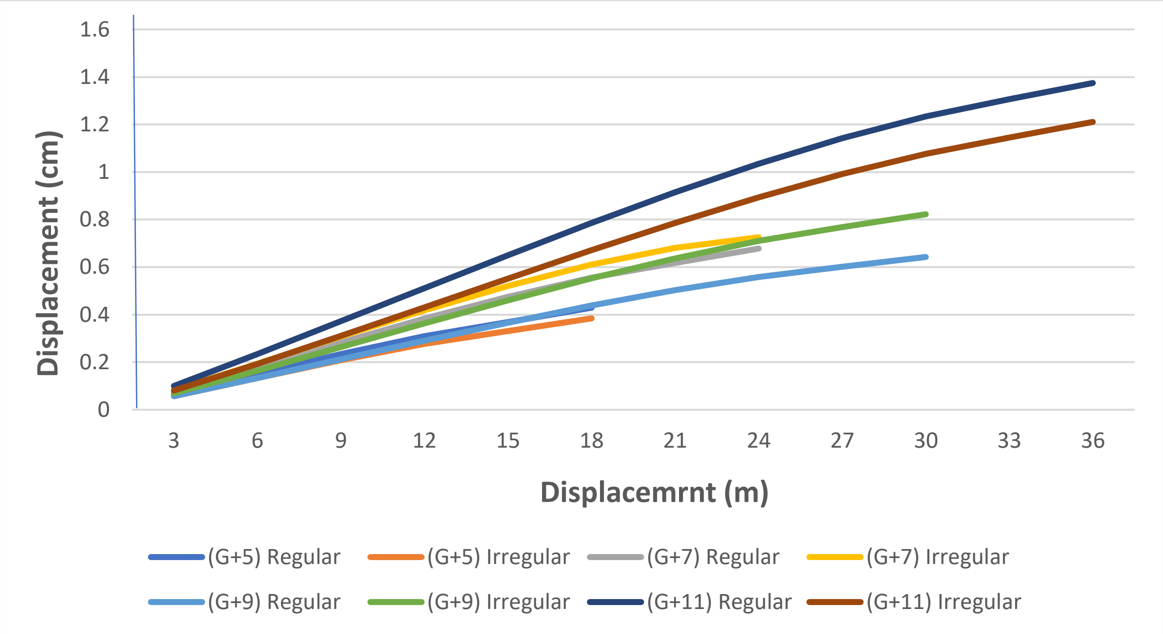


Displacement in zone III in z direction:

Story height (m)	Displacement in structure (cm)							
	(G+5) Regular	(G+5) Irregular	(G+7) Regular	(G+7) Irregular	(G+9) Regular	(G+9) Irregular	(G+11) Regular	(G+11) Irregular
3	0.0652	0.0570	0.0771	0.0826	0.0572	0.0691	0.1000	0.0809
6	0.1510	0.1336	0.1795	0.1942	0.1339	0.1644	0.2339	0.1931
9	0.2346	0.2089	0.2830	0.3077	0.2125	0.2634	0.3723	0.3109
12	0.3095	0.2769	0.3831	0.4181	0.2906	0.3627	0.5117	0.4311
15	0.3692	0.3312	0.4756	0.5209	0.3665	0.4600	0.6503	0.5518
18	0.4293	0.3843	0.5557	0.6107	0.4381	0.5525	0.7856	0.6708
21			0.6178	0.6810	0.5029	0.6370	0.9149	0.7857
24			0.6781	0.7257	0.5582	0.7100	1.0351	0.8937

27					0.6012	0.7679	1.1428	0.9918
30					0.6425	0.8224	1.2342	1.0768
33							1.3059	1.1457
36							1.3745	1.2109

Graph of displacement in zone V in z direction:

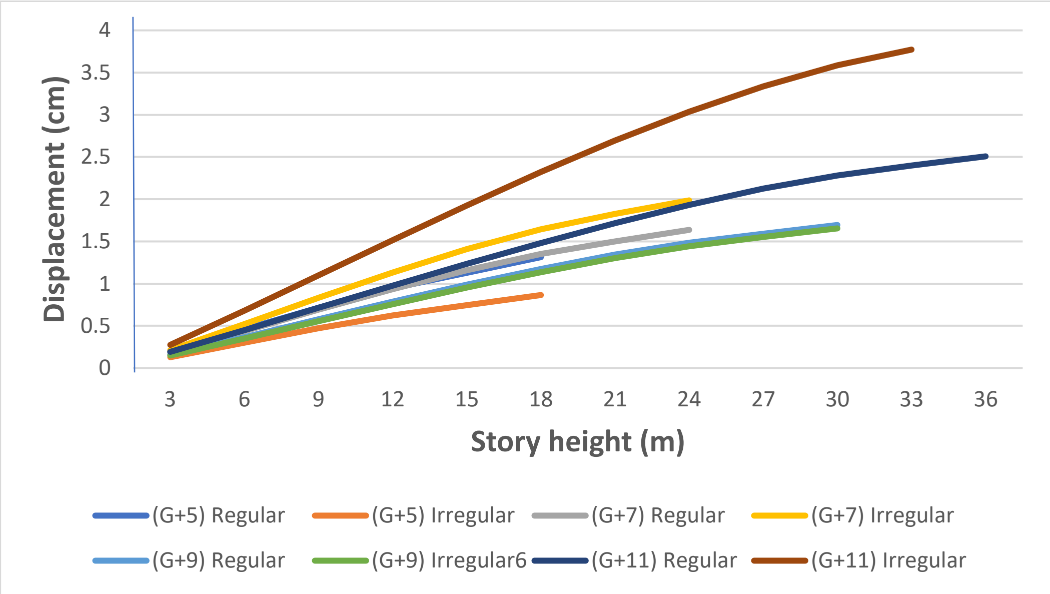


Displacement in zone V in x direction:

Story height (m)	Displacement in structure (cm)							
	(G+5) Regular	(G+5) Irregular	(G+7) Regular	(G+7) Irregular	(G+9) Regular	(G+9) Irregular	(G+11) Regular	(G+11) Irregular
3	0.1982	0.1282	0.1841	0.2122	0.1582	0.1492	0.1920	0.2744
6	0.4594	0.3006	0.4365	0.5195	0.3662	0.3489	0.4499	0.6731
9	0.7149	0.4701	0.6909	0.8320	0.5773	0.5532	0.7133	1.0985
12	0.9449	0.6229	0.9355	1.1326	0.7857	0.7558	0.9757	1.5164
15	1.1288	0.7452	1.1600	1.4085	0.9867	0.9521	1.2334	1.9263
18	1.3138	0.8648	1.3525	1.6448	1.1748	1.1367	1.4824	2.3217
21			1.4998	1.8261	1.3436	1.3031	1.7176	2.6950

24			1.6366	1.9860	1.4853	1.441	1.9336	3.0371
27					1.5924	1.5522	2.1239	3.3379
30					1.6945	1.6543	2.2813	3.5862
33							2.3990	3.7721
36							2.5078	3.9302

Graph of displacement in zone V in x direction:

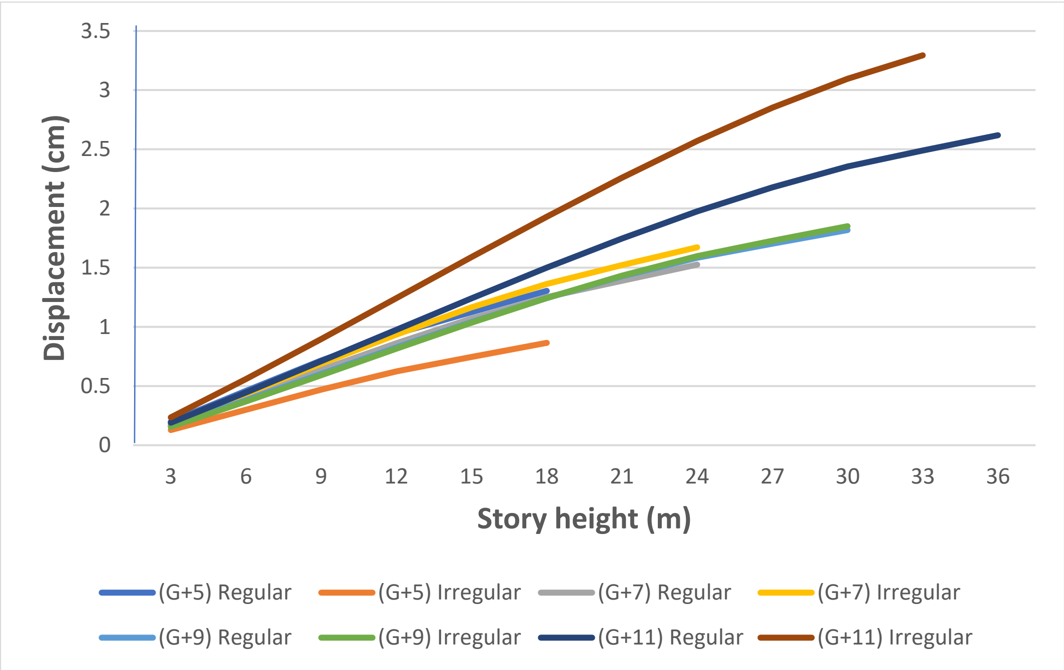


Displacement in zone V in z direction:

Story height (m)	Displacement in structure (cm)							
	(G+5) Regular	(G+5) Irregular	(G+7) Regular	(G+7) Irregular	(G+9) Regular	(G+9) Irregular	(G+11) Regular	(G+11) Irregular
3	0.1982	0.1282	0.1734	0.1847	0.1625	0.1554	0.1902	0.2744
6	0.4594	0.3006	0.4040	0.4342	0.3804	0.3699	0.4460	0.5583
9	0.7149	0.4701	0.6368	0.6878	0.6036	0.5926	0.7103	0.8970
12	0.9426	0.6229	0.8619	0.9344	0.8255	0.8161	0.9768	1.2424
15	1.1235	0.7452	1.0702	1.1637	1.0408	1.0350	1.2413	1.5890
18	1.3042	0.8648	1.2503	1.3634	1.2437	1.2431	1.4994	1.9306

21			1.3901	1.5206	1.4271	1.4334	1.7460	2.2603
24			1.5258	1.6722	1.5830	1.5975	1.9751	2.5704
27					1.7035	1.7278	2.1802	2.8521
30					1.8179	1.8504	2.3541	3.0963
33							2.4899	3.2944
36							2.6191	3.4837

Graph of displacement in zone V in z direction:



Eigen values & eigen vector:

(G+5) regular building in zone III:

Mode	Frequency (cycle/sec)	Period (sec)	Modal Participation Factor in Percent		
			X	Y	Z
1.	0.961	1.04010	0.00	0.00	77.10
2.	0.964	1.03700	83.31	0.00	0.00
3.	1.017	0.98370	0.00	0.00	6.41
4.	2.760	0.36235	0.00	0.00	8.67
5.	2.772	0.36071	9.55	0.00	0.00

(G+5) Irregular building in zone V:

Mode	Frequency (cycle/sec)	Period (sec)	Modal participation factor in percent		
			X	Y	Z
1.	1.075	0.93010	36.04	0.00	36.04
2.	1.081	0.92514	41.49	0.00	41.49
3.	1.139	0.87795	5.49	0.00	5.49
4.	3.123	0.32022	4.56	0.00	4.56
5.	3.129	0.31954	4.91	0.00	4.91

(G+7) Irregular in zone 3:

Mode	Frequency (cycles/sec)	Period (sec)	Modal participation factor in percent		
			X	Y	Z
1.	0.665	1.50408	82.08	0.00	0.00
2.	0.720	1.38912	0.08	0.00	54.99
3.	0.751	1.33109	0.19	0.00	27.39
4.	2.029	0.49274	9.92	0.00	0.00
5.	2.193	0.45600	0.01	0.00	7.63

(G+7) Irregular in zone 5:

Mode	Frequency (cycle/sec)	Period (sec)	Modal participation factor in percent		
			X	Y	Z
1.	0.665	1.50472	81.88	0.00	0.00
2.	0.719	1.39012	0.07	0.00	55.35
3.	0.751	1.33208	0.18	0.00	26.77
4.	1.988	0.50596	9.71	0.00	0.00
5.	2.144	0.46644	0.00	0.00	7.83

(G+9) Regular building in zone III:

Mode	Frequency (cycle/sec)	Period (sec)	Modal participation factor in percent		
			X	Y	Z
1.	0.650	1.53909	82.28	0.00	0.00
2.	0.835	1.19711	0.00	0.00	0.00
3.	0.894	1.11838	0.00	0.00	81.79
4.	1.939	0.51573	9.82	0.00	0.00
5.	2.494	0.40092	0.00	0.00	0.00

(G+9) Regular building in zone V:

Mode	Frequency (cycle/sec)	Period (sec)	Modal participation factor in percent		
			X	Y	Z
1.	0.631	1.58574	0.00	0.00	81.72
2.	0.650	1.53924	82.26	0.00	0.00
3.	0.675	1.48179	0.00	0.00	0.00
4.	1.887	0.52999	0.00	0.00	10.25
5.	1.938	0.51613	9.83	0.00	0.00

(G+9) Irregular building in zone III:

Mode	Frequency (cycle/sec)	Period (sec)	Modal Participation Factor in Percent		
			X	Y	Z
1.	0.613	1.63067	0.39	0.00	65.20
2.	0.646	1.54866	59.39	0.00	6.32
3.	0.667	1.49946	22.07	0.00	9.46
4.	1.854	0.53941	0.04	0.00	9.29
5.	1.935	0.51686	7.86	0.00	0.58

(G+11) Regular building in zone III:

Mode	Frequency (cycle/sec)	Period (sec)	Modal Participation Factor in Percent		
			X	Y	Z
1.	0.447	2.23830	81.76	0.00	0.00
2.	0.471	2.12359	0.00	0.00	81.03
3.	0.498	2.00800	0.00	0.00	0.00
4.	1.342	0.74502	9.66	0.00	0.00
5.	1.416	0.70607	0.00	0.00	10.60

(G+11) Regular building in zone V:

Mode	Frequency (cycles/sec)	Period (sec)	Modal Participation factor in percent		
			X	Y	Z
1.	0.501	1.99780	0.00	0.00	81.04
2.	0.506	1.97533	81.86	0.00	0.00
3.	0.533	1.87563	0.00	0.00	0.00
4.	1.506	0.66399	0.00	0.00	10.58
5.	1.518	0.65888	9.80	0.00	0.00

(G+11) Irregular building in zone III:

Mode	Frequency (cycles/sec)	Period (sec)	Modal Participation factor in percent		
			X	Y	Z
1.	0.478	2.09239	0.33	0.00	57.26
2.	0.505	1.97903	71.68	0.00	4.28
3.	0.525	1.90634	9.47	0.00	18.53
4.	1.460	0.68490	0.05	0.00	8.82
5.	1.520	0.65793	9.18	0.00	0.47

(G+11) Irregular building in zone V:

Mode	Frequency (cycles/sec)	Period (sec)	Modal Participation Factor in percent		
			X	Y	Z
1.	0.411	2.43057	81.08	0.00	0.00
2.	0.432	2.31694	0.15	0.00	49.13
3.	0.473	2.11586	0.18	0.00	31.03
4.	1.241	0.80608	9.72	0.00	0.00
5.	1.319	0.75819	0.01	0.00	7.67

Conclusion:

From above study and analysis part we can conclude that:

1.Regular building is showing greater base shear as compared to irregular building. As greater is story height greater will be its base shear.

2.As far as cost is considered, regular building is 3.05% times more than irregular building in Zone V. (G+5) irregular building in Zone III is same as (G+5) irregular building in Zone V.

Cost of irregular building is 0.6 times of regular building.

3.Displacement of regular buildings in Zone III is more as compared to irregular building. In Zone III, (G+11) regular building is 1.1 times more in X direction as compared to (G+11) regular building in Z direction. In Zone V, (G+11) irregular building in X direction is also 1.1 times more than that of (G+11) irregular building in Z direction. So, higher is height of building higher will be its displacement.

4.Structure in X direction shows much higher story drift & displacement than in Z direction.

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