© 2017 IJSRSET | Volume 3 | Issue 6 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

A Study by Comparison on Vertical Geometric Irregular Frame-Wall Structure Under Lateral Loading

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ABSTRACT

Recent earth quakes in many parts of the globe have revealed the issue regarding the vulnerability of existing buildings. The exiting building structures which were designed and constructed according to earlier code provisions do not satisfy requirement of current seismic code and design practice. Many reinforced concrete buildings in urban regions lying in active seismic zone may suffer moderate to severe damages during future ground motion therefore it is essential to mitigate unacceptable hazards to property and life of occupant. Building may be considered as asymmetric in plan or in elevation based on the distribution of mass and stiffness along each storey throughout the height of the buildings. Most of the hilly regions of India are highly seismic. Buildings on hill slopes differ in a way from other buildings. The various floors of such building steps back towards the hill slope and at the same time buildings may have setbacks also. Due to varied configurations of these buildings become highly irregular and asymmetric. Buildings situated in hilly areas are much more vulnerable to seismic environment. The performance of structures during past earthquakes has shown that asymmetric-plan buildings are especially vulnerable to earthquake damage. Therefore, numerous investigations in the past have investigated the earthquake behavior of asymmetric-plan buildings. In the study, 3D analytical model Ascending and Descending buildings have been generated and analyzed using structural analysis tool "STAAD. Pro." To study the effect of varying height of columns in top storey due to Architectural purpose. The analytical model of the building includes all important components that influence the mass, strength, stiffness, and deformability of the structure. The deflections at each storey level has been compared by performing response spectrum method has been performed to determine capacity, demand and performance level of the considered building models.
Keywords: STAAD, 3D Analytical Model, Complete Quadratic Combination

I. INTRODUCTION

Man is familiar with many natural disasters that occur on the surface of earth, e.g., earthquakes, floods, tornadoes, hurricanes, droughts, and volcanic eruptions etc. Of all natural disasters the least understood and most destructive are earthquakes. The annual losses due to earthquakes are very large in many parts of the world. Although the incidence of earthquakes of destructive intensity has been confined to a relatively few areas of the world, the catastrophic consequences attending the few that have struck near centers of population have focused attention on the need to provide adequate safety against disaster.
Obviously it is impossible to build an earthquake proof structure. All that possible is with effective application of earthquake engineering knowledge the collapse of structures and the consequent loss of life can be avoided. Usually all structures are designed to resist the intensity of moderate earthquake. This is based on the philosophy that it is less expensive to repair or replace the small number if structures which will be hit by a major earthquake than to build all structures strong enough to avoid damage.

Wind loads are of important, particularly in the design of large structures. The wind velocity that should be considered in the design of structure depends upon the geological location and the exposure of the structure. Wind is a phenomenon of great complexity because of the many flow situations arising from the interaction of wind with structures.

II. OBJECTIVES OF THE STUDY

The objective of the present work is to study the behaviour of a six, eight & ten storey building with different irregularity in geometry under earthquake loading. Irregularity are categories ranging from 0 percentage to 75 percentage with interval of 25 percentage is considered in this study which generally covers the irregular structures encountered in practice.

For each case member forces (such as Bending moment, Shear force Base shear, Displacement, and Drift) are estimated and studied the effect of irregular structures on the member forces. The analysis of the building has been carried out using STAAD PRO V8i.

III. LITERATURE REVIEW

Kumar and Paul (1994) have stated that buildings having step back and setback configurations are unsymmetrical in horizontal and vertical planes. These are subjected to translational and torsional deformations under earthquake excitations. Centre of mass of each floor of this type of buildings normally lie on different vertical axes. A method of analysis based on transformation of stiffness and mass matrices about a vertical reference axis is developed. Each storey of the building is modelled as having three degrees of freedom per floor with floor diaphragm as rigid.

J. A. Amin Et al. has done the experiments on wind tunnel models to evaluate wind pressure distributions on different faces of typical-plan shape buildings. Models, having the same plan area and height but varying plan shape (“L” and “T”) are tested in a closed circuit wind tunnel under boundary layer flow. It was observed that there is a large variation in pressure along the height as well as along the width of different faces of the models. The location and magnitude of the measured peak pressure co-efficient vary considerably with wind direction. It was also observed that changing the plan dimensions considerably affects the wind pressure distributions on different faces of the building models.

IV. METHODOLOGY

When a structure is subjected to earthquake, it responds by vibrating. An earthquake can be resolved in any three mutually perpendicular directions-the two horizontal directions (x and y) and the vertical direction (z). This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. All the structures are primarily designed for gravity loads-force equal to mass times gravity in the vertical direction. Because of the inherent factor of safety used in the design specifications, most structures tend to be adequately protected against vertical shaking. Vertical acceleration should also be considered in structures with large spans, those in which stability for design, or for overall stability analysis of structures.

Equivalent Lateral Force (Seismic Coeficient) Method:

In all the methods of analyzing multi story buildings recommended in the code, the structure is treated as discrete system having concentrated masses at floor levels which include half that of columns and below the floor. In addition, the appropriate amount of live load at this is also lumped with it. It is also assumed that the structure flexible and will deflect with respect to the position of foundation the lumped mass system reduces to the solution of a system of second order differential equations. These equations are formed by distribution of mass and stiffness in a structure, together with its damping characteristics of the ground motion.

1) BASE SHEAR:

According to IS 1893(part1): 2002, the base shear Vb is given by the following formula:

$$V_b = A_h W \quad \text{eq. 3.1}$$

Here,

Ah = Design horizontal acceleration spectrum value using the fundamental natural period ‘T’ in the considered direction of vibration

W = seismic weight of the building

$$A_h = \left(\frac{Z}{2}\right) \frac{I}{R} \frac{S_a}{g} \quad \text{eq. 3.2}$$

Z= Zone factor as per table 2 of IS: 1893

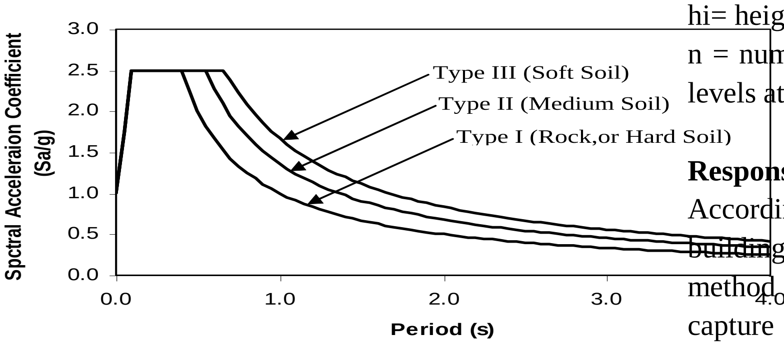
I= Importance factor as per table 6 of IS: 1893

= 1.5 for important structures

= 1.0 for all other buildings

R= Response reduction factor as per table 7 of IS: 1893 value varies between
3 and 5 with respect to ductile reinforcement detailing
Sa/g= Average response acceleration coefficient as per clause 6.4.5 of the
Indian Standard IS 1893:2002.

Figure 3.1 Design spectrum for 5% damping as per Indian Standards



SEISMIC WEIGHT: The seismic weight of building is the sum of seismic weight of all the floors. The seismic weight of each floor is its full dead load plus appropriate amount of imposed load. While computing the seismic weight of columns and walls in any story shall be equally distributed to the floors above and below the story.

TIME PERIOD:

The approximate fundamental natural period of vibration Ta in seconds, of a moment resisting frame building without brick infill panels may be estimated by the following empirical formula

Ta = 0.075h0.75 for RC frame building eq.3.3

Ta = 0.085h0.75 for steel frame building eq.3.4

The approximate fundamental natural period of vibration in seconds of all other, buildings including moment resisting frame buildings with brick infill panels may be estimated by the following expression.

$T_a = \frac{0.09h}{\sqrt{d}}$eq 3.5

Where

H= Height of building in meters. (This excludes the basement stories where basement walls are connected with the ground floor deck or fitted between the columns. But it includes the basement stories, when they are not connected)

d= base dimensions of the building at the plinth level, in m, along the consider direction of the lateral force.

As per IS 1893: 2002 in clause 7.7.1 mentioned that the force thus obtained shall be distributed along the height of the building as per the following expression:

$$Q_i = \frac{V_b \ W_i \ h_i^2}{\sum W_j \ h_j^2}$$ eq. 3.6

Where

Qi = Design lateral force at floor i,

Wi=seismic weight of floor

hi= height of floor measured from base, and

n = number of storeys in the building i.e., number of levels at which masses are located.

Response spectrum analysis

According to IS 1893:2002, high rise and irregular buildings must be analysed by response spectrum method using response spectra. Sufficient modes to capture at least 90% of the participating mass of the building (in each of two orthogonal principle horizontal directions) have to be considered the analysis. If base shear calculated from the response spectrum analysis $(\bar{V}_B)$ is less than the design base shear (V_B), the response quantities (member forces, displacements, storey shears and base reactions) have to be scaled up by the factor $V_B / \bar{V}_B$.

The response spectra are given by the following equations

For type I soil (Rock or Hard Soil sites)

$$\frac{S_a}{g} = \begin{cases} 1+15T; 0.00 \le T \le 0.10 \\ 2.50 \quad 0.10 \le T \le 0.40 \\ \frac{1}{T} \quad 0.40 \le T \le 4.00 \end{cases}$$

For type II (Medium soil)

$$\frac{S_a}{g} = \begin{cases} 1+15T; 0.00 \le T \le 0.10 \\ 2.50 \quad 0.10 \le T \le 0.55 \\ \frac{1.36}{T} \quad 0.55 \le T \le 4.00 \end{cases}$$

For type III (Soft soil)

$$\frac{S_a}{g} = \begin{cases} 1+15T; 0.00 \le T \le 0.10 \\ 2.50 \quad 0.10 \le T \le 0.67 \\ \frac{1.67}{T} \quad 0.67 \le T \le 4.00 \end{cases}$$

Response quantities (member forces, displacements, storey forces, storey shears and base reactions) for each mode of response shall be combined by either the

SRSS (square root sum of squares) or the CQC (complete quadratic combination) rule.

WIND LOADS:

Basic Wind Speed (VB): Figure gives basic wind speed map of India, as applicable at 10 m height above mean ground level for different zones of the country. Basic wind speed is based on peak gust speed averaged over a short time interval of about 3 seconds and corresponds to 10m height above the mean ground level in an open terrain (Category 2). Basic wind speeds presented in Fig.1 have been worked out for a 50-year return period.

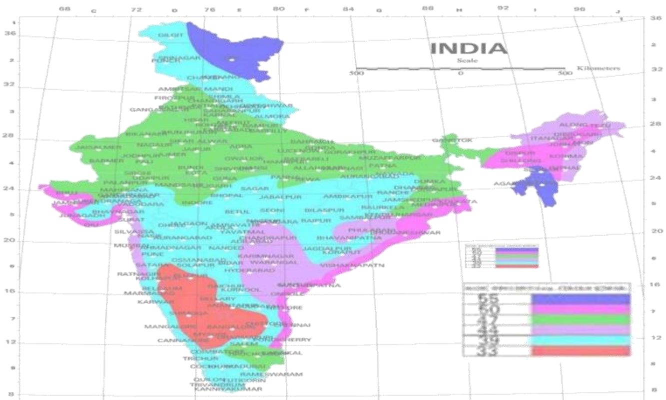


Figure 1. Basic wind speed in m/s (based on 50 year return period)

Design Wind Speed (V_z)

The basic wind speed for any site shall be obtained from Fig. 3.2 and shall be modified to include the following effects to get design wind speed, Vz at any height, Z for the chosen structure: (a) Risk level, (b) Terrain roughness and height of structure, (c) Local topography, and (d) Importance factor for the cyclonic region. It can be mathematically expressed as follows:

$V_z = V_b \; k_1 \, k_2 \, k_3$

where

V_z = design wind speed at any height z in m/s,

Vb = basic wind speed in m/s,

k1 = probability factor (risk coefficient)

k2 = terrain roughness and height factor

k3 = topography factor and

k4 = importance factor for the cyclonic region

NOTE: The wind speed may be taken as constant up to a height of 10 m. However, pressures for buildings less than 10m high may be reduced by 20% for stability and design of the framing.

Risk Coefficient (k1)

Fig.1 gives basic wind speeds for terrain category 2 as applicable at 10 m height above mean ground level based on 50 years mean return period. The suggested life span to be assumed in design and the corresponding k factors for different class of structures for the purpose of design are given in Table 3.3. In the design of all buildings and structures, a regional basic wind speed having a mean return period of 50 years shall be used except as specified in the note of Table 1

Height (z) (m)	Terrain and height multiplier (m)			
	Terrain Category 1	Terrain Category 2	Terrain Category 3	Terrain Category 4
10	1.05	1.00	0.91	0.80
15	1.09	1.05	0.97	0.80
20	1.12	1.07	1.01	0.80
30	1.15	1.12	1.06	0.97
50	1.20	1.17	1.12	1.10
100	1.26	1.24	1.20	1.20
150	1.30	1.28	1.24	1.24
200	1.32	1.30	1.27	1.27
250	1.34	1.32	1.29	1.28
300	1.35	1.34	1.31	1.30
350	1.37	1.36	1.32	1.31
400	1.38	1.37	1.34	1.32
450	1.39	1.38	1.35	1.33
500	1.40	1.39	1.36	1.34

Table. 1 *k* factors to obtain design wind speed variation with height in different terrains

Terrain and Height Factor (k2)

Terrain – Selection of terrain categories shall be made with due regard to the effect of obstructions which constitute the ground surface roughness. The terrain category used in the design of a structure may vary depending on the direction of wind under consideration. Wherever sufficient meteorological information is available about the wind direction, the orientation of any building or structure may be suitably planned.

Terrain in which a specific structure stands shall be assessed as being one of the following terrain categories:

Category 1 – Expo sed open terrain with a few or no obstructions and in which the average height of any object surrounding the structure is less than 1.5 m. This category includes open sea coasts and flat treeless plains.

Category 2 – Open terrain with well-scattered obstructions having height generally between1.5 and 10 m. This is the criterion for measurement of regional basic wind speeds and includes airfields, open parklands and undeveloped sparsely built-up outskirts of towns and suburbs. Open land adjacent to seacoast may also be classified as Category 2 due to roughness of large sea waves at high winds.

Category 3 – Terrain with numerous closely spaced obstructions having the size of building-structures up to 10 m in height with or without a few isolated tall structures. This category includes well-wooded areas, and shrubs, towns and industrial areas fully or partially developed.

Category 4 –Terrain with numerous large high closely spaced obstructions. This category includes large city centers, generally with obstructions taller than 25 m and well-developed industrial complexes

Variation of wind speed with height for different terrains (k 2 factor) –

Table 1 gives multiplying factor (k2) by which the basic wind speed given in Fig.1 shall be multiplied to obtain the wind speed at different heights, in each terrain category.

Terrain categories in relation to the direction of wind –

As also mentioned above, the terrain category used in the design of a structure may vary depending on the direction of wind under consideration. Where sufficient meteorological information is available, the basic wind speed may be varied for specific wind directions

Changes in terrain categories –

The speed profile for a given terrain category does not develop to full height immediately with the commencement of that terrain category but develops gradually to height (h) which increases with the fetch or upwind distance (x).

Topography (k3 factor) –

The basic wind speed V b given in Fig. 3.1 takes account of the general level of site above sea level. This does not allow for local topographic features such as hills, valleys, cliffs, escarpments, or ridges, which can significantly affect the wind speed in their vicinity. The effect of topography is to accelerate wind near the summits of hills or crests of cliffs, escarpments or ridges and decelerate the wind in valleys or near the foot of cliffs, steep escarpments, or ridges. The effect of topography will be significant at a site when the upwind slope (θ) is greater than about 3 , and below that, the value of k3 may be taken to be equal to 1.0. The value of k is confined in the range of 1.0 to 1.36 for slopes greater than 3 . A method of evaluating the value of k3 for values greater than 1.0 is given in Appendix C. It may be noted that the value of k3 varies with height above ground level, at a maximum near the ground, and reducing to1.0 at higher levels, for hill slope in excess of 17

Importance factor for cyclonic region (k4)

Cyclonic storms usually occur on the east coast of the country in addition to the Gujarat coast on the west. Studies of wind speed and damage to buildings and structures point to the fact that the speeds given in the basic wind speed map are often exceeded during the cyclones. The effect of cyclonic storms is largely felt in a belt of approximately 60 km width at the coast. In order to ensure greater safety of structures in this region (60 km wide on the east coast as well as on the Gujarat coast),the following values of k4 are stipulated, aapplicable according to the importance of the structure:

Structures of post–cyclone importance	1.30
Industrial structures	1.15
All other structures	1.00

Design wind pressure:

The wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind speed:

$$P_z = 0.6 V_z^2$$

where p z = wind pressure in N/m at height z, and

V z= design wind speed in m/s at height z.

V. MODELLING DESCRIPTION OF BUILDING

The structure chosen for study is a six storied commercial complex building. The building is located in seismic zone II on a site with medium soil. A three-dimensional mathematical model for the same is generated in STAAD PRO software the building with dimensions 30m x 30m. Analysis and design for typical building is to be performed.

BASIC DATA:

Structure	symmetric regular building
Plan dimensions	30 × 30 m
Height of each floor	3 m
Ground floor height	3 m
Dimension of columns	300x600 mm

Dimension of beams (main) 230 × 600 mm
Slab thickness 125 mm
Support fixed
Zone II
LOADS
Water proofing on terrace = 1.0 kN/m2
Floor finishes = 1.0 k N/m2
Live load = 2 k N/m2

LOAD CALCULATION

(Seismic weight calculations)

The weight of columns and walls in any story shall be equally distributed to the floors above and below the story. Following reduced live loads are used for analysis: zero on terrace, and 50% on other floors [IS:1893 (Part 1):2002, Clause 7.4]

(1) Story 7 (Terrace)

From slab = 30*30* 25*(0.125)=2812.5

Column =0.3*0.6*25*147=661.5

Beams = 0.23*0.6*25*245 = 3105 kN
Floor finishes = (30*30*1)= 900
Wall load=1*0.115*20*(30*4)=276KN
Live load = (30*30*2) = 1800 kN
Total dead load = 7756kN
Total live load = 1800kN
PLINTH
Dead loads:
Beams = 0.23*0.6*25*245= 3105kN
Coloums = 0.3*0.6*25*147=661.5KN
Wall load= 2.4*0.115*20*245=1353KN
Total dead load= 5120 KN
TYPICAL FLOORS (2,3,4,5,)
Dead load:
From slab = 30*30* 25*0.125=2812.5, 2812.5*4=11250
Column =0.3*0.6*25*147=661.5, 661.5*4=2646
Beams = 0.23*0.6*25*900 = 3105 kN, 3105*4=12420
Floor finishes = (30*30*1)= 900, 900*4=3600
Wall load=2.4*0.115*20*245=1353KN = 1353*4=5412
Live load = (30*30*2) = 1800 kN=1800*4= 7200
Total dead load = 35328kN
Total live load = 7200 kN
Seismic weight of the entire building =48204 +0.25*9000
= 50454 kN

Calculation of lateral forces as per IS 1893: 2002 in clause 7.5

Ta = 0.075 h 0.75 IS: 1893 (Part 1):2002, Clause 7.6.1
= 0.075 * (18)0.75
= 0.65 sec
Zone factor, z = 0.16 for Zone III as per IS: 1893 (Part 1):2002, Table 2
Importance factor, I = 1
Medium soil site and 5% damping
Sa/g = 2.50/0.65 = 3.846 IS: 1893 (Part 1):2002, Figure 2.
Response reduction factor = 3
Ah = (Z/2) (I/R)(Sa/g) = 0.10256

Hence the total design lateral force or design seismic base shear along any principle direction

Vb = AhW
W = 42305.5 kN

Vb= AhW

=0.10256 * 50454

Vb= 5175kN.

WIND LOAD
k factors to obtain design wind speed variation with height in different terrains.

Height (mt)	K1	K2	K3	Vz	Pz Kn/m2
10	1	0.88	1	38.70	0.98
15	1	0.94	1	41.36	1.02
20	1	0.98	1	43.12	1.11
30	1	1.03	1	45.32	1.23
50	1	1.09	1	47.96	1.38

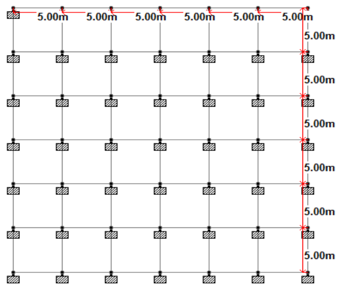
LOAD CASES
The loading on the buildings are dead load, live load, and wind load.

1. Dead load case:
   a) Floor load
   b) Wall load
   c) Self weight

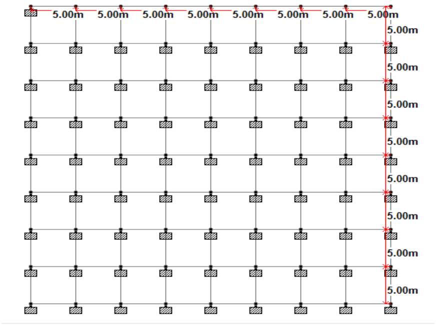
The building is designed as a concrete structure and the self weight of the building is taken in the dead load case

2. Live load case:

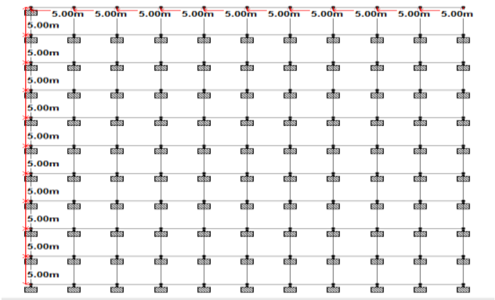
a) live load 2 KN/m2



Plan of the six storey building



Plan of the eight storey building



Plan of the ten storey building

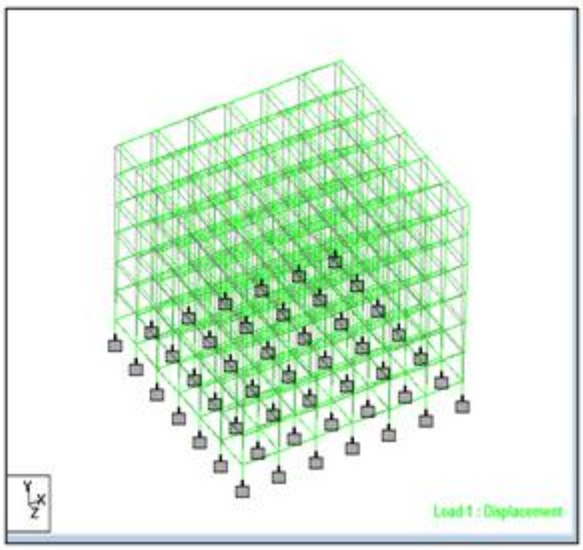
VI. RESULT AND DISCUSSIONS

Model Description

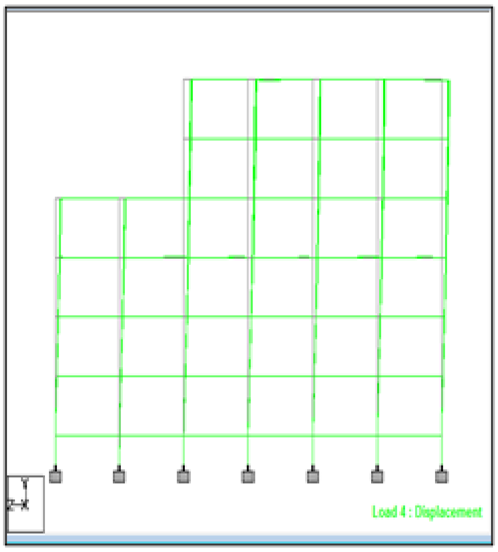
MA1= 6 storey Basic Model without vertical irregularity.
MA2= 6 storey Basic Model with 25% vertical irregularity.
MA3= 6 storey Basic Model with 50% vertical irregularity.
MA4= 6 storey Basic Model with 75% vertical irregularity.
MB1= 6 storey Basic Model without vertical irregularity.
MB2= 6 storey Model with 25% vertical irregularity.
MB3= 6 storey Model with 50% vertical irregularity.
MB4= 6 storey Model with 75% vertical irregularity.

MC1= 8 storey Basic Model without vertical irregularity.
MC2= 8 storey Basic Model with 25% vertical irregularity.
MC3= 8 storey Basic Model with 50% vertical irregularity.
MC4= 8 storey Basic Model with 75% vertical irregularity.
MD1= 8 storey Basic Model without vertical irregularity.
MD2= 8 storey Model with 25% vertical irregularity.
MD3= 8 storey Model with 50% vertical irregularity.
MD4= 8 storey Model with 75% vertical irregularity.

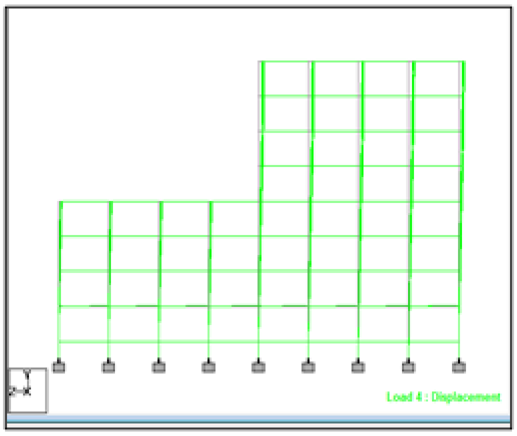
ME1= 10storey Basic Model without vertical irregularity.
ME2= 10storey Basic Model with 25% vertical irregularity.
ME3= 10storey Basic Model with 50% vertical irregularity.
ME4= 10storey Basic Model with 75% vertical irregularity.
MF1= 10storey Basic Model without vertical irregularity.
MF2= 10storey Model with 25% vertical irregularity.
MF3= 10storey Model with 50% vertical irregularity.
MF4= 10storey Model with 75% vertical irregularity.



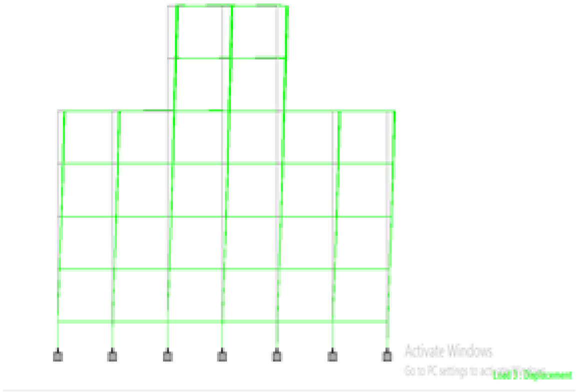
6storey building



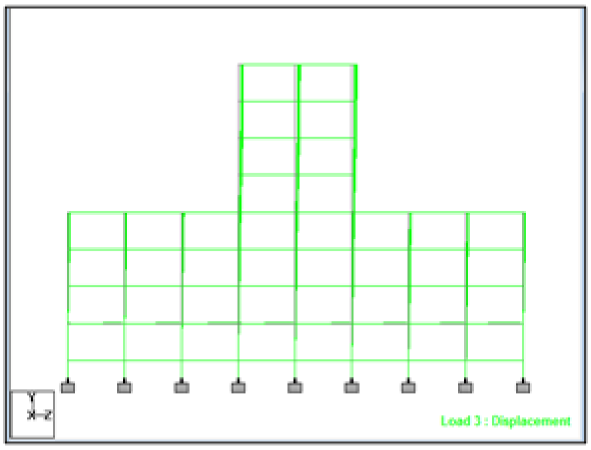
6 storey building with 25% reduction



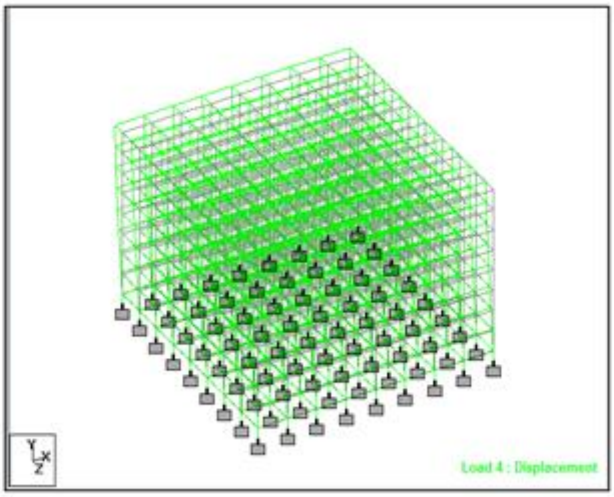
8 storey building with 50% reduction



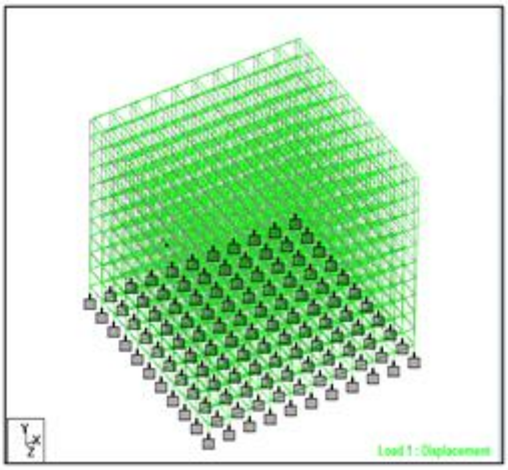
6 storey building with 25% reduction



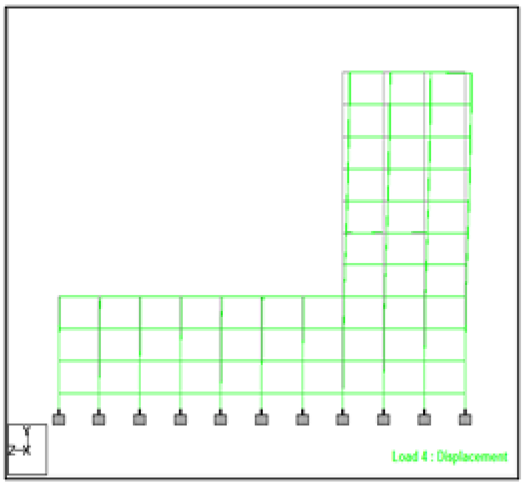
8 storey building with 50% reduction



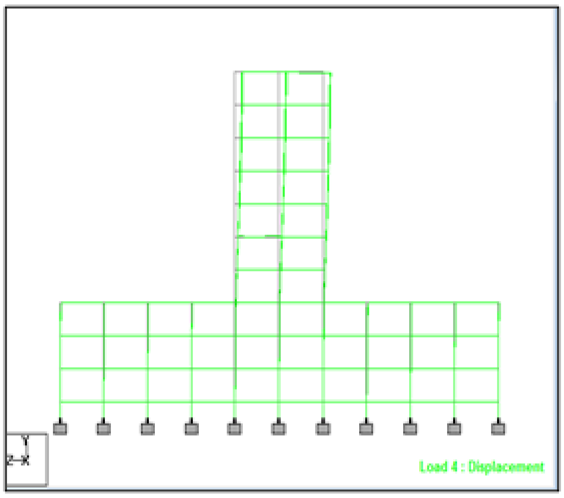
8 storey building



10 storey buildig



10 storey building with 75% reduction



10 storey building with 75% reduction

MODEL PROPERTIES:

Maximum bending moment.

Type Model	Storey No.	Maximum Bending Moment			
		M1 (0%)kN	M2 (25%)kN	M3 (50%) kN	M4 (75%) kN
Basic Model	6	2140	2260	2305	2840
	8	2150	2540	2850	3320
	10	2380	2800	3010	3890
Modified Model	6	2140	2560	2880	2700
	8	2150	2580	2020	2260
	10	2380	2480	3250	3316

Maximum Shear Force

Type Model	Storey No.	Maximum Shear Force			
		M1 (0%)kN	M2 (25%)kN	M3 (50%) kN	M4 (75%) kN
Basic Model	6	1340	689	1370	1680
	8	1400	1030	1220	2160
	10	1410	1640	1970	2310
Modified Model	6	1340	1340	1430	1420
	8	1400	828	912	1080
	10	1410	1130	1450	1480

Comparison of base shear on vertical irregularity for 6 storey building.

Building Reduction (%)	Fy (MA) (kN)	Fy (MB) (kN)
0	7360	8687
25	7663	10384
50	8317	10967
75	18752	10855

Comparison of base shear on vertical irregularity for 8 storey building.

Building Reduction (%)	*Fy (MC) (kN)*	*Fy (MD) (kN)*
0	8725	10577
25	9849	11061
50	10441	11867
75	11466	12995

Comparison of base shear on vertical irregularity for 10 storey building.

Building Reduction (%)	*Fy (ME) (kN)*	*Fy (MF) (kN)*
0	10260	12317
25	10351	15584
50	11577	20417
75	14537	20340

Displacement for 6 storey building with vertical irregularity.

Displacements in (mm)		
MA1 (0%)	MA2 (25%)	MA3 (50%)
0	0	0
14	12	14
91	74	88
179	144	174
264	207	267
337	257	306
394	289	343
427	306	364

Displacement for 6 storey building with vertical irregularity.

Storey level	Displacements in (mm)			
	MB1 (0%)	MB2 (25%)	MB3 (50%)	MB4 (75%)

0	0	0	0	0
G	16	20	22	23
1	103	132	140	139
2	204	261	277	274
3	300	386	409	403
4	386	495	524	518
5	452	578	613	606
6	491	629	668	660

Displacement for 8 storey building with vertical irregularity.

Storey level	Displacements in (mm)			
	MC1 (0%)	MC2 (25%)	MC3 (50%)	MC4 (75%)
0	0	0	0	0
G	14	10	12	22
1	91	66	79	140
2	179	131	155	276
3	268	194	230	412
4	351	252	300	540
5	427	301	357	656
6	490	338	401	753
7	535	362	428	826
8	564	374	443	867

Displacement for 8 storey building with vertical irregularity.

Storey level	Displacements in (mm)			
	MD1 (0%)	MD2 (25%)	MD3 (50%)	MD4 (75%)
0	0	0	0	0
G	15	12	16	16.5
1	100	79	104	106
2	200	156	206	210
3	299	232	307	312
4	393	301	400	406
5	478	360	478	485
6	550	404	534	543.5
7	604	427	565	576
8	635	441	583	593.5

Displacement for 10 storey building with vertical irregularity.

Storey level	Displacements in (mm)			
	0%	25%	50%	75%
0	0	0	0	0
G	14	19.5	19.5	22.6
1	91	127.5	126	148
2	179	253	250	293
3	269	380	374	440
4	356	503	496	584
5	440	620	612	720
6	516	727	718	845
7	584	822	812	956
8	639	900	888	1050
9	678	956	945	1110
10	703	988	976	1150

Displacement for 10 storey building with vertical irregularity.

Storey level	Displacements in (mm)			
	MF1 (0%)	MF2 (25%)	MF3(50%)	MF4 (75%)
0	0	0	0	0
G	15	20	26	26.5
1	99	129	168	171
2	197	257	336	341
3	296	386	508	513
4	392	513	678	682
5	484	635	842	845
6	569	748	995	998
7	645	848	1130	1130
8	707	931	1250	1250
9	752	992	1330	1330
10	780	1030	1390	1380

Storey Drift for 6 storey building with vertical irregularity.

Storey level	Storey drift			
	MA 1 (0%)	MA 2 25 %	MA 3 50 %	MA4 75%
0	0	0	0	0
G	14	12	14	17
1	77	62	74	92
2	88	70	86	102
3	85	63	93	93
4	73	50	60	72
5	57	32	37	46
6	33	17	21	25

Storey Drift for 6 storey building with vertical irregularity.

Storey level	Storey drift			
	MB1 (0%)	MB2 25%	MB3 50%	MB4 75%
0	0	0	0	0

G	16	20	22	23
1	87	112	118	116
2	101	129	137	135
3	96	125	132	129
4	86	109	115	115
5	66	83	89	88
6	39	51	55	54

Storey Drift for 8 storey building with vertical irregularity.

Storey level	Storey drift			
	MC1 (0%)	MC2 25%	MC3 50%	MC4 75%
0	0	0	0	0
G	14	10	12	22
1	77	56	67	118
2	88	65	76	136
3	89	63	75	136
4	83	58	70	128
5	76	49	57	116
6	63	37	44	97

Storey Drift for 8 storey building with vertical irregularity.

Storey level	Storey drift		
	MD1 (0%)	MD2 (25%)	MD3
0	0	0	
G	15	12	
1	85	67	
2	100	77	1
3	99	76	1
4	94	69	
5	85	59	
6	72	44	
7	54	23	
8	31	14	

Storey Drift for 10 storey building with vertical irregularity.

Storey level	Storey drift		
	ME1 (0%)	ME2 (25%)	ME
0	0	0	
1	14	19.5	
2	77	108	1
3	88	125.5	
4	90	127	
5	87	123	
6	84	117	
7	76	107	

8	68	95	94
9	55	78	76
10	39	56	57
11	25	32	31

Storey Drift for 10 storey building with vertical irregularity.

Storey level	Store	
	ME1 (0%)	ME2 (25%)
0	0	0
1	15	20
2	84	109
3	98	128
4	99	129
5	96	127
6	92	122
7	85	113
8	76	100
9	62	83
10	45	61
11	28	38

VII. CONCLUSIONS

Based on the limited study of analysis results the following conclusions are drawn

The base shear were increased by an average 19%, 28% & 42% for regular model with irregularity and whereas for +shape model increased by 25% , 47% and 65%. However, as the height of the structure was increasing the base shear due to vertical irregularity was increasing gradually.

The drift of all the building with increasing in percentage of irregularity got increased gradually. That means the greater the drift, greater the likelihood of damage of structure. The value of inter-storey drift exceed 0.10 indicate probable of building collapse.

The maximum displacement of 75 percentage irregularity in building were increased by about 75% with respect to +shape without irregularity & similarly 65% were increased for regular shape without irregularity.

Bending moment & shear force got increased maximum in 75 percentage irregular building then basic building. It can be seen that as the irregularity in structure increases, the bending moments & shear force also increases for column.

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