Shear Wall Analysis and Design Optimization In Case of High Rise Buildings Using Etabs (software)

M.Pavani, G.Nagesh Kumar, Dr. Sandeep Pingale

Abstract—Due to increase in population spacing in India is needed, especially in urban areas. Also due to increase in the transportation and safety measure the FSI (Floor Spacing Index) in Indian cities is increasing considerably. Structural engineers in the seismic regions across the world often face the pressure to design high rise buildings with stiffness irregularities, even though they know these buildings are vulnerable under seismic loading. Today's tall buildings are becoming more and more slender, leading to the possibility of more sway in comparison with earlier high rise buildings .improving the structural systems of tall buildings can control their dynamic response. With more appropriate structural forms such as shear walls and tube structures and improved material properties. The general design concept of the contemporary bearing wall building system depends upon the combined structural action of the floor and roof systems with the walls. The floor system carries vertical loads and, acting as a diaphragm, lateral loads to the walls for transfer to the foundation. Lateral forces of wind and earthquake are usually resisted by shear walls which are parallel to the direction of lateral load. These shear walls, by their shearing resistance and resistance to overturning, transfer the lateral loads to the foundation. In the present study a 45 storey high rise building, with podium up to 4th floor level is considered. After podium level (4th floor level), there is no sudden change in plan because if there is any sudden change it may result in the stiffness/torsional irregularities of building if a small seismic forces or any other less magnitude horizontal force strike the structure. The optimization techniques which are used in this project are firstly considered the size of shear wall is same throughout the building and then analysis is done from the result the failed shear wall dimensions are increased to resist the whole structure, in this way the optimization was done for number of time till the whole structure comes to stable to resist the forces .In this present project shear wall design and optimization is done by using the software Etabs and the shear walls are arranged in such a way to resist the lateral forces in zone III region throughout the structure according to Indian codes.

Key Words: Storey Drifts, shear wall, Storey Stiffness, base shear.

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1.1 INTRODUCTION

THE design of tall buildings essentially involves a conceptual design, approximate analysis, preliminary design and optimization, to safely carry gravity and lateral loads. The primary purpose of all kinds of structural systems used in the building type of structures is to transfer gravity loads effectively. 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, earthquake forces. 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.

The static and dynamic structural responses of high rise buildings are governed by the distributions of transverse shear stiffness and bending stiffness per each storey. "Making changes to the systems inside the building or even the structure itself at some point after its initial construction and occupation.

1.1.1REQUIREMENTS OF STRUCTURAL ELEMENT IN HIGH RISE BUILDINGS

The impact of wind and seismic forces acting on High rise buildings becomes an important aspect of the design. Improving the structural system of tall buildings can control their dynamic response with more appropriate structural elements such as shear walls and tube structures, and by improving material properties; the maximum height of concrete buildings has soared in recent decades. Under the large overturning effects caused by horizontal Earthquake forces, edges of shear walls experience high compressive and tensile stresses. To ensure that shear walls behave in a ductile way, concrete in the wall end regions must be reinforced in special manner to sustain these load reversals without losing strength. End regions of wall with increased confinement are called boundary elements. This special confining transverse reinforcement in the boundary elements is similar to that provided in columns of reinforced concrete frames. Sometimes, the thickness of the shear wall in these boundary elements is also increased.

1.1.2. DIFFERENCE BETWEEN COLUMN AND SHEAR WALL

Columns are compression elements where as shear wall is compression as well as shear resisting elements. A shear wall is a vertical structural element that resists lateral forces in the plane of the wall through shear and bending. Shear walls are usually provided along both length and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings (depends on structure). If the ratio of length to the breath is less than 4 then it is considered as shear wall. Columns are line loaded elements and shear wall is area loaded elements.

1.1.3. CENTER OF MASS AND CENTER OF STIFFNESS LOCATIONS TO REDUCE THE TORSIONAL EFFECT

Center of mass and center of stiffness study shall be made in this report to get the minimum eccentricity. Try to avoid the torsional irregularity in the building by positioning the shear wall in such a way that center of stiffness and center of mass lies in one line parallel(or) perpendicular to the force acting on it.

1.2 AIMS AND OBJECTIVES

In this study R.C.C. building is modelled, analyzed and designed. Design of shear wall by itself is a study of demand Vs capacity ratio adhered to the properties of shear wall sections. This can be generated by the mathematical model created in Etabs by considering the earthquake and wind forces. There is various ways to find out the capacity of a section mainly stated as below

1. Object based model
2. Idealization for shear design and boundary line checks
3. Idealization for flexural design(or) check

The stability of the building is evaluated by checking of Storey Drifts, Lateral Displacements, Lateral Forces, Storey Stiffness, Base shear, Time period, Torsion.

1.3 METHOD OF ANALYSIS

The most commonly used methods of analysis are based on the approximation that the effects of yielding can be accounted for by linear analysis of the building, using the design spectrum for inelastic system. Forces and displacements due to each horizontal component of ground motion are separately determined by analysis of an idealized building having one lateral degree of freedom per floor in the direction of the ground motion component

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being considered. Such analysis may be carried out by the seismic coefficient method (static method) or response spectrum analysis procedure (dynamic method).

1.3.1 RESPONSE SPECTRUM ANALYSIS

According to the Indian code in the response spectrum method, the response of a structure during an earthquake is obtained directly from the earthquake response (or design) spectrum. This procedure gives an approximate peak response, but this is quite accurate for structural design applications. In this approach, the multiple modes of response of a building to an earthquake are taken into account. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass. The responses of different modes are combined to provide an estimate of total response of the structure using modal combination methods such as complete quadratic combination (CQC), square root of sum of squares (SRSS), or absolute sum (ABS) method. Response spectrum method of analysis should be performed using the design spectrum specified or by a site – specific design spectrum, which is specifically prepared for a structure at a particular project site. The same may be used for the design at the discretion of the project authorities

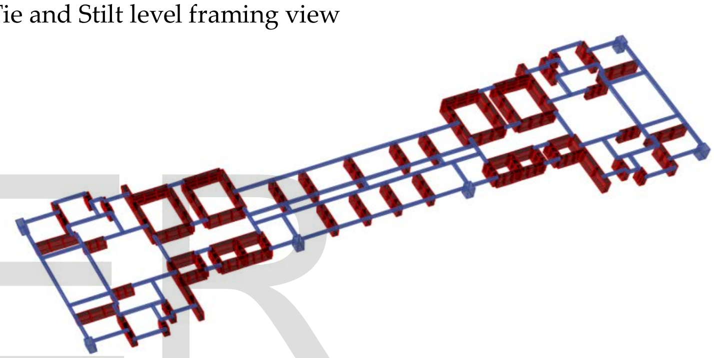
1.4 ANALYSIS OF BUILDING

A hypothetical building is assumed for seismic analysis that consists of a G+44+terrace R.C.C. residential cum commercial building. The plan of the building is irregular in nature but considered as it is regular for easy analysis. The building is located in Seismic Zone III and is founded on medium type soil. The building is 158.92 m (162.58 along with others) in height 73.95m in length and 23.8m in width. The important details of the structure is as follows

Table -1: Building Features

Structure	OMRF
Floors	G.F + 44+terrace
Ground storey height	4.2m
Typical floor to floor height in m	3.66m(typical floor)
Max. floor to floor height in entire height of building in mts	4.2 m
Live load	2.0 kN/m^2 [typical floor] 3.0kN/m^2[corridors, staircase] 1.5 kN/m^2 [terrace]
Floor finish	1.0 kN/m^2
Water proofing	1.0 kN/m^2
Grade of concrete	M40/M35/M30(for shear walls) M30(for beams and slabs) M40(for raft)
Grade of Steel	Fe500
Zone	III
Average Thickness of slab	125mm

Tie and Stilt level framing view



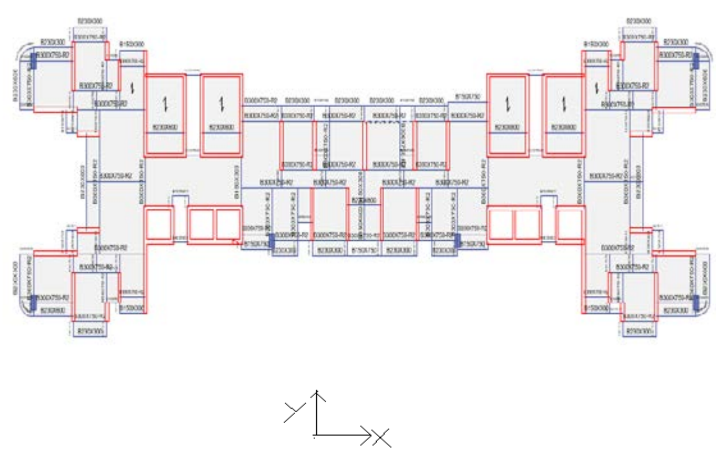


Figure - 1: Typical Floor

The E-TABS software is used to develop 3D space frame model and to carry out the analysis. Dynamic analysis of the building models is performed on ETABS. The lateral loads generated by ETABS correspond to the seismic zone III and the 5% damped response spectrum given in IS: 1893-2002.

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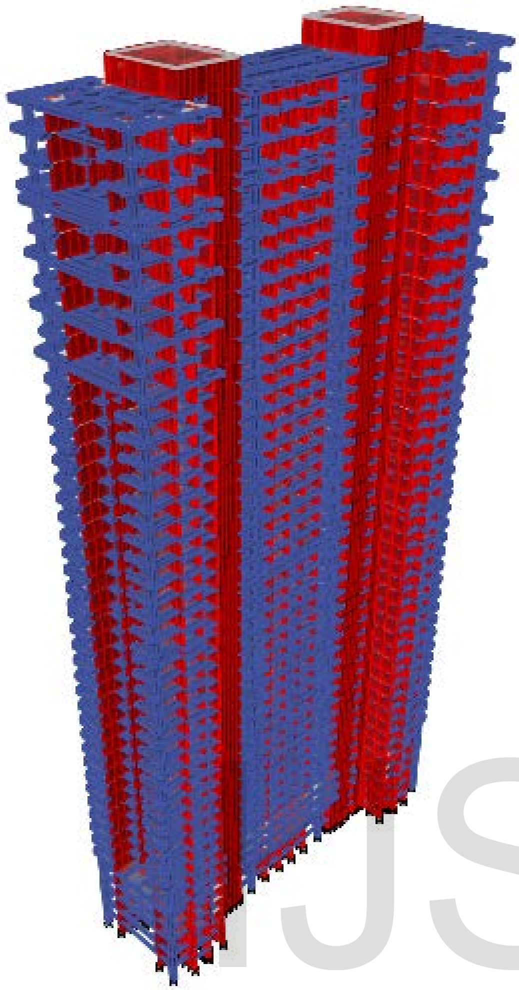

Figure -2: 3D view of Model in ETabs

LOAD PATTERNS:

Table 2: loads taken according to the codes in ETABS

Name	Type	Self Weight Multiplier	Auto Load
DEAD	Dead	1	
LIVE	Live	0	
EQLXP	Seismic	0	IS1893 2002
EQLYP	Seismic	0	IS1893 2002
WPLX	Wind	0	Indian IS875:1987
WPLY	Wind	0	Indian IS875:1987
WPLXG	Wind	0	User Loads
WPLYG	Wind	0	User Loads

WIND LOAD CALCULATION:

Along Wind Load: Along wind load on a structure on a strip area (Ae,) at any height (z) is given by:

$$F_z = C_{t*} A_{e*} P_{z*} G$$

Where

F_z= along wind load on the structure at any height z corresponding to strip area

C_t = force coefficient for the building,

A_e = effective frontal area considered for the structure at height c,

P_z = design pressure at height z due to hourly mean wind obtained as 0.6 v^2 (N/ma),

G = Gust factor given as,

$$G = 1 + g_f.r \sqrt{B(1+\Phi)^2 + \frac{SE}{\beta}}$$

(All fig and tables are taken as per IS specifications)

Where

$g_f r$ = peak factor defined as the ratio of the expected peak value to the root mean

Value of a fluctuating load, and

r = roughness factor which is dependent on the size of the structure in relation to the ground roughness. The value of ('$g_f r$' is given in Fig. 8,)

B = background factor indicating a measure of slowly varying component of Fluctuating wind load and is obtained from Fig.9,

$\frac{SE}{\beta}$ = measure of the resonant component of the fluctuating wind load

S = size reduction factor (see fig 10 for S)

E = measure of available energy in the wind stream at the natural frequency of the structure (see Fig. 11),

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β = damping coefficient (as a fraction of critical damping) of the structure (see Table 34), and

$\Phi = \frac{g t r \sqrt{B}}{4}$ and is to be accounted only for buildings less than 75 m high in terrain Category 4 and for buildings .less than 25 m high in terrain Category 3, and is to be taken as zero in all other cases.

Providing the wind loading details as per IS875:1987

a) Category of building =3

b) Class of building =C

c) Basic wind speed in m/sec =44m/se

Windward Coefficient, $C_{p,wind} = 0.8$

Leeward Coefficient, $C_{p,lee} = 0.5$

Risk Coefficient, $k_1 = 1$

Topography Factor, $k_3 = 1$

Design Wind Speed, $V_z = V_b k_1 k_2 k_3$

= 44X1X1.15X1

$V_z = 50.865584$

Design Wind Pressure, P = 0.6 X V² XCF

= 0.6 (50.6)² X1.4

=2150.70N/m²

= 2.15 KN/m²

For gust factor calculation:

WIND DATA	
BASIC WIND SPEED	44m/s
Terrain Category	3
Terrain Class	C
Risk Coefficient (K_1)	1

Terrain & Height Factor (K_2)	0.84 as per code
Topographic Factor	1
Design Wind Pressure (V_z):	36.96
P_z=	819.62
F= C_f x A_e x pd x G	
a=	73.95
b=	22.8
h=	119.3
a/b=	3.24
h/b=	5.23

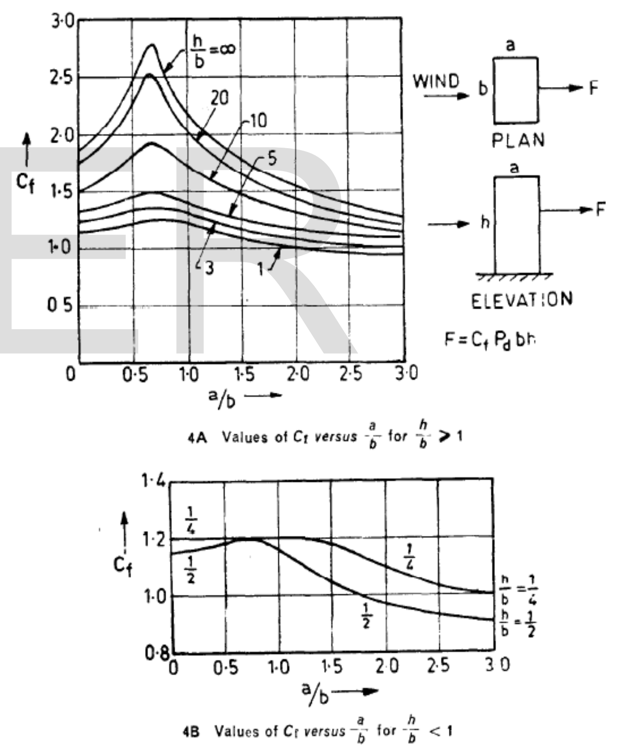

FIG. 4 FORCE COEFFICIENTS FOR RECTANGULAR CLAD BUILDINGS IN UNIFORM FLOW

Figure-3: force coefficient as in IS 875 (part3)

Along X Axis:

Considering Higher Shape factor for irregular shape

C_f = 1.4

Along Y Axis:

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Considering Higher Shape factor for irregular shape

C_f = 1.4

Gust factor calculation

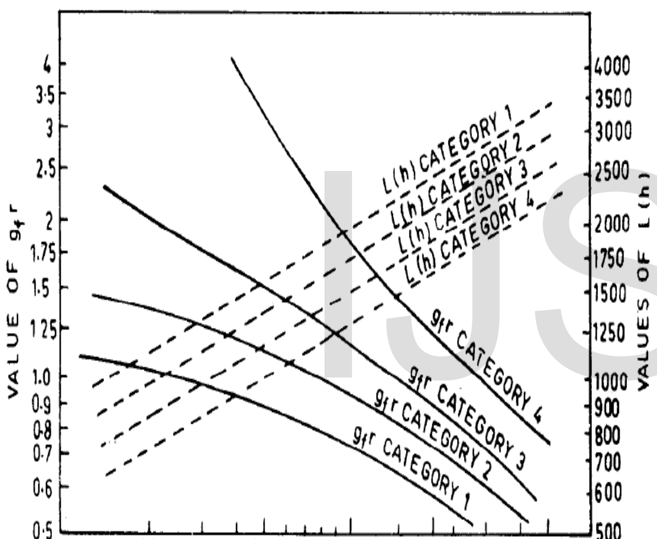
Fundamental natural period of building T_o = 4.92

T_{90} = 4.92

C_y = 10; C_z = 12 are constants from IS: 875 (part 3)

$\lambda = \frac{C_y . b}{C_z . h}$ = 0.16 and in y-direction 0.52

$F_0 = \frac{C_z . f_0 . h}{Vh}$ =4.86 and in y-direction 4.86



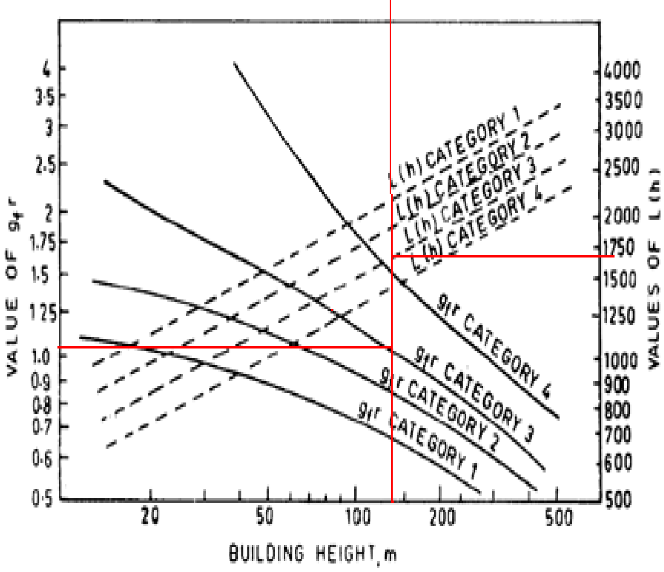


FIG. 8 VALUES OF $g_f r$ AND $L(h)$

Figure-4: Values of g_f.r and L(h)

For terrain category -3

$g_f r$=1.1 L(h) =1700

$\frac{C_z . h}{L(h)}$ = 0.84

For T_0 & T_{90}

$f_0 \frac{L(h)}{Vh}$ =5.77 on both directions

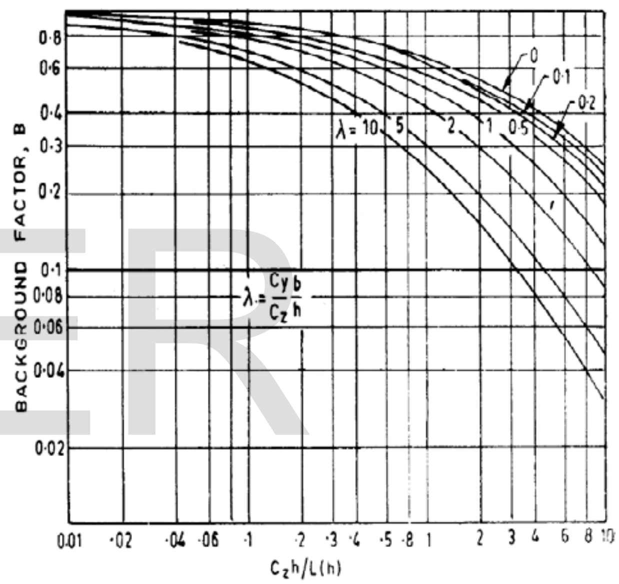


FIG. 9 BACKGROUND FACTOR B

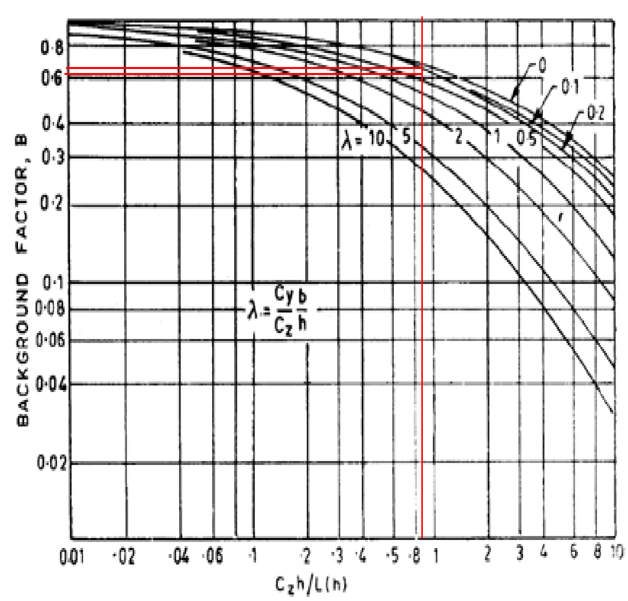


FIG. 9 BACKGROUND FACTOR B

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Figure-5: Background factor B

From graph B = 0.65 & 0.61 in both the directions

Φ=0

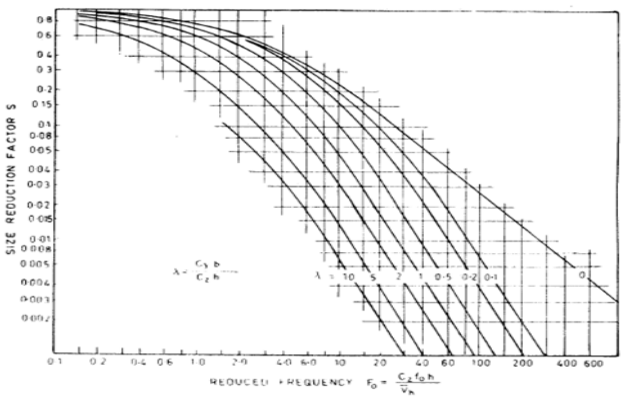

Fig. 10 Size Reduction Factor, S

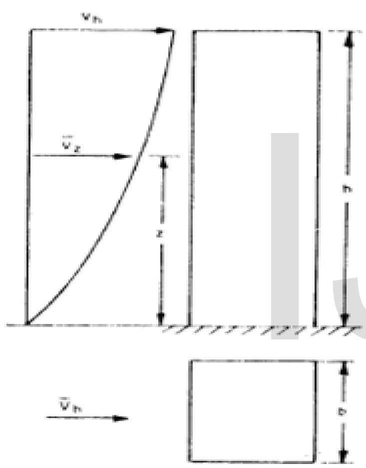

Figure-6: Size reduction factor S

S =0.32 & 0.28

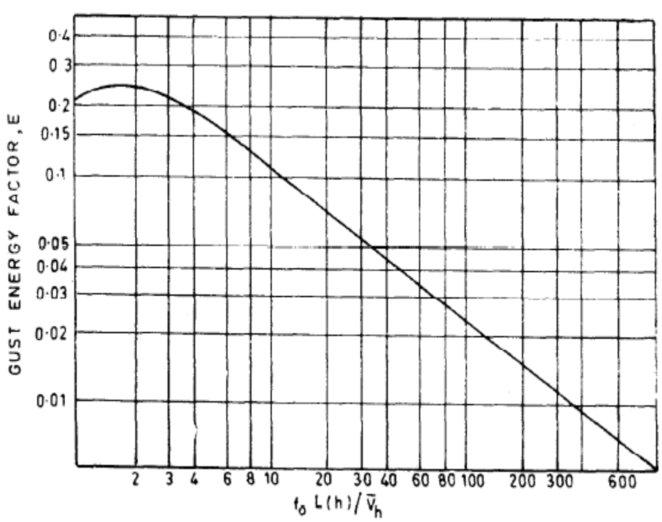

Fig. 11 Gust Energy Factor, E

Figure-7: Gust energy factor E

Table3: Suggested values of damping coefficient

(Clause 8.3)

Nature of structures (1)	Damping coefficient ,β (2)
Welded steel structures	0.010
Bolted steel structures	0.020
RC structures	0.016

E =0.17

β=0.016

$$G = 1 + g_f . r \sqrt{B(1+\Phi)^2 + \frac{SE}{\beta}}$$

G = 3.21 & 3.08 is gust calculated at a distance z in both directions

SEISMIC LOAD CALCULATIONS:

Providing the EQ loading details

a) Zone factor =0.16

b) Importance factor =1

c) Response reduction factor =4 (for ductile shear wall code IS 1893:2002)

d) Soil type = type II (medium)

e) %LL considered in seismic = 25%

Time period in horizontal X-direction

$T_x = \frac{0.09h}{\sqrt{d}}$

$= \frac{0.09 \times 158.92}{\sqrt{73.95}}$

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= 1.7

Similarly T_y = 3.09

Seismic weight W = 945198 (from Etabs)

Seismic coefficient, $A_h = \frac{Z\, I\, Sa}{2\, R\, g}\, W$

Table 4: static base shear values

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	1.7	945198	15123
Y	3.09	945198	8320

DYNAMIC ANALYSIS:

Table 5: Result from Etabs for dynamic base shear at bottom of the building

Story	Load case/combo	Location	VX KN	VY (kN)
TIE	SPECX Max	Top	15855	4119
TIE	SPECX Max	Bottom	15855	4119
TIE	SPECY Max	Top	1915	8765
TIE	SPECY Max	Bottom	1915	8765

Table 6: Modal load participation ratios

Case	Item Type	Item	Static %	Dynamic %
Modal	Acceleration	UX	100	98.01
Modal	Acceleration	UY	100	97.93
Modal	Acceleration	UZ	0	0

From the above table we can say as

Static base shear ≈ Dynamic base shear

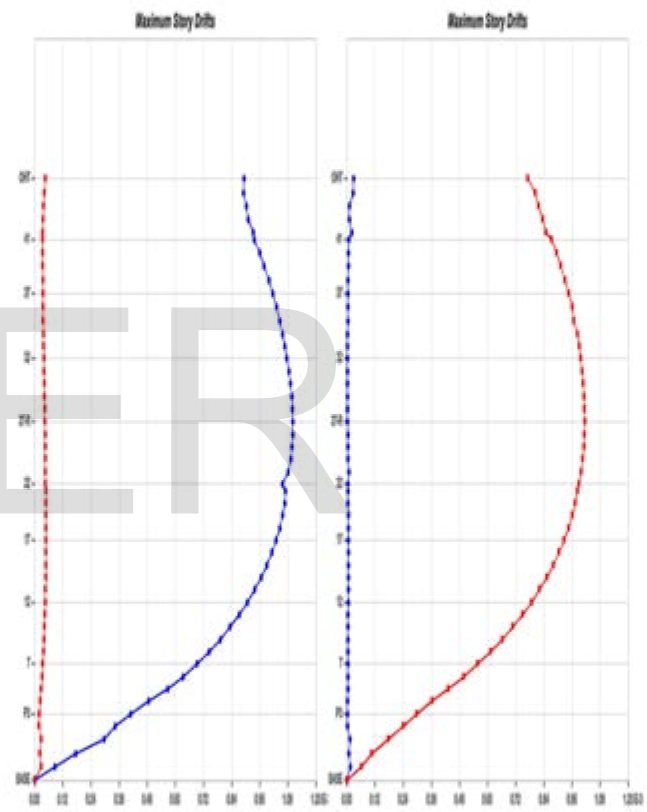
STOREY DRIFT:

It is the displacement of one level relative of the other level above or below. The storey drift in any storey shall not exceed 0.004 times the height of storey height

Height of Storey = 3660mm

0.004(h) = 0.004(3660) = 14.64mm

Hence after analyzing the Building the results obtained for entire structure in both longitudinal and transverse directions are presented in tabular form.



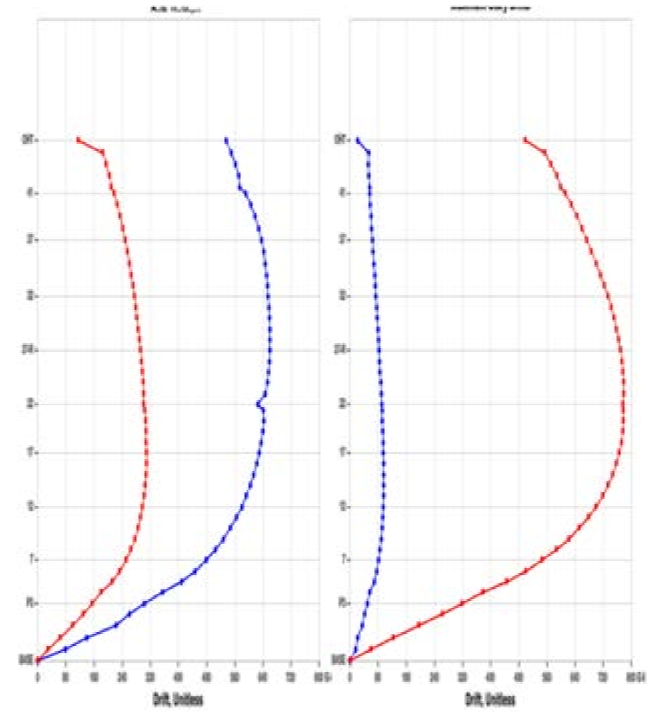


Figure -8: Storey Drift of Building in Longitudinal and transverse direction for static and dynamic cases

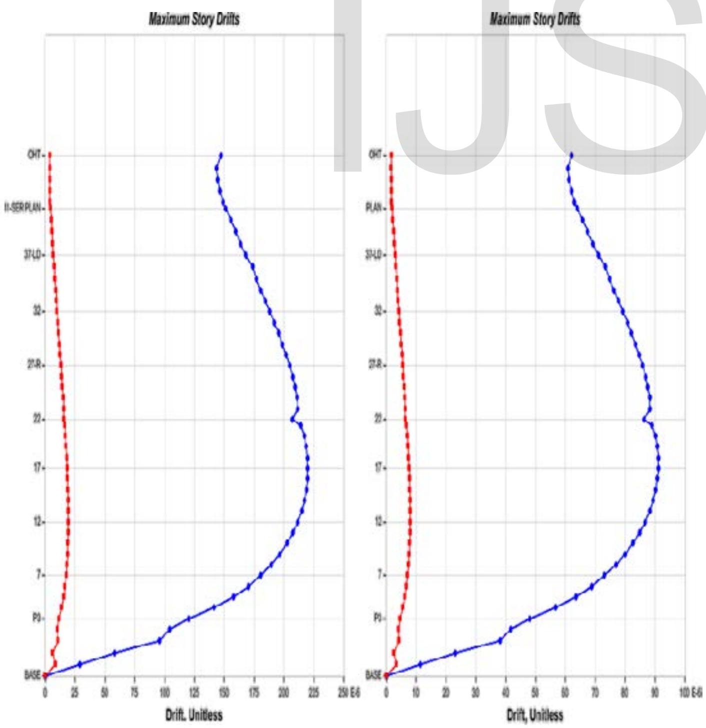


Figure-9: Storey drift for wind load with and without gust factor in logitudinal direction

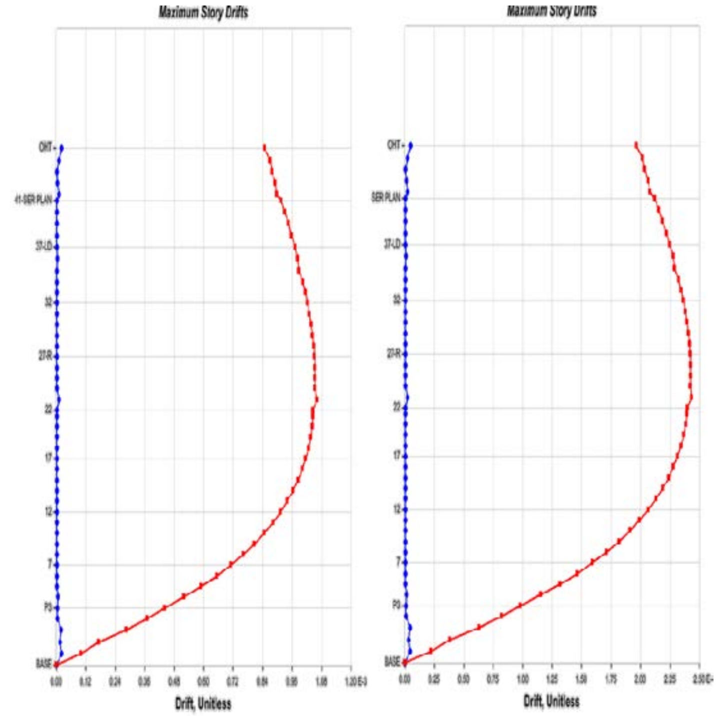


Figure-10: Storey drift for wind load with and without gust factor in logitudinal direction

(ALL GRAPHS OBTAINED FROM SOFTWARE)

Table 7: max. Storey Drift from static load case

Story	Load case/combinations			
	EQLXP		EQLYP	
	X	Y	X	Y
OHT	0.00089	4.50E-05	2.80E-05	0.00077
TER	0.00089	0.00089	0.00089	0.00089
44	0.0009	0.000902	0.0009	0.0009
43	0.00091	3.60E-05	9.00E-06	0.00084
42	0.00093	3.50E-05	2.10E-05	0.00085
41	0.00094	3.50E-05	8.00E-06	0.00087
40	0.00096	3.50E-05	7.00E-06	0.00089
39	0.00098	3.40E-05	6.00E-06	0.00091
38	0.001	3.50E-05	5.00E-06	0.00093
37	0.00102	3.50E-05	4.00E-06	0.00095
36	0.00103	3.60E-05	4.00E-06	0.00096
35	0.00105	3.70E-05	3.00E-06	0.00097
34	0.00106	3.70E-05	3.00E-06	0.00098
33	0.00107	3.80E-05	2.00E-06	0.00099
32	0.00108	3.90E-05	2.00E-06	0.001

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31	0.00108	4.00E-05	2.00E-06	0.001
30	0.00109	4.10E-05	2.00E-06	0.00101
29	0.0011	4.20E-05	2.00E-06	0.00101
28	0.0011	4.30E-05	2.00E-06	0.00101
27-R	0.0011	4.40E-05	3.00E-06	0.00102
26	0.0011	4.50E-05	3.00E-06	0.00101
25	0.0011	4.50E-05	3.00E-06	0.00101
24	0.00109	4.60E-05	4.00E-06	0.00101
23	0.00106	4.60E-05	4.00E-06	0.00099
22	0.00106	4.60E-05	4.00E-06	0.00099
21-SER	0.00107	4.70E-05	4.00E-06	0.00098
20	0.00107	4.80E-05	5.00E-06	0.00098
19	0.00106	4.80E-05	5.00E-06	0.00096
18	0.00105	4.90E-05	5.00E-06	0.00095
17	0.00103	4.90E-05	5.00E-06	0.00093
16	0.00101	4.80E-05	5.00E-06	0.00091
15	0.00099	4.80E-05	5.00E-06	0.00088
14	0.00097	4.70E-05	5.00E-06	0.00085
13R	0.00094	4.60E-05	5.00E-06	0.00082
12	0.00091	4.50E-05	5.00E-06	0.00079
11	0.00087	4.40E-05	5.00E-06	0.00075
10	0.00083	4.20E-05	5.00E-06	0.00071
9	0.00079	4.00E-05	4.00E-06	0.00066
8	0.00074	3.70E-05	4.00E-06	0.00061
7	0.00069	3.40E-05	3.00E-06	0.00056
6R	0.00063	3.10E-05	4.00E-06	0.0005
5	0.00057	2.80E-05	5.00E-06	0.00043
4	0.00049	2.40E-05	3.00E-06	0.00036
P3	0.00041	2.00E-05	2.00E-06	0.0003
P2	0.00034	1.70E-05	2.00E-06	0.00024
P1	0.0003	2.70E-05	1.20E-05	0.00018
STILT	0.00018	2.20E-05	9.00E-06	0.00011
TIE	8.50E-05	2.80E-05	1.40E-05	6.10E-05

Table 8: max. Storey Drift from Dynamic load case

Story	Load case/combinations			
	SPECX		SPECY	
	X	Y	X	Y
OHT	0.00053	0.00053	0.000535	0.0005
TER	0.00055	0.00055	0.00055	0.0005
44	0.000562	0.00056	0.000562	0.000562
43	0.000571	0.0002	5.30E-05	0.000588
42	0.000574	0.00021	5.30E-05	0.000599
41	0.000591	0.00022	5.60E-05	0.000613
40	0.000606	0.00023	5.70E-05	0.000629
39	0.000617	0.00023	5.90E-05	0.000645
38	0.000627	0.00024	6.10E-05	0.00066
37	0.000636	0.00025	6.30E-05	0.000673
36	0.000642	0.00026	6.50E-05	0.000687
35	0.000647	0.00026	6.70E-05	0.0007
34	0.00065	0.00027	7.00E-05	0.000713
33	0.000653	0.00027	7.10E-05	0.000723
32	0.000655	0.00028	7.30E-05	0.000733
31	0.000657	0.00028	7.50E-05	0.000743
30	0.000658	0.00028	7.70E-05	0.000751
29	0.000659	0.00029	7.90E-05	0.000758
28	0.00066	0.00029	8.00E-05	0.000764
27-R	0.000659	0.00029	8.20E-05	0.00077
26	0.000658	0.0003	8.40E-05	0.000774
25	0.000656	0.0003	8.50E-05	0.000777
24	0.000653	0.0003	8.70E-05	0.000778
23	0.000626	0.0003	9.00E-05	0.000776
22	0.000626	0.0003	9.00E-05	0.000776
21-SER	0.000641	0.0003	9.10E-05	0.000778
20	0.000643	0.00031	9.20E-05	0.000778
19	0.00064	0.00031	9.30E-05	0.000776
18	0.000635	0.00031	9.30E-05	0.000772
17	0.00063	0.00031	9.40E-05	0.000766
16	0.000622	0.00031	9.50E-05	0.000758
15	0.000614	0.00031	9.50E-05	0.000747
14	0.000604	0.00031	9.50E-05	0.000734
13R	0.000593	0.0003	9.50E-05	0.000719

12	0.00058	0.0003	9.40E-05	0.0007
11	0.000565	0.00029	9.30E-05	0.000678
10	0.000548	0.00029	9.10E-05	0.000652
9	0.000528	0.00028	8.90E-05	0.000622
8	0.000505	0.00026	8.50E-05	0.000587
7	0.000478	0.00025	8.10E-05	0.000547
6R	0.000447	0.00023	7.50E-05	0.0005
5	0.000409	0.00021	6.90E-05	0.000445
4	0.000354	0.00018	5.60E-05	0.000378
P3	0.000303	0.00015	4.80E-05	0.000319
P2	0.00026	0.00013	4.10E-05	0.000263
P1	0.000222	9.90E-05	3.50E-05	0.000195
STILT	0.000139	6.30E-05	2.10E-05	0.000123
TIE	7.80E-05	2.90E-05	1.60E-05	5.90E-05

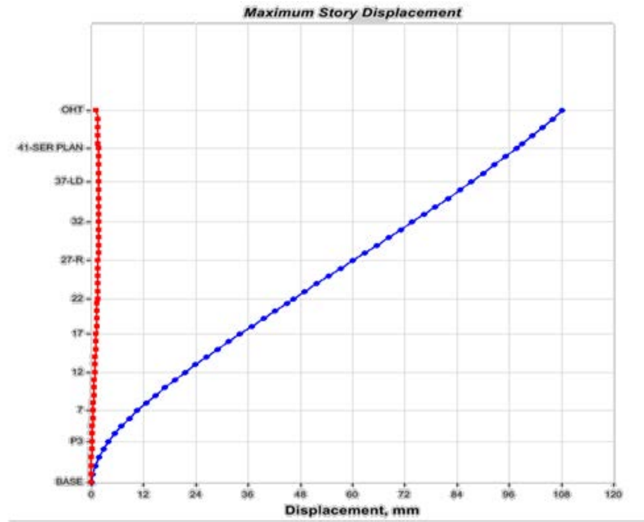

Figure-11: Storey Displacement for static case

LATERAL DISPLACEMENTS:

It is displacement caused by the Lateral Force on the each storey level of structure. Lateral displacement will be more on top storey. Hence after analyzing the Building the results obtained for model in both longitudinal and transverse direction and there comparison is presented in tabular form.

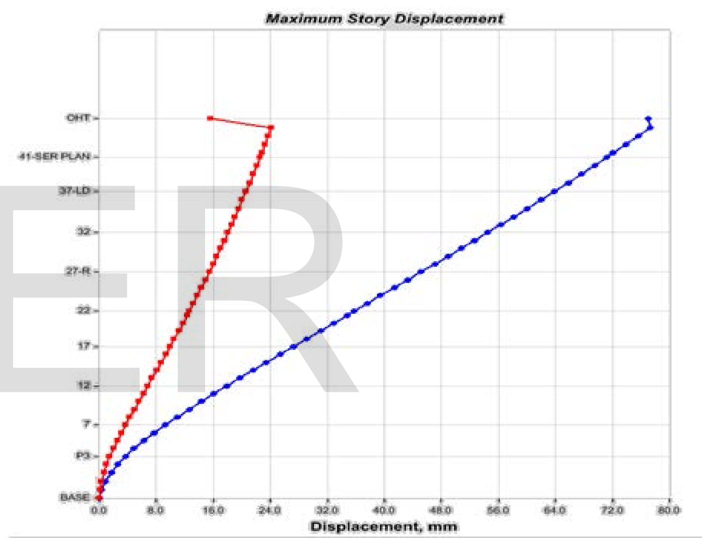

Figure-12: Storey Displacement for Dynamic case

CHECK FOR ALLOWABLE DEFLECTION

Max. Deflection against wind allowed is given as

$\frac{H}{500}=\frac{162.58}{500}$=0.325=325 mm

From the graph it is less than 325 hence it is ok

Similarly Max. Deflection against earthquake allowed is

Given as $\frac{H}{250}=\frac{162.58}{250}$=0.650=650mm

From the graph it is ok. Hence it is safe

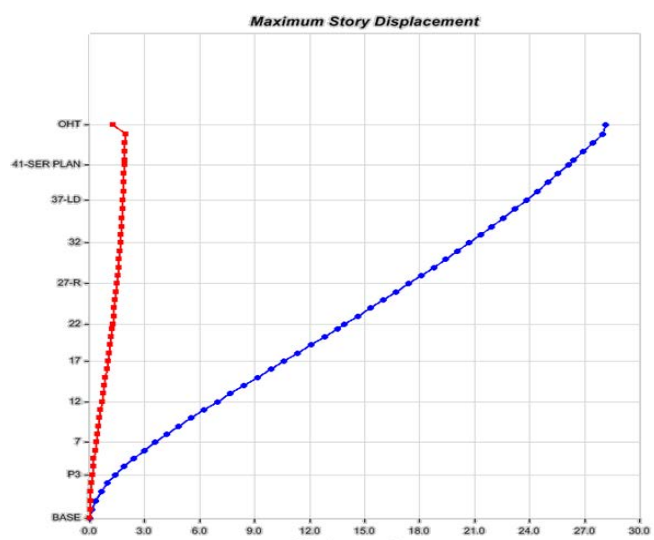

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Figure-13: Displacement for wind loads

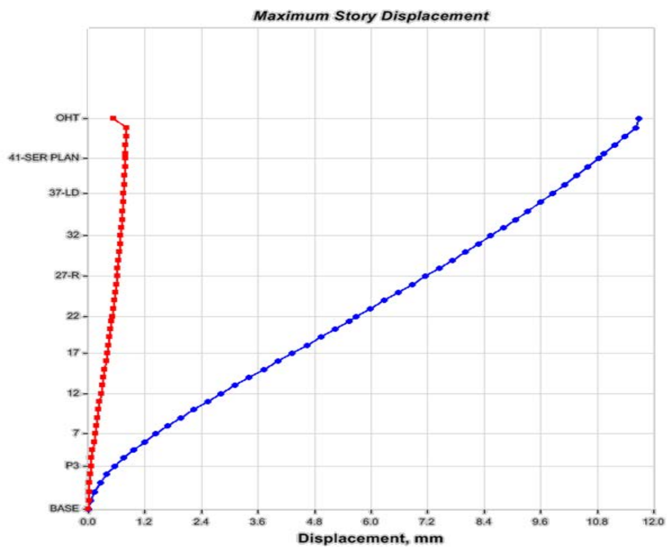

Figure-14: Displacement for Gust wind loads

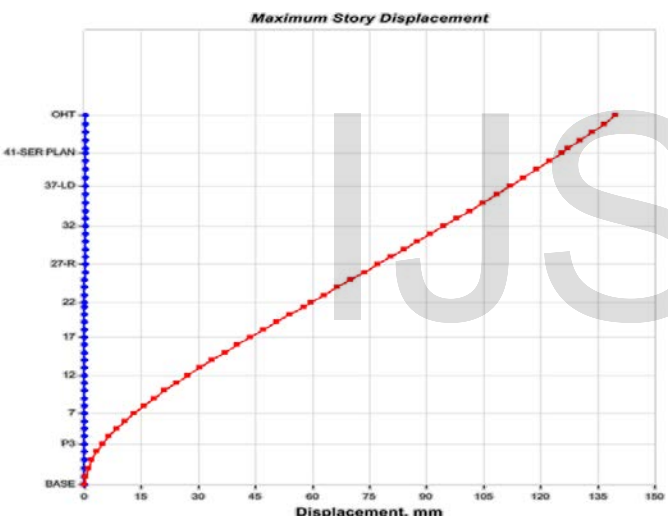

Figure-15: Displacement for wind loads

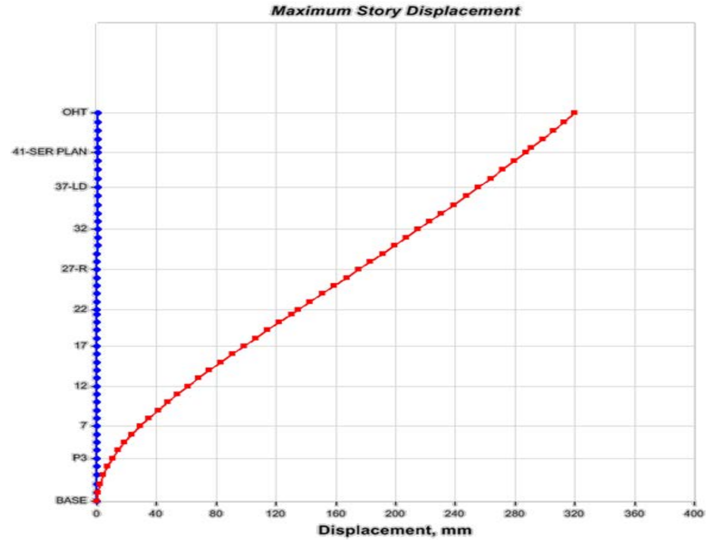

Figure-16: Displacement for Gust wind loads

(ALL GRAPHS OBTAINED FROM SOFTWARE)

Table 9: displacement of building for different load cases

Story	Load case					
	EQL XP	EQL YP	SPE CX Max	SPEC Y Max	WPL XG kN	WPLY G kN
OHT	0	0	0	0	0	0
TER	139.7	123.6	81.5	95.1	80.2	1341.8
44	136.5	120.8	79.6	93.3	79.6	1331.3
43	133.2	118	77.8	91.4	78.9	1319.7
42	129.8	115.2	75.9	89.4	58.3	975.8
41	128.2	113.7	74.9	88.4	58.1	971.6
40	124.8	110.7	73	86.4	77.2	1291.1
39	121.3	107.6	71	84.2	76.5	1279.6
38	117.7	104.4	69	82	75.8	1268.3
37	114.1	101.1	67	79.8	75.2	1319.7
36	110.4	97.8	64.9	77.5	74.5	1245.7
35	106.6	94.4	62.8	75.1	73.8	1234.4
34	102.8	90.9	60.7	72.7	70.1	1173.1
33	99.2	87.6	58.8	70.4	66.6	1113.6
32	95.6	84.3	56.8	68.2	66	1104.3
31	92	81	54.9	65.8	65.5	1095
30	88.4	77.7	52.9	63.5	64.9	1085.8
29	84.7	74.3	50.9	61.1	63.9	1069.4
28	81	70.9	48.9	58.7	63	1052.9

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27-R	77.4	67.5	46.9	56.2	62	1036.6

Case	Mode	Period	UX	UY	RZ
		sec			
Modal	1	4.921	5.2E-06	0.6557	0.0001
Modal	2	4.086	0.0425	0.0001	0.6535
Modal	3	3.867	0.6315	1.7E-05	0.0437
Modal	4	1.176	8.7E-06	0.1577	0.0012
Modal	5	1.11	0.0131	0.0017	0.1209
Modal	6	1.045	0.1416	0.0001	0.0117
Modal	7	0.518	0.0054	0.0054	0.0435
Modal	8	0.506	0.0019	0.0529	0.0035
Modal	9	0.487	0.0501	0.0004	0.0064
Modal	10	0.305	0.0312	0.0002	0.0004
Modal	11	0.295	0.0002	0.0351	0.0001
Modal	12	0.208	0.0232	0.0004	0.0016
Modal	13	0.183	0.0004	0.0302	0.0006
Modal	14	0.117	0.0388	0.0001	0.001
Modal	15	0.091	1.3E-05	0.0393	0.001

26	73.7	64.1	44.9	53.8	61	1020.5
25	70	60.7	42.8	51.3	60.1	1004.4
24	66.3	57.3	40.8	48.8	59.1	988.5
23	62.6	53.9	38.8	46.3	58.2	972.7
22	59	50.6	36.8	43.8	43.9	734.8
21-SER	57.1	48.8	35.7	42.4	43.6	728.4
20	53.5	45.5	33.7	39.9	55.8	933.2
19	49.9	42.2	31.7	37.4	54.9	917.8
18	46.4	39	29.7	34.9	54	902.6
17	42.9	35.8	27.7	32.4	53.1	887.5
16	39.4	32.7	25.7	29.9	52.2	872.6
15	36	29.6	23.7	27.4	51.3	857.7
14	32.7	26.7	21.7	25	50	836.9
13R	29.5	23.8	19.8	22.6	48.6	812.7
12	26.3	21.1	17.9	20.2	47.2	788.9
11	23.3	18.4	16	17.9	45.8	765.5
10	20.4	15.9	14.2	15.7	44.4	742.4
9	17.6	13.5	12.4	13.5	43	719.7

Case Mode	Item Type	Item	Static %	Dynamic %
1	Acceleration	UX	100	98.01
1	Acceleration	UY	100	97.93

8	14.9	11.3	10.6	11.5	41.1	687.3
7	12.4	9.2	9	9.6	38.9	651
6R	10.1	7.4	7.4	7.8	36.8	615.8

5	8	5.7	5.9	6.1	33.9	567.3
4	6.1	4.2	4.6	4.6	30.6	512.5
P3	4.4	3	3.4	3.4	27	451
P2	3.1	2	2.4	2.3	26	434.8
P1	1.9	1.2	1.5	1.4	29.2	489.2
STILT	0	0	0	0	0	0
TIE	0	0	0	0	0	0
BASE	0	0	0	0	0	0

Table 10.a: Modal participation mass-ratio

Table 10.b: Modal participation mass-ratio

OBSERVATIONS AND CONCLUSIONS

1. Storey drift of building is within the limit as clause no 7.11.1 of IS-1893 (Part-1):2002.
2. Storey Stiffness of the building is within the limit as clause no 4.20 of IS-1893 (Part-1):2002.
3. In this paper due to the presence of shear wall at all possible deflection positions there is possible of controlling the damage that may occur due to wind and earthquake forces.

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BIOGRAPHIES

- **M.Pavani** holds a B. Tech degree (Civil Engineering) JNTU A, Anantapur, India. she is currently Pursuing her PG degree in structural Engineering under the guidance of G. Nagesh Kumar Andhra Pradesh, India. Her present area of research interest is in structural design

- **G. Nagesh Kumar** He has received his M. Tech degree (Structural Engineering) from JNTU, Anantapur, Andhra Pradesh, India. He is currently pursuing his research under the guidance of Dr. CH. Sudharani at SVU, Tirupati , Andhra Pradesh, India. Presently, he is working as Sr. Asst. Prof in the CED of G. Pulla Reddy Engineering College (Autonomous) and has 28 years of experience in teaching. His research interest includes Material Science

- **Dr.Sandeep Pingale** He has over 14 years of experience of civil & structural engineering. International experience in structural analysis, design, execution & management of up toG+81 storey structure in Dubai. He has worked with various international multidisciplinary organizations that have given him "State of Art" in providing the services with international quality standards. He has worked in the area of structural engineering by using different international codes with ACI-318, ASCE-7, IBC-2006, UBC-97, CEB-FIP Euro code, and BS8110