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Interpretation of Seismic Load and Wind Load as per Latest Indian Standard Codes

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ABSTRACT

Earthquake and Wind loads are the most hazardous loads that tends to acts on high rise buildings. Dynamic actions are caused on buildings by both earthquake and wind loads but their intensities will be different. In this work, seismic and wind loads are compared by considering G+5, G+10, G+15 and G+20 storey building frames. Base shear for maximum Earthquake zone and maximum basic wind speed are calculated as per IS 1893 (Part 1):2016 and IS 875 (Part 3): 2015. Base shear at each storey for all the buildings are calculated, based on which the conclusions are drawn.

Keywords *- Base shear, basic wind speed, Equivalent static method, pressure co-efficient, time period*

1. INTRODUCTION

Earthquake is a natural phenomenon, which results in damaging of structures and causing loss of lives. This leads to need of structural design based on seismic responses by adopting suitable methods to increase strength and stability of structures.

The aim of the earthquake resistant design is to have structures that will behave elastically and survive without collapse under major earthquakes that might occur during the life of the structure.

Seismic code help designer to construct and improve the behavior of structure under earthquake loading. So, it can withstand during Earthquake effect and reduce loses. Seismic code is unique for particular country and region.

IS 1893 (Part 1):2016 is the latest code for seismic analysis which primarily deals with earthquake hazard assessment for earthquake resistant design of buildings. This code is used for the calculation of seismic load in this work.

Wind is essentially the large scale Horizontal movement of free air. It plays an important role in design of tall structures because it exerts loads on Building. Wind usually produces three different types of effects on buildings. These effects are

1) Static
2) Dynamic and
3) Aerodynamic

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The response of load depends on type of building. When the building deflects inresponse to wind load, then the dynamic and aerodynamic effects should be analyzed in addition to static effect.

Flexible slender buildings and structural elements are usually subjected to wind along and across the direction of wind most of the time.

The complexity of wind flow is not only introduced by the geometries of typical structures, but also by the characteristics of the terrain and other structures in the close vicinity.

IS 875 (Part 3): 2015 is the latest code for wind analysis which specifies wind forces and their effects (static and dynamic) that should be taken into account when designing buildings, structures and components thereof. This code is used for calculation of wind load in this work.

2. CALCULATION OF SEISMIC LOAD AND WIND LOAD AS PER IS CODES

2.1 Detailed specifications of the Buildings

Table 1 gives the detailed specifications of the buildings considered for earthquake and wind analysis

Total height of building	21, 38.5, 56 and 73.5 m
Storey height	3.5 m
Length of building in X - direction	36 m
Length of building in Z - direction	30 m
Number of bays in X and Z direction	6 and 5 respectively
Bay width m in both the directions	6 m
Density of Reinforced concrete	25 kN/m^3
Density of Masonry infill	20 kN/m^3
Thickness of infill wall	0.23 m
Thickness of slab	0.15 m
Beam size in both directions	0.23 x 0.45 m
Column size	0.45 x 0.45 m

Plan and section of the building considered are shown in Fig 1.

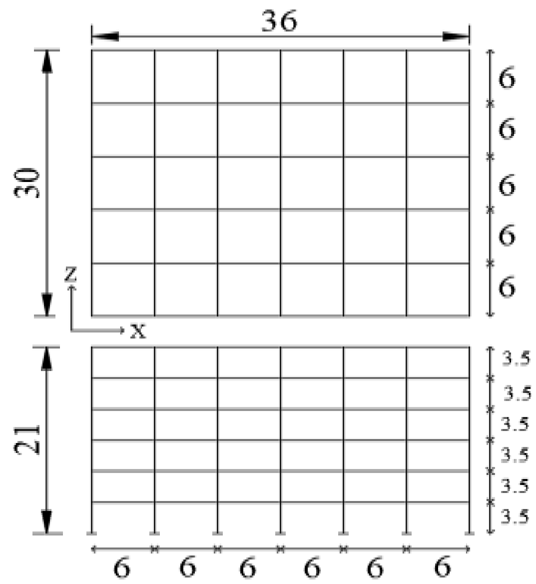

Figure 1: Plan and elevation of G+5 storey building (All Dimensions in metres)

2.2 Seismic load calculation

Parameters considered for seismic analysis

- Type of structure = Special Moment Resisting Frame (R = 5)
- Usage = Commercial Building (I = 1.2)
- Type of soil = Medium
- Seismic Zone = V (Z = 0.36)
- Imposed load = 4 kN/m^2 (IS 875 (Part 2): 1987)

2.2.1 Calculation of seismic weight at each Floor levels

Seismic weight = (Mass of infill in both longitudinal and transverse direction) + (Mass of Columns) + (Mass of Beams in both longitudinal and transverse direction) + (Mass of Slab) + (Imposed Load at that floor if permissible).

For roof, W_6 = {[6 x 0.23 x (6 - 0.45) x ((3.5 - 0.45) / 2) x 20] + [7 x 0.23 x (6 - 0.45) x ((3.5 - 0.35) / 2) x20]} $_{\text{(infill)}}$ + [0.45 x 0.45 x ((3.5 - 0.15)/2) x 7 x 25] $_{\text{(column)}}$ + {[0.23 x (0.45 - 0.15) x (6 - 0.45) x 6 x 25] + [0.23 x (0.45 - 0.15) x 7 x (6 - 0.45) x 25]} $_{\text{(Beam)}}$ + [36 x 6 x 0.15 x 25] $_{\text{(Slab)}}$ + (0) $_{\text{(Imposed load)}}$

W_6 = 1500 kN

For 5th, 4th,3rd, 2nd, 1st floors

W_1 = [0.23 x 6 x (6 - 0.45) x (3.5 - 0.45) x 20] + [0.23 x 7 x (6 - 0.45) x (3.5 - 0.35) x 20] + [0.45 x 0.45 x (3.5 - 0.15) x 7 x 25] + [0.23 x (0.45 - 0.15) x (6 - 0.45) x 6 x 25] + [0.23 x (0.45 - 0.15) x 7 x (6 - 0.45) x 25] + [36 x 6 x 0.15 x 25] + [36 x 6 x 4 x 0.50]

W_1 = 2497.44 kN = W_2 = W_3 = W_4 = W_5

Total Seismic Weight of Building

W = Seismic weight of all floors

= $W_1 + W_2 + W_3 + W_4 + W_5 + W_6$

= 5 x 2497.44 + 1500

W = 13987.14 kN

T_a for Moment resisting frame building with brick infill panels is

$$T_a = \frac{(0.09 \text{ x } h)}{\sqrt{d}} \qquad (h = 21 \text{ m, } d = 36 \text{ m})$$

$$= \frac{0.09 \text{ x } 21}{\sqrt{36}}$$

T_a = 0.315 s

2.2.2 Determination of Base shear

$V_B = A_h \text{ x } W$

$$Ah = \frac{\left(\frac{Z}{2}\right)\left(\frac{S_a}{g}\right)}{\left(\frac{R}{I}\right)}$$

For T_a = 0.315 s and medium soil,

$$\left(\frac{S_a}{g}\right) = 2.50$$

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Therefore,

$$A_h = \frac{\left(\frac{0.1}{2}\right) x\ (2.50)}{\left(\frac{5}{1.2}\right)}$$

$A_h = 0.030$

Design seismic Base shear

$V_B = 0.030 \text{ x } 13987.14 = 419.61$ kN

2.2.3 Vertical Distribution of Base Shear (Q_i)

$$Q_i = \left(\frac{W_i h^2{}_i}{\sum_{j=1}^{n} Wjh^2{}_j}\right) \text{ x } V_B$$

$\sum W_j h^2{}_j = 2497.44 \text{ x } (3.5^2 + 7^2 + 10.5^2 + 14^2 + 17.5^2) + 1500 \text{ x } 21^2$

$= 2344126.87$

$Q_1 = \left(\frac{2497.44 \text{ x } 3.5^2}{2344126.87}\right) \text{ x } 419.61 = 5.48$ kN

$Q_2 = \left(\frac{2497.44 \ x\ 7^2}{2344126.87}\right) \text{ x } 419.61 = 21.91$ kN

$Q_3 = \left(\frac{2497.44 \ x\ 10.5^2}{2344126.87}\right) \text{ x } 419.61 = 49.29$ kN

$Q_4 = \left(\frac{2497.44 \ x\ 14^2}{2344126.87}\right) \text{ x } 419.61 = 87.62$ kN

$Q_5 = \left(\frac{2497.44 \ x\ 17.5^2}{2344126.87}\right) \text{ x } 419.61 = 136.91$ kN

$Q_6 = \left(\frac{1500 \ x\ 21^2}{2344126.87}\right) \text{ x } 419.61 = 118.41$ kN

2.3 Wind load calculation

Parameters considered for wind analysis

- Basic wind speed, $V_b = 55$ m/s
- Terrain Category = 3
- Wind angle, $\theta = 0^{\circ}$
- Roof angle, $\alpha = 0^{\circ}$
- Window size = 1.2 x 1.5 m
- h/w = 0.7
- l/w = 1.2

2.3.1 Design Wind Speed (V_z)

$V_z = V_b \text{ x } k_1 \text{ x } k_2 \text{ x } k_3 \text{ x } k_4$

$V_z = 55 \text{ x } 1 \text{ x } k_2 \text{ x } 1 \text{ x } 1$

$V_z = 55 \text{ x } k_2$

2.3.2 Design Wind Pressure (p_d)

$p_d = K_d \times K_a \times K_c \times p_z$

K_d = Wind directionality factor = 0.9 (cl 7.2.1)

K_c = Combination factor = 0.9 (cl 7.3.3.13)

$p_z = 0.6 \times V^2_z$

Tributary area

For columns = 6 x 21 = 126 m^2, K_a = 0.8 (Table-4 of IS 875 (Part-3) :2015)

For roof = 6 x 30 = 180 m^2, K_a = 0.8 (Table-4 of IS 875 (Part-3) :2015)

2.3.3 Pressure Coefficients

Internal Pressure Coefficients (C_{pi})

Window size = 1.2 x 1.5 m

Surface area of building = (21 x 36 x 2) + (21 x 30 x 2)

= 2772 m^2

Area of Openings provided = Number of windows in each storey x Number of storeys x Area of each window

= 22 x 6 x 1.2 x 1.5

= 237.6 m^2

Percentage area opening = $\left(\frac{\text{Area of openings provided}}{\text{Total surface area of building}}\right) \times 100$

$= \left(\frac{237.6}{2772}\right) \times 100$

= 8.57 %

Since, Percentage area opening is in between 5% to 20%, the building has medium permeability

Therefore, Internal pressure coefficient, $C_{pi} = \pm 0.5$

External Pressure Coefficients (C_{pe})

C_{pnet} for walls along X direction = [0.7 – (-0.5)] = 1.2 (Pressure)

= (-0.6 – 0.5) = -1.1 (Suction)

C_{pnet} for walls along Z direction = [0.7 – (-0.5)] = 1.2 (Pressure)

= (-0.6 – 0.5) = -1.1 (Suction)

2.3.4 Wind Load on individual Members

$$F = (C_{pe} - C_{pi}) \times A \times p_d$$

For walls along X,

At **h = 3.5 m**, k_2 = 0.318

Design wind speed, $V_z = 55 \times k_2$

= 55 x 0.318 = 17.49 m/s

Design wind pressure, $p_d = K_d \times K_a \times K_c \times p^2_z$

$= 0.9 \times 0.8 \times 0.9 \times (0.6 \times 17.49^2)$

= 0.118 kN/m^2

This p_d should not be less than (0.7 x p_z) = 0.7 x 0.183 = 0.128 kN/m^2

Since 0.118 kN/m^2 < 0.128 kN/m^2, p_d = 0.128 kN/m^2

Therefore, for C_{pnet} = 1.2 (Pressure)

F = 1.2 x 3.5 x 6 x 0.128

= 3.225 kN (Pressure)

For, C_{pnet} = 1.1 (Suction)

F = 1.1 x 3.5 x 6 x 0.128

F = 3.548 kN (Suction)

For top floor, h = 21 m

F = 1.2 x (3.5/2) x 6 x 1.468 = 18.5 kN (Pressure)

F = 1.1 x (3.5/2) x 6 x 1.468 = 16.958 kN (Suction)

For roof, p_d is same as that for wall (or) column as K_a is same.

F = (-1 - 0.5) x 6 x 6 x 1.468

F = 79.284 kN (Suction)

3. RESULTS AND DISCUSSIONS

Earthquake analysis for zone V and Wind analysis for basic wind speed of 55 m/s are carried out for G+5, G+10, G+15 and G+20 storey buildings from which Base shear and wind force at each storey are obtained which are tabulated from Table 2 to 5 and are plotted from Fig 2 to 9.

Table 2: Vertical distribution of EQ and Wind loads for G+5 storey building

		EQ load (kN)		Wind load (kN)		
Storey	**Storey Height, m**	**Q_i**	**Cum Q_i**	**F_i**	**Cum F_i**	**Roof**
5	21	426.27	426.27	18.50	18.50	25.45
4	17.5	492.88	919.15	35.97	54.47	--
3	14	315.44	1234.60	34.63	89.10	--
2	10.5	177.44	1412.04	32.34	121.44	--
1	7	78.86	1490.90	15.69	137.13	--
G	3.5	19.72	1510.61	3.92	141.05	--

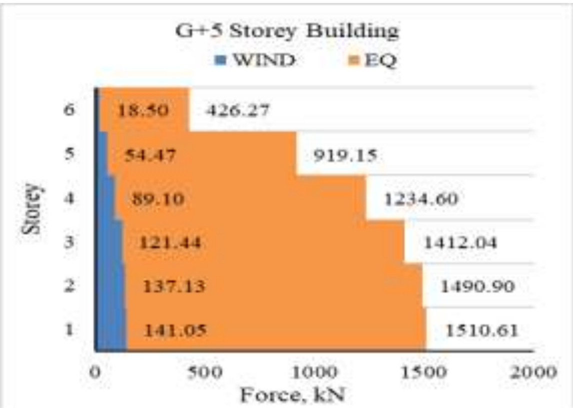

Figure 2: Comparison of seismic load and Wind load for G+5 Storey Building

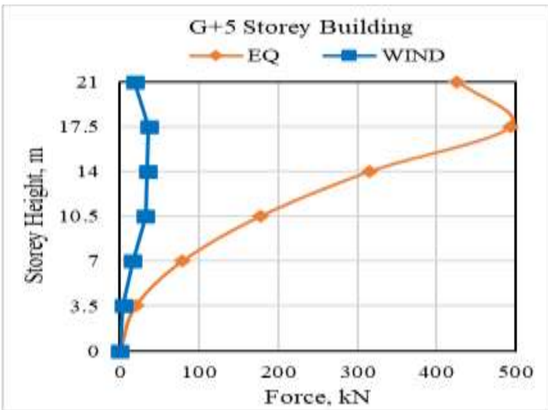

Figure 3: Storey wise Distribution of seismic load and wind load for G+5 Storey Building

Table 3: Vertical distribution of EQ and Wind loads for G+10 storey building

		EQ load (kN)		Wind load (kN)		
Storey	Storey Height, m	Q_i	Cum Q_i	F_i	Cum F_i	Roof
10	38.5	427.67	427.67	20.85	20.85	89.36
9	35	588.49	1016.16	41.06	61.91	--
8	31.5	476.68	1492.84	40.43	102.34	--
7	28	376.64	1869.48	39.45	141.79	--
6	24.5	288.36	2157.84	38.21	180.01	--
5	21	211.86	2369.7	37.00	217.01	--
4	17.5	147.12	2516.82	35.97	252.98	--
3	14	94.16	2610.98	34.63	287.61	--
2	10.5	52.96	2663.94	32.34	319.95	--
1	7	23.54	2687.48	15.69	335.63	--
G	3.5	5.88	2693.37	3.92	339.56	--

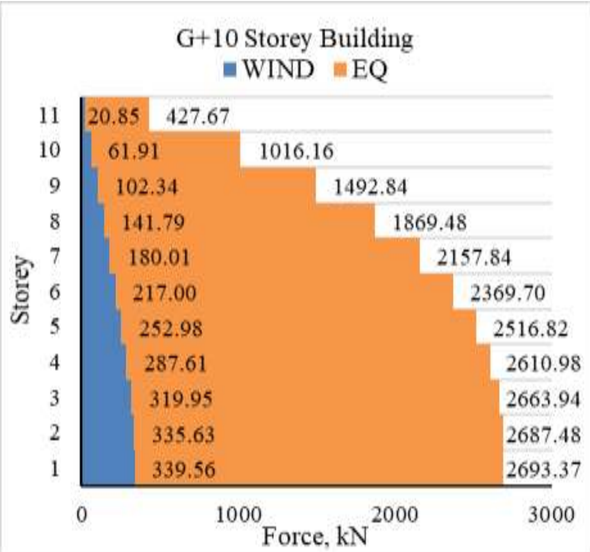

Figure 4: Comparison of seismic load and Wind load for G+10 Storey Building

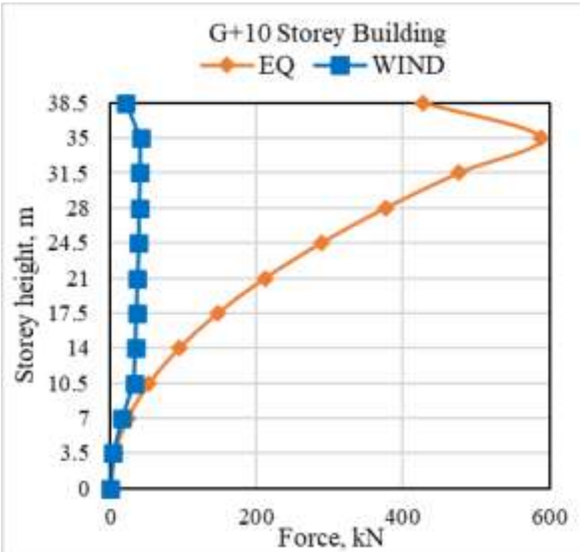

Figure 5: Storey wise Distribution of seismic load and wind load for G+10 Storey Building

Table 4: Vertical distribution of EQ and Wind loads for G+15 storey building

		EQ load (kN)		Wind load (kN)		
Storey	Storey Height, m	Q_i	Cum Q_i	F_i	Cum F_i	Roof
15	56	300.62	300.62	24.08	24.08	88.92
14	52.5	439.92	740.54	47.76	71.85	--
13	49	383.22	1123.76	47.28	119.12	--
12	45.5	330.43	1454.19	46.57	165.69	--
11	42	281.55	1735.74	45.87	211.56	--

10	38.5	236.58	1972.32	45.18	256.74	--
9	35	195.52	2167.85	44.49	301.22	--
8	31.5	158.37	2326.22	43.80	345.02	--
7	28	125.13	2451.35	42.74	387.76	--
6	24.5	95.81	2547.16	41.40	429.16	--
5	21	70.39	2617.54	40.08	469.24	--
4	17.5	48.88	2666.42	38.97	508.21	--
3	14	31.28	2697.71	37.52	545.73	--
2	10.5	17.6	2715.3	35.03	580.76	--
1	7	7.82	2723.13	17.00	597.75	--
G	3.5	1.96	2725.08	4.25	602.00	--

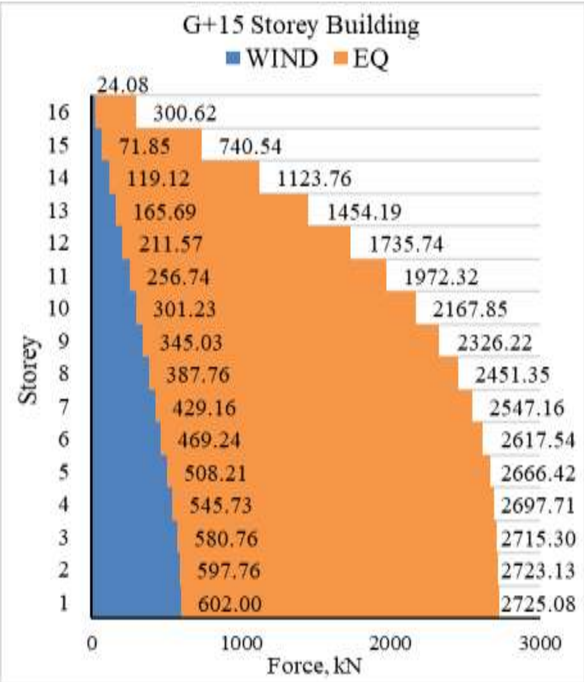

Figure 6: Comparison of seismic load and Wind load for G+15 Storey Building

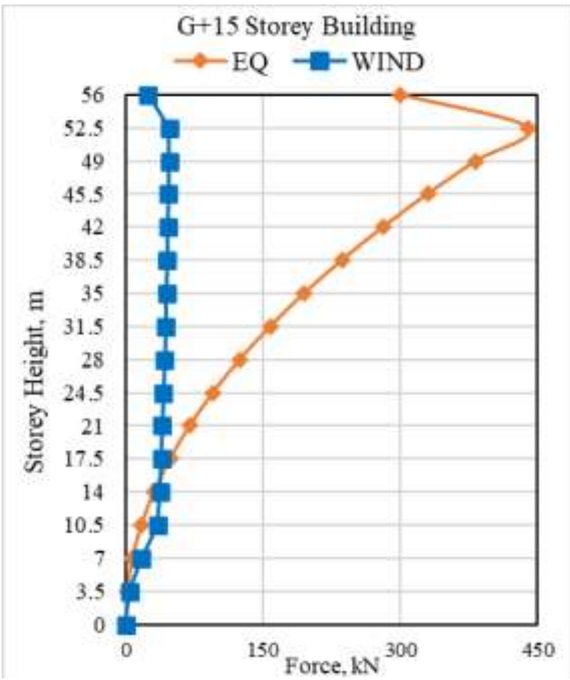

Figure 7: Storey wise Distribution of seismic load and wind load for G+15 Storey Building

Table 5: Vertical distribution of EQ and Wind loads for G+20 storey building

		EQ load (kN)		Wind load (kN)		
Storey	Storey Height, m	Q_i	Cum Q_i	F_i	Cum F_i	Roof
20	73.5	231.64	231.64	25.09	25.09	92.65
19	70	349.83	581.48	49.78	74.87	--
18	66.5	315.72	897.20	49.37	124.25	--
17	63	283.36	1180.56	48.97	173.22	--
16	59.5	252.75	1433.32	48.57	221.78	--

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15	56	223.89	1657.21	48.16	269.94	--
14	52.5	196.78	1853.99	47.76	317.71	--
13	49	171.42	2025.41	47.28	364.99	--
12	45.5	147.80	2173.21	46.57	411.56	--
11	42	125.94	2299.15	45.87	457.43	--
10	38.5	105.82	2404.98	45.18	502.60	--
9	35	87.46	2492.44	44.49	547.09	--
8	31.5	70.84	2563.28	43.80	590.89	--
7	28	55.97	2619.25	42.74	633.62	--
6	24.5	42.85	2662.11	41.40	675.02	--
5	21	31.48	2693.59	40.08	715.10	--
4	17.5	21.86	2715.45	38.97	754.07	--
3	14	13.99	2729.45	37.52	791.59	--
2	10.5	7.87	2737.32	35.03	826.62	--
1	7	3.50	2740.82	24.28	850.90	--
G	3.5	0.87	2741.69	12.14	863.04	--

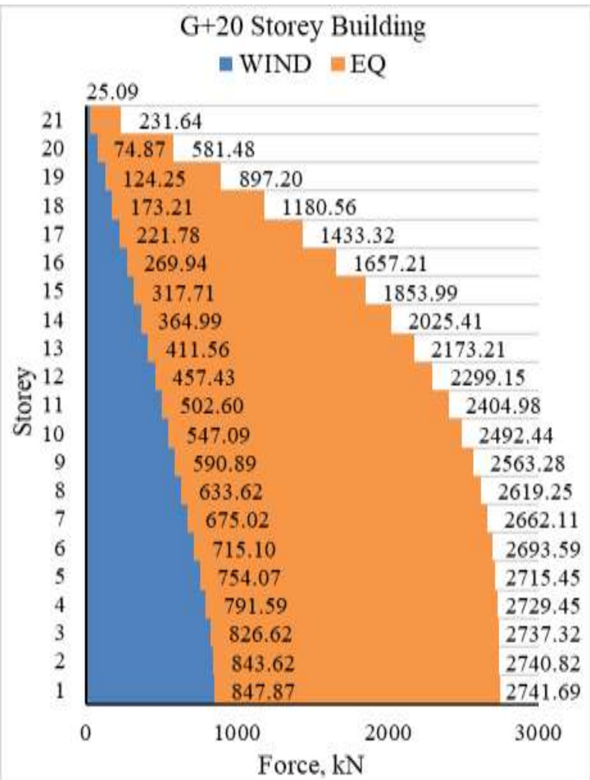

Figure 8: Comparison of seismic load and Wind load for G+20 Storey Building

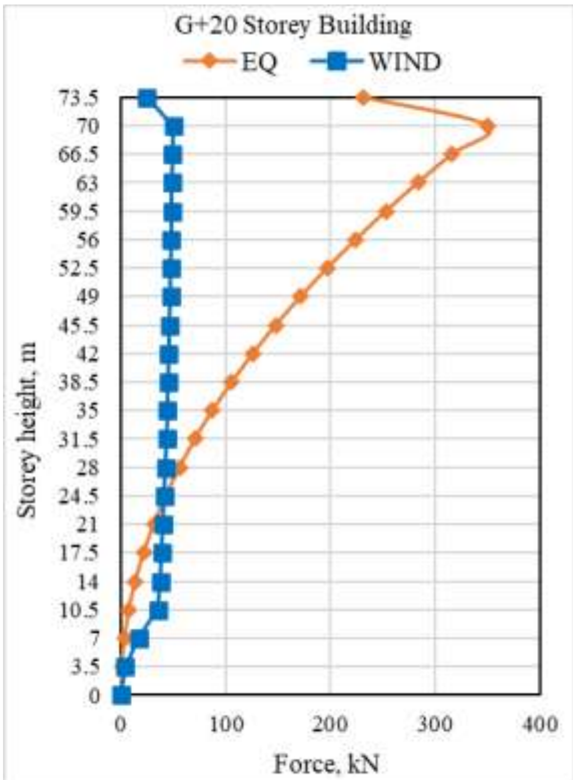

Figure 9: Storey wise Distribution of seismic load and wind load for G+20 Storey Building

From the graphs shown from Figs 2 to 9, following are the discussions

1. As the height of the building increases base shear increases, this is due to increase in mass of the structure.
2. Base shear of seismic load is 9.07, 6.93, 3.53 and 2.23 times the base shear of wind load for G+5, G+10, G+15 and G+20 storey buildings respectively.
3. The maximum Seismic load for G+5, G+10, G+15 and G+20 storey buildings is 13.70, 14.33, 9.21 and 7.03 times the Wind load respectively.

As the height of the building increases the Base shear of the building due to earthquake load increases. The variation of this base shear between G+5 and G+10 storey building is very large, as the value of Design Acceleration Co-efficient (S_a/g) for G+5 and G+10 storey building is near to peak. Whereas when compared to G+10, G+15 and G+20 storey building the variation of base shear is very small. This is due to S_a/g value which decreases as the height of the building increases due to the influence of Time Period (T_a) as shown in Fig 10.

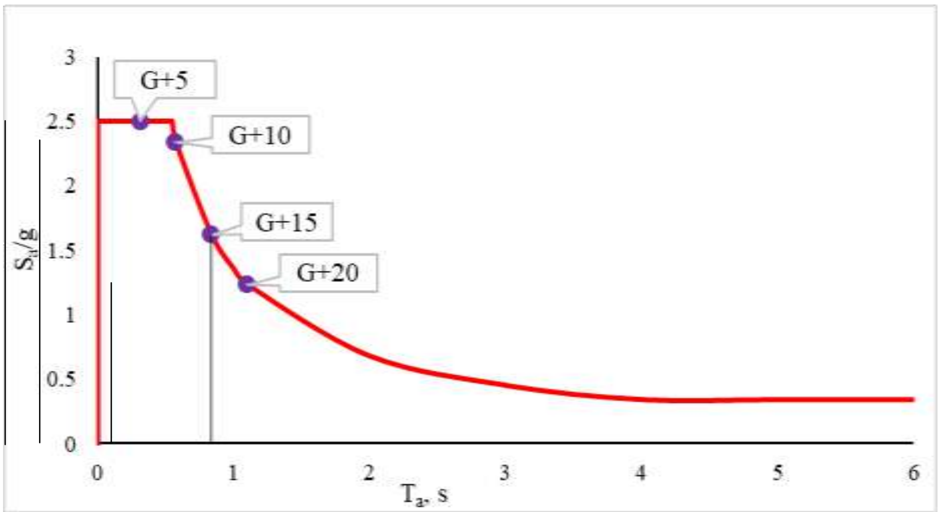

Figure 10: Spectra for Equivalent Static Method.

4. CONCLUSIONS

G+5, G+10, G+15 and G+20 storey buildings are analysed for maximum Earthquake zone and wind speed. The Earthquake and Wind loads are compared and following conclusions are drawn.

1. As the height of the building increases base shear increases, this is due to increase in mass of the structure.
2. Base shear of seismic load is 9.07, 6.93, 3.53 and 2.23 times the base shear of wind load for G+5, G+10, G+15 and G+20 storey buildings respectively.
3. The maximum Seismic load for G+5, G+10, G+15 and G+20 storey buildings is 12.70, 13.33, 8.21 and 6.03 times the Wind load respectively.
4. As the Height of building increases the effect of Seismic load on the building increases compared to wind load because, wind load varies linearly whereas Earthquake load varies square times the storey height (h).
5. The seismic forces in the building depends on the Time Period (T_a) which increases as the height of the building increases thereby Design Acceleration Co-efficient (S_a/g) decreases.

REFERENCES

[1] *An Explanatory Handbook on Proposed IS 875 (Part 3) Wind loads on Buildings and Structures*, by Dr. N.M. Bhandari, Dr. Prem Krishna, Dr. Krishen Kumar, Department of Civil engineering, Indian Institute of Technology and Science, Indore. Document No.:: IITK-GSDMA-Wind06-V3.0

[2] *A Comparative Study of Various Clauses of New IS 1893 (Part 1):2016 and Old IS 1893 (Part-1): 2002*, Mayur R. Rethaliya, Bhavik R. Patel, Dr. R. P. Rethaliya, International Journal for Research in Applied Science & Engineering Technology (IJRASET) *ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887 Volume 6 Issue I, January 2018.*

Codes

[3] Bureau of Indian Standard, IS 1893 (Part 1): 2016, *Criteria for Earthquake Resistant Design of Structures, Part 1 General Provisions and Buildings.*

[4] Bureau of Indian Standard, IS 875 (Part 3): 2015, *Design loads (Other than Earthquake) for Buildings and Structures – Code of Practice, Part 3 Wind Loads.*

Books

[5] *Earthquake Resistant Design of Structures* Pankaj Agarwal and Manish Shrikande, PrenticeHall of India Private Ltd, New Delhi

[6] Internet source.