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# STABILIZATION OF TALL BUILDING AGAINST THE WIND LOAD

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**ABSTRACT**

Due to urbanization, tall building became most suitable option for offices and residential building. Where space is limited, Tall and slender buildings can be utilize. In the present study the wind analysis of G+34 floor was done by Gust Loading Factor approach according to the guideline of IS-456 (Part 3)-1987 and compare the results by analyzing the same model according the guideline of the IITK. G+34 floor building were analyze by Gust Loading Factor to identify the base shear, storey drift and storey shear by using software package ETAB's 15.0.0 version. New advancement require for the calculation of the wind load in India. In this research the comparison of wind load calculation between the old IS-456(Part 3)-1987 code and proposed draft code made, so clear idea can be suggested for the wind analysis of the high rise building in India.

## INTRODUCTION

Day by day development in the vertical cities is increasing in the India as peoples are migrating from the villages to the cities for the easy life and the different purposes. For the accommodation of the more population in less space, high rise building is most suitable option. As the height of the structure increases, impact of the lateral load increases. Generally wind load governing for the structure more than the 100 m height. For the wind analysis of the tall building guideline is given in to the IS-456 (Part 3)-1987. Which majorly includes the effect of the roughness, terrain category, surrounding building, basic wind speed, soil type and importance factor in only along the wind direction. From the previous cyclone and wind data it is observed that when wind occurs, structure not only effected in along the wind direction but also in across the wind direction. Because of this reason, damage observed in so many structures although structure is well design for the wind effect according the IS-456 (Part 3)-1987.

## LITERATURE REVIEW

(Chen, 1994) analyzed the response of the structure under the random wind loading and observed the effect of wind in along the wind direction. (Yu, *et al*., 2012) researched about the effect of the wind on the low rise building and effect of the geometry on the wind loading. (Sygulski, 1996) checked the stability of the structure and find the effect of the damping on the wind calculation. (Chen, *et al.,* 2011) done the wind tunnel test. So many researcher has done work for the dynamic wind analysis. (Solari, 1990) finds the effect of local wind. (Wood, 1983) modified gust factor approach. (Paginini and Piccardo, 2017) checked the gust factor approach by flow dynamic concept. (Deaves, 1993) researched about the effect expouser in the wind loading. For the coastal wind climate (Bardal and Saetran, 2016) analyzed the structure. (Kolchi, *et al.,* 1993; Abohela, *et al.,* 2013) analyzed the different shaped model for the wind loading.

## MODELING AND ANALYSIS

For the accurate result generally Static and Dynamic analysis is done as per guideline given into the Indian standards. Static analysis can be perform as per guideline mentioned in IS-875 (Part 3)-section 5.3 and dynamic analysis is done by applying the

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gust factor approach as per guided in section 7. Specific criteria are mention for the condition where dynamic analysis is required. If the maximum lateral dimension to height is less than 5 and /or building natural frequency is less than 1 hz than dynamic analysis is required. For this research work G+34 building is analyzed which has 106 height. The structure has natural frequency less than one. For the study of the proposed guideline of the dynamic analysis in the IITK guideline handbook, analysis of three model is done to compare the result of storey drift. All the parameters of the three model is shown in the Table 1 (Baker and Pawlikowski, 2015; Smethrust and Green; 2012).

**Table 1.** Parameters of the model

| Parameters | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Height (m) | 106 | 106 | 106 |
| Bottom Storey Height (m) | 4 | 4 | 4 |
| Storey Height (m) | 3 | 3 | 3 |
| Soil Type | Medium | Medium | Medium |
| Terrain Category | 3 | 3 | 3 |
| Apply Code | IS-875 (Part 3) 1987 | IS-875 (Part 3) 1987 | Proposed Draft IS-875 (Part 3)2015 |
| Type of Analysis | Static | Dynamic | Dynamic |
| Shape | Y | Y | Y |
| Thickness of Slab (mm) | 125 | 125 | 125 |
| Beam Size | | | |
| **Material properties** | | | |
| Grade of Concrete | M25 | M25 | M25 |
| Grade of Steel | Fe 415 | Fe 415 | Fe 415 |
| **Dead load intensities** | | | |
| Floor Finish on floors (kN/m$^2$) | 1.75 | 1.75 | 1.75 |
| Floor Finish on roof (kN/m$^2$) | 2 | 2 | 2 |
| **Live load intensities (Kn/m$^2$)** | | | |
| Live load on floors | 3 | 3 | 3 |
| Live load on roof | 1.5 | 1.5 | 1.5 |

Y shape G+34 floor building with 106 m height is taken consider for the all three analysis. Plan view and 3D view is shown in Fig.1 and 2).

## GUST LOADING FACTOR

For the dynamic analysis first of all the gust factor is calculated according to the Indian standards and IITK guideline book. Gust factor is the ratio of the gust wind to mean wind. Gust factor acted like a dynamic factor for the static load and multiplied it with static force on the each floor. For the calculation of the Gust loading factor, guideline is given into the IS - 456 (Part 3)-1987 in section 7. In Table 2 gust loading factor in along the wind direction and across the wind direction is written for the each floor. This load factor is multiplied by area and constant and converted into the static force. The same amount of static force applied to each floor and analysis is done.

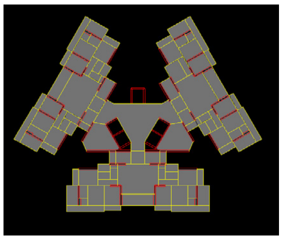

**Fig. 1** Plan view of model.

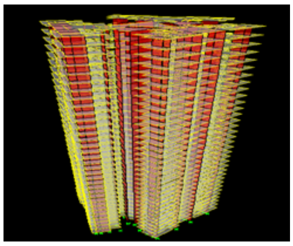

**Fig. 2** 3D view of model.

**Force calculation**

**Wind load force on each floor:**

F=(Cpe-Cpi)×A×Pz

Where,

Cpe=External pressure coefficient, Cpi=Internal pressure coefficient, A=Surface area of structural or cladding unit, Pz=Design wind pressure Table 3.

## RESULT AND DISCUSSION

Three models analyzed using Static and Dynamic approach. For the each model, storey drift is taken as an output and compared.

a) The building of Base + 34 Floor (Static analysis as per IS-875 part -3, 1987)

b) The building of Base + 34 Floor (Gust Loading Factor analysis as per IS-875 part -3, 1987)

c) The building of Base + 34 Floor (Gust Loading factor Analysis as per Proposed Draft code and IITK guideline)

For the above three model Storey drift is been

**Table 2.** Gust loading factor

| Floor | As Per IS 456 (Part 3)-1987 | | As per IITK Guideline Along the Wind Direction | | As per IITK Guideline Across the wind direction | |
|---|---|---|---|---|---|---|
| | Gx | Gy | Gx | Gy | Gx | Gy |
| GRFL | 2.0496 | 2.0496 | 2.8887 | 2.9763 | 0.0868 | 0.0456 |
| 1 Floor | 2.0505 | 2.0533 | 3.0118 | 3.0958 | 0.1519 | 0.0798 |
| 2 Floor | 2.0514 | 2.0542 | 3.1047 | 3.189 | 0.217 | 0.114 |
| 3 Floor | 2.0521 | 2.0556 | 3.1853 | 3.2733 | 0.2821 | 0.1482 |
| 4 Floor | 2.0544 | 2.0558 | 3.2561 | 3.3486 | 0.3472 | 0.1823 |
| 5 Floor | 2.0554 | 2.0584 | 3.3204 | 3.4178 | 0.4123 | 0.2165 |
| 6 Floor | 2.0585 | 2.0625 | 3.38 | 3.4826 | 0.4774 | 0.2507 |
| 7 Floor | 2.0618 | 2.0671 | 3.4363 | 3.5447 | 0.5425 | 0.2849 |
| 8 Floor | 2.0657 | 2.0885 | 3.4904 | 3.605 | 0.6075 | 0.3191 |
| 9 Floor | 2.0702 | 2.0888 | 3.5425 | 3.6641 | 0.6726 | 0.3533 |
| 10 Floor | 2.0707 | 2.0938 | 3.5931 | 3.722 | 0.7377 | 0.3875 |
| 11 Floor | 2.0728 | 2.1037 | 3.6426 | 3.7795 | 0.8028 | 0.4217 |
| 12 Floor | 2.0755 | 2.1072 | 3.6911 | 3.8368 | 0.8679 | 0.4558 |
| 13 Floor | 2.0755 | 2.1117 | 3.7389 | 3.894 | 0.933 | 0.49 |
| 14 Floor | 2.0761 | 2.1176 | 3.7859 | 3.9512 | 0.9981 | 0.5242 |
| 15 Floor | 2.0782 | 2.1291 | 3.8323 | 4.0086 | 1.0632 | 0.5584 |
| 16 Floor | 2.0811 | 2.1368 | 3.8779 | 4.066 | 1.1283 | 0.5926 |
| 17 Floor | 2.0833 | 2.1416 | 3.9229 | 4.1235 | 1.1934 | 0.6268 |
| 18 Floor | 2.0833 | 2.1463 | 3.9671 | 4.1811 | 1.2585 | 0.661 |
| 19 Floor | 2.0854 | 2.1486 | 4.0106 | 4.2388 | 1.3236 | 0.6952 |
| 20 Floor | 2.0862 | 2.1594 | 4.0531 | 4.2965 | 1.3887 | 0.7294 |
| 21 Floor | 2.0884 | 2.1681 | 4.0947 | 4.3539 | 1.4538 | 0.7635 |
| 22 Floor | 2.0885 | 2.1714 | 4.135 | 4.4108 | 1.5189 | 0.7977 |
| 23 Floor | 2.1255 | 2.1766 | 4.1741 | 4.467 | 1.584 | 0.8319 |
| 24 Floor | 2.1278 | 2.1801 | 4.2115 | 4.5219 | 1.6491 | 0.8661 |
| 25 Floor | 2.1343 | 2.185 | 4.2473 | 4.5753 | 1.7142 | 0.9003 |
| 26 Floor | 2.1366 | 2.2117 | 4.281 | 4.6266 | 1.7792 | 0.9345 |
| 27 Floor | 2.1366 | 2.2167 | 4.3125 | 4.6751 | 1.8443 | 0.9687 |
| 28 Floor | 2.1389 | 2.2359 | 4.3415 | 4.7203 | 1.9094 | 1.0029 |
| 29 Floor | 2.1389 | 2.2533 | 4.3679 | 4.7614 | 1.9745 | 1.0371 |
| 30 Floor | 2.1391 | 2.2646 | 4.3913 | 4.7978 | 2.0396 | 1.0712 |
| 31 Floor | 2.1414 | 2.2731 | 4.4116 | 4.8288 | 2.1047 | 1.1054 |
| 32 Floor | 2.1459 | 2.2831 | 4.4287 | 4.8538 | 2.1698 | 1.1396 |
| 33 Floor | 2.148 | 2.2904 | 4.4423 | 4.8723 | 2.2349 | 1.1738 |
| 34 Floor | 2.1482 | 2.311 | 4.4525 | 4.8841 | 2.3 | 1.208 |

**Table 3.** Force calculation

| Floor | | | As Per IS 456 (Part 3)-1987 | | As per IITK Guideline Along the Wind Direction | | As per IITK Guideline Across the wind direction | |
|---|---|---|---|---|---|---|---|---|
| | Fx (KN) | Fy (KN) | Fx (KN) | Fy (KN) | Fx (KN) | Fy (KN) | Fx (KN) | Fy (KN) |
| GRFL | 249.027 | 174.30 | 128.50 | 93.44145 | 181.116 | 130.47234 | 5.4417 | 1.9983 |
| 1 Floor | 247.757 | 173.41 | 96.419 | 70.20812 | 141.623 | 101.78296 | 7.1422 | 2.6228 |
| 2 Floor | 246.912 | 172.82 | 96.463 | 70.23981 | 145.994 | 104.84827 | 10.203 | 3.7469 |
| 3 Floor | 244.807 | 171.35 | 108.42 | 78.97480 | 168.295 | 120.92339 | 14.903 | 5.473 |
| 4 Floor | 242.710 | 169.8 | 120.31 | 87.54800 | 190.694 | 137.11931 | 20.332 | 7.4665 |
| 5 Floor | 241.039 | 168.71 | 130.94 | 95.36039 | 211.546 | 152.24983 | 26.266 | 9.6456 |
| 6 Floor | 238.875 | 167.20 | 139.38 | 101.5542 | 228.869 | 164.8830 | 32.323 | 11.87 |
| 7 Floor | 236.887 | 165.80 | 146.67 | 106.932 | 244.464 | 176.31781 | 38.591 | 14.172 |
| 8 Floor | 234.906 | 164.42 | 154.21 | 113.3767 | 260.568 | 188.17424 | 45.356 | 16.656 |
| 9 Floor | 232.934 | 163.04 | 160.99 | 118.1207 | 275.488 | 199.22953 | 52.309 | 19.209 |
| 10 Floor | 230.971 | 161.66 | 165.57 | 121.7367 | 287.299 | 208.0861 | 58.988 | 21.662 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11 Floor | 229.015 | 160.29 | 170.34 | 125.7182 | 299.350 | 217.17494 | 65.978 | 24.229 |
| 12 Floor | 227.068 | 158.93 | 175.24 | 129.3738 | 311.657 | 226.51022 | 73.283 | 26.912 |
| 13 Floor | 225.130 | 157.57 | 179.98 | 133.1615 | 324.226 | 236.10423 | 80.91 | 29.712 |
| 14 Floor | 223.199 | 156.22 | 184.84 | 137.0950 | 337.067 | 245.96759 | 88.864 | 32.634 |
| 15 Floor | 221.277 | 154.88 | 189.90 | 141.4706 | 350.181 | 256.10918 | 97.153 | 35.677 |
| 16 Floor | 219.364 | 153.54 | 193.78 | 144.6820 | 361.094 | 264.71877 | 105.06 | 38.582 |
| 17 Floor | 217.458 | 152.20 | 196.97 | 147.2413 | 370.908 | 272.59920 | 112.84 | 41.437 |
| 18 Floor | 215.561 | 150.88 | 199.98 | 149.8205 | 380.826 | 280.63665 | 120.81 | 44.365 |
| 19 Floor | 213.123 | 149.17 | 203.22 | 152.2599 | 390.839 | 288.82747 | 128.99 | 47.368 |
| 20 Floor | 209.608 | 146.71 | 206.37 | 155.329 | 400.936 | 297.16446 | 137.37 | 50.446 |
| 21 Floor | 206.123 | 144.27 | 209.67 | 158.2880 | 411.100 | 305.63621 | 145.96 | 53.6 |
| 22 Floor | 202.667 | 141.85 | 212.79 | 160.8784 | 421.313 | 314.22637 | 154.76 | 56.831 |
| 23 Floor | 199.240 | 139.45 | 219.75 | 163.6349 | 431.553 | 322.91289 | 163.76 | 60.139 |
| 24 Floor | 195.842 | 137.07 | 223.20 | 166.2959 | 441.794 | 331.66718 | 172.99 | 63.526 |
| 25 Floor | 192.474 | 134.72 | 227.14 | 169.0930 | 452.007 | 340.45352 | 182.43 | 66.992 |
| 26 Floor | 187.660 | 131.35 | 230.66 | 173.6214 | 462.161 | 349.22857 | 192.08 | 70.538 |
| 27 Floor | 182.181 | 127.51 | 233.96 | 176.5088 | 472.222 | 357.94133 | 201.96 | 74.165 |
| 28 Floor | 176.783 | 123.73 | 237.54 | 180.5595 | 482.155 | 366.53367 | 212.06 | 77.873 |
| 29 Floor | 170.413 | 119.28 | 240.89 | 184.5328 | 491.922 | 374.94169 | 222.38 | 81.664 |
| 30 Floor | 162.102 | 113.46 | 244.28 | 188.0546 | 501.487 | 383.09791 | 232.93 | 85.537 |
| 31 Floor | 151.343 | 105.93 | 247.95 | 191.3862 | 510.816 | 390.93450 | 243.7 | 89.495 |
| 32 Floor | 139.681 | 97.769 | 251.90 | 194.8825 | 519.875 | 398.38717 | 254.71 | 93.537 |
| 33 Floor | 139.681 | 97.769 | 254.06 | 196.9937 | 525.445 | 402.94934 | 264.35 | 97.076 |
| 34 Floor | 163.137 | 114.06 | 256.01 | 200.2763 | 530.644 | 406.9888 | 274.11 | 100.66 |

taken as an output and compare with each other in the graph for various condition.

In the (Fig. 3) graph clearly shows that storey drift value is higher in draft code compare to IS -875 (Part 3)-1987 and it also vary from the static analysis output. In the draft code both condition is considered, along the wind condition and across the wind condition. In (Fig. 4-6) we can clearly observe the effect of across the wind direction's component.

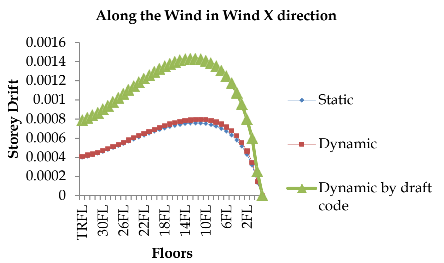


**Fig. 3** Storey drift vs. floors graph for along the wind in wind X direction.

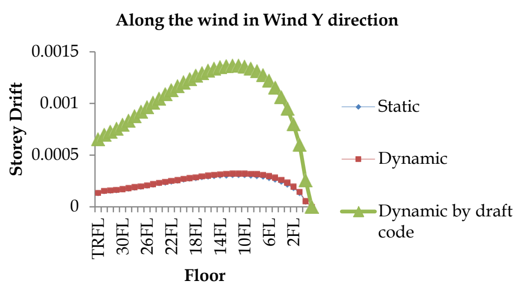


**Fig. 4** Storey drift vs. floors graph for along the wind in wind Y direction.

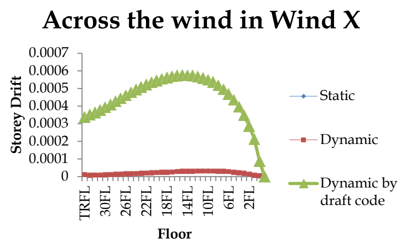


**Fig. 5** Storey drift vs. floors graph for across the wind in wind X direction.

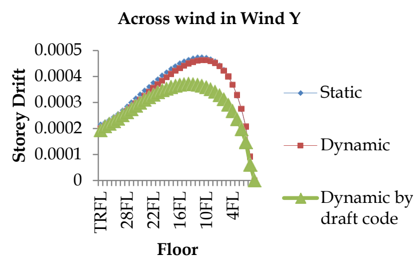


**Fig. 6** Storey drift vs. floors graph for across the wind in wind Y direction.

## CONCLUSION

In the present study, three type of model analyzed by ETAB 15.0.0 and storey drift of the all model checked for Gust Loading Factor and compared with each other. From this study, it is concluded that:

1. In all other cases major difference will not come between static and dynamic analysis. But if we observe the (Fig. 3 and 6). In (Fig. 3) dynamic analysis shows higher value, which indicated that

for the two condition mentioned in the IS 875 (Part 3)-1987 dynamic analysis is required.

2. In the (Fig. 3-5), we can observe that storey drift value is coming higher when it is calculated by proposed draft guideline. Recent changed view of wind blowing is necessary to be implemented for the accurate analysis for keeping structure safe from the wind loading (Fig. 6).

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