Comparison of Static Wind Load on High Rise Building According to Different Wind Loading Codes and Standards

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***Abstract*— All the International wind loading codes and standards provide guidelines and procedure for evaluation of wind load and effect of wind on high rise structures. This paper describes a comparison of response of building due to wind load by four countries' wind loading code. The different codes used in this present study include Japan (AIJ-RLB-2004), India (IS 875-3), Hong-Kong (CP-2004), New-Zealand (AS/NZS1170.2:2002). The study was conducted on 200m high rise rectangular building for static wind characteristics i.e. static analysis. The comparative results are obtained from the different international wind loading codes and standards for terrain category 2 for all codes. Different perimeter like design wind pressure at different height, gust factor, base shear and base bending moment also compare. The aim of this paper is comparing the results of various wind loading codes and standards with Indian wind loading code and standard. The difference in these parameters have been given in this paper. For high rise building, the first mode of natural frequencies also specified for dynamic analysis of building.**

Keywords—Static Wind Load, Tall Builliding

I. INTRODUCTION

Wind load on the buildings are typical dynamic in nature. The approach wind speed largely depends on surface roughness and topography condition for the approach flow of wind. Wind plays an important role in the design of the tall structure because it exerts a load on the structures. For any high rise vertical construction, wind is more significant load factor than the earthquake and gravity load. Calculated results can be used in the selection of the design parameter of the building. As we know that if the load increases this will affect most of parameters of design such as dimensions of structural members, strength of material, and quantity of material and cost of the construction. Terrain category define as the surface condition of approach flow (smooth or rough). Different wind loading codes considered different terrain condition from terrain category 1 to terrain category 5 where terrain category 1 to 5 indicate smoother to rougher condition. Table: 1 show the terrain category considered by different wind loading codes and standards.

Table: 1 Terrain Category Considered by Different Wind Loading Codes and Standards.

Code/standard	Number of terrain categories
IS : 875 (part 3)-1987 (INDIA)	4
CP-2004 (Hong-Kong)	1
AIJ-RLB-2004 (Japan)	5
AS/NZS1170.2:2002 (New-Zealand)	4

The code and standards considered in this report are:

1. Architectural Institute of Japan (AIJ-2004) Recommendation for Load on Building.
2. Code of Practice on Wind Effect in Hong-Kong (CP-2004)
3. Code of Practice for Design Load for Buildings and Structures Is 875(part 3)-1987
4. Australia / New-Zealand : Minimum Design Load on The Structures (AS/NZS1170.2:2002)

For a building of height of 200m and 70m by 40m in plan, the results calculated for this structure in along wind direction are design wind pressure at different height of the building, base shear and base bending moments. The comparison of wind pressure, base shear and base bending moments using these different wind loading codes and standards for terrain category 2, are presented in this study.

II . LITERATURE REVIEW

Although the comparison of wind load on medium rise building is given as earlyas 2009. This comparison given by Yukio Tamura, John D. Holmes, Prem Krishna, Lu Guo, Akira Katsumua. They compare the wind load according to 15 Asia-Pacific wind loading code and standard. Most of the researchers in the past two decades have focused on the wind load comparison on structures (Nilhil Agrawal, V. K. Gupta, Amit Gupta, Achal Mittal in 2012)

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III. PROBLEM STATEMENT

The study is carried out on a high rise building which is a reinforce cement concrete frame structure type residential plus commercial building assumed to be located in a cyclonic zone in Vishakhapatnam (Figure: 1).Topography is flat in all directions. Building is rectangular in cross-section (70m by 40m in plan), building having height ground surface is 200m. The roof is flat. Wind direction is normal to the 70m wall face. Basic wind speed is 50m/s. Terrain category is considered 2 category in all wind loading codes.

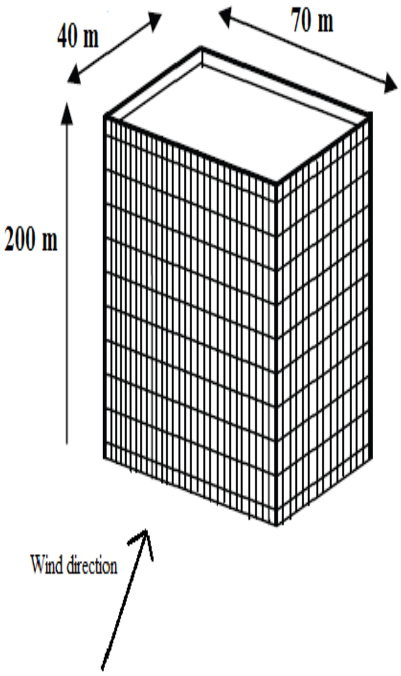

Fig: 1 High Rise Building

Table: 2 calculation procedure for design wind speed and design wind pressure in codes/standards

Is 875(part3) India	AIJ-RLB-2004 (Japan)	CP-2004 (Hong- Kong)	AS/NZS1170.2:2002 (New-Zealand)
Design wind speed $V_Z = V_b K_1 K_2 K_3$ m/s Where, Vz=design wind speed V_b= basic wind speed K_1= probability factor K_2=height factor K_3=topography factor	Design wind speed $U_H= U_0K_DE_HK_{rw}$ Where, U_H U_0= basic wind speed K_D= wind directional factor E_H = wind speed profile factor at reference height K_{rw} = return period conversion factor	Design wind speed $\bar{V}z= 1.05\bar{V}g\,(Z/Zg)^{\alpha}$ Where $\bar{V}g$ = basic wind speed Z = Zg = gradient height α = power exponent for mean wind	Design wind speed $V_{sitB} = V_R M_d(M_{z,cat}, M_s, M_t)$ Where V_R = regional 3s gust wind speed in m/s M_d = wind directional multiplier $M_{z,cat}$ = height multiplier M_s = shield multiplier =1 M_t = topography multiplier =1
Design wind pressure $Pz=0.6\ Vz^2/1000$ KN/m^2	Designwind pressure $q_H = (1/2)\ P\ U_H^2$ where P(kg/m^3): air density 1.22 assumed	Design wind pressure $q_H=(1/2)\ P\ U_H^2$ where P(kg/m^3): air density 1.2 assumed	Design wind pressure P= (0.5) Pair V_{sitB}^2 P(kg/m^3): air density 1.2 assumed

IV. CHECK FOR DYNAMIC ANALYSIS

1. The ratio of height to minimum lateral dimension of the building is (200/40)= 5
2. Natural frequency in first mode = 0.09H/√d and F_0 = 1/T

- For 70m face

  H=200, d=70
  F_0= 0.46 Hz < 1Hz
- For 40m face

  H=200, d=40
  F_0= 0.35 Hz < 1Hz

In both case natural frequency is less than 1 Hz, in this case dynamic analysis is needed, but this paper consist only static analysis.

V. RESULTS AND DISCUSSION

Wind Velocity Profile According to Different Wind Loading Codes and Standards
Where H is height in meter

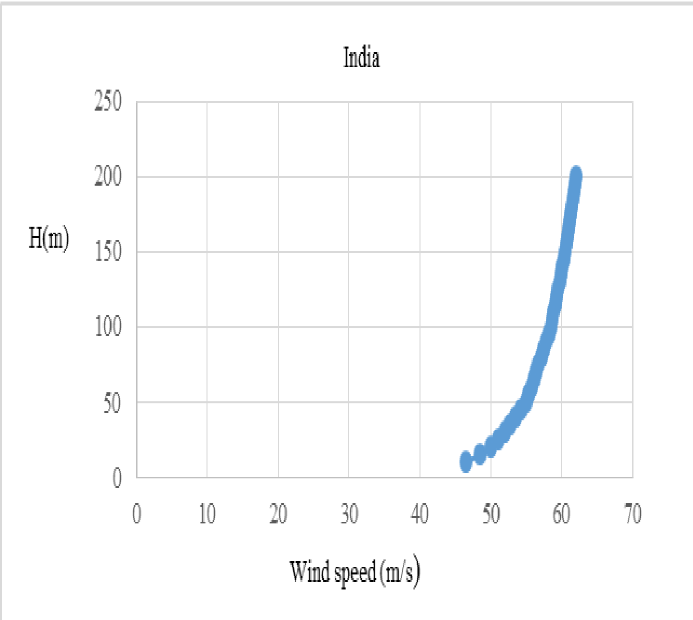

Fig: 2 Wind Velocity Profile (IS 875-3)

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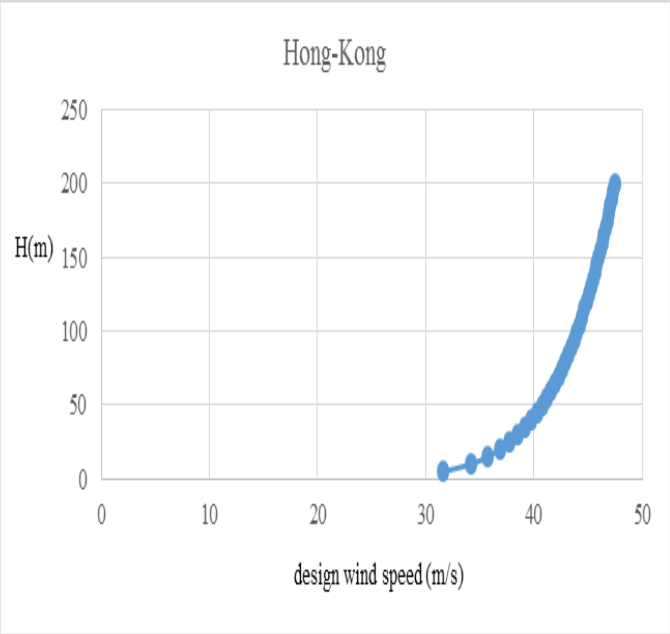

Fig: 3 Wind Velocity Profile (CP-2004)

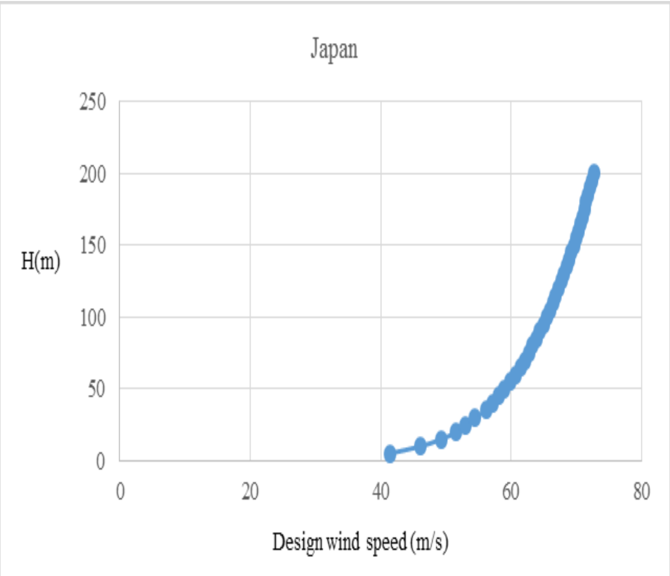

Fig: 4 Wind Velocity Profile (AIJ-RLB-2004)

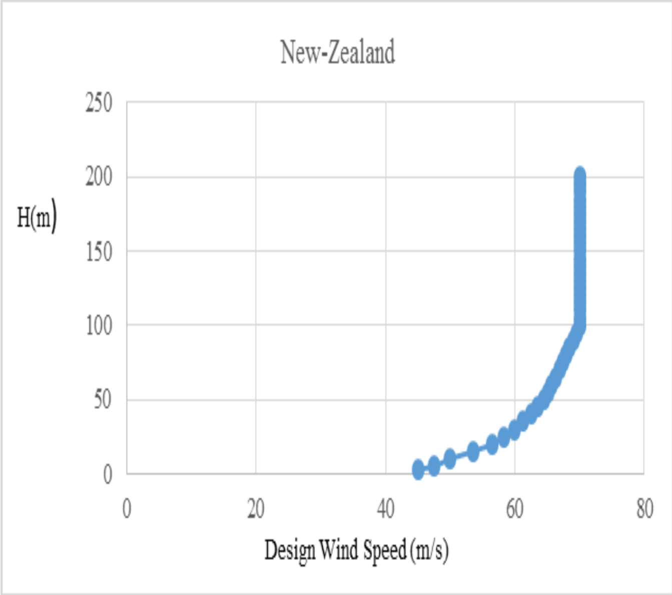

Fig: 5 Wind Velocity Profile (AS/NZS 1170.2:2011)

New-Zealand show that velocity is constant from 100m to 200m of building height. Velocity is constant because of in AS/NZS 1170.2:2011 code the terrain factor for 100m and for any height more than 100m is 1.40(In Terrain category 2). In AS/NZS1170.2:2011 the terrain multipliers for regions C and D.

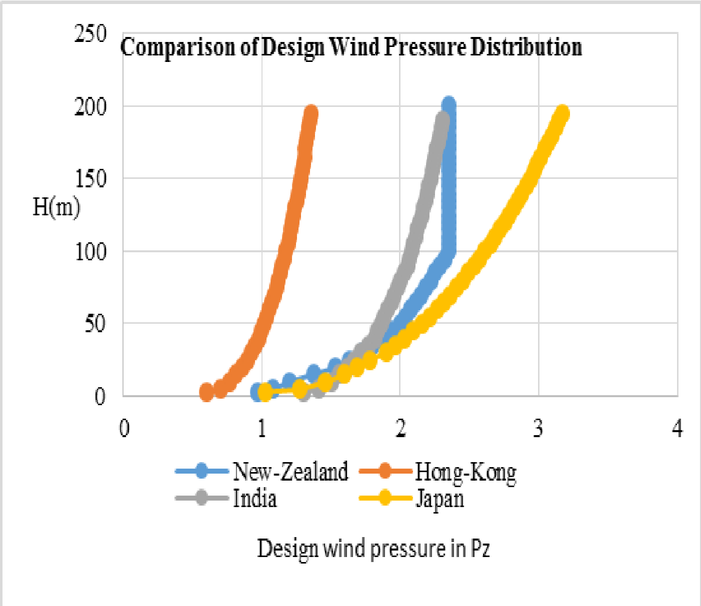

Fig: 6 pressure distribution along height of the building

In figure 2, the pressure distribution by Indian code and standard and New Zealand code and standard show nearly equal values of pressure distribution along the different height of the building. The pressure distribution up to height 200m, New-Zealand shows the pressure distribution is constant from 100m to 200m of building height. Pressure is constant because of in AS/NZS 1170.2:2011code the terrain factor for 100m and for any height more than 100m taking 1.40. In

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AS/NZS1170.2:2011 the terrain multipliers for regions C and D (regions near to sea shore). Fig: 6 show the higher pressure distribution values of Japan than other wind loading codes and standards and Hong- Kong have lower values of pressure distribution than others.
In the Hong- Kong there is no any formulation and table given for calculation of design wind speed and design wind pressure the whole calculation is based on power law equation.

Table: 3 Base shear Q (KN) and Base bending moment M (MN-m)

Code	Q	M
India	33174.19 KN	3573.716 MN-m
Japan	34565.41 KN	3883.01 MN-m
Hong-Kong	31374.68 KN	3428.629 MN-m
New-Zealand	29298.63 KN	3131.810 MN-m

Comparison of base shear Q of other codes with Indian code

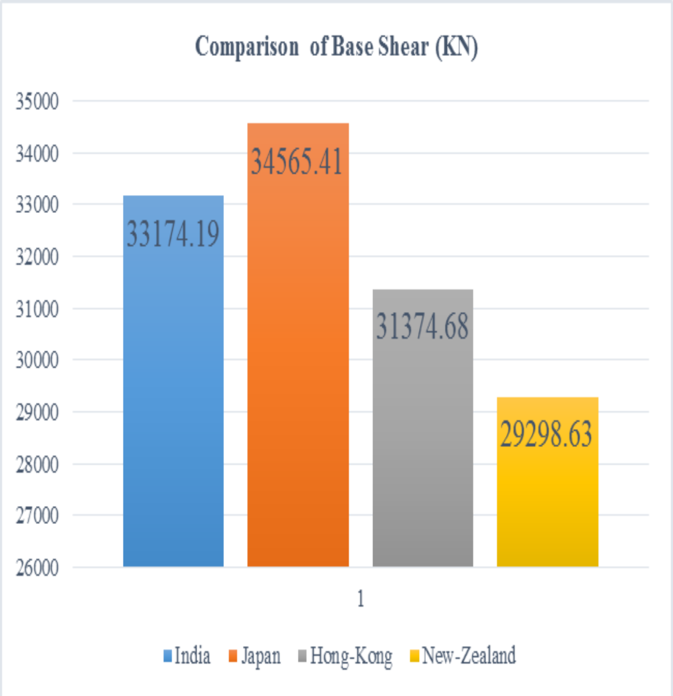

Fig: 7 Comparison of base shear of other codes with Indian code

- Hong-Kong shows the value of Q is 5.43% less than Indian code value
- New-Zealand shows 11.68% less value of Q than Indian code value
- Japan have 4.19% higher value of Q than Indian code value

Comparison of base Bending moment M of other codes with Indian Code

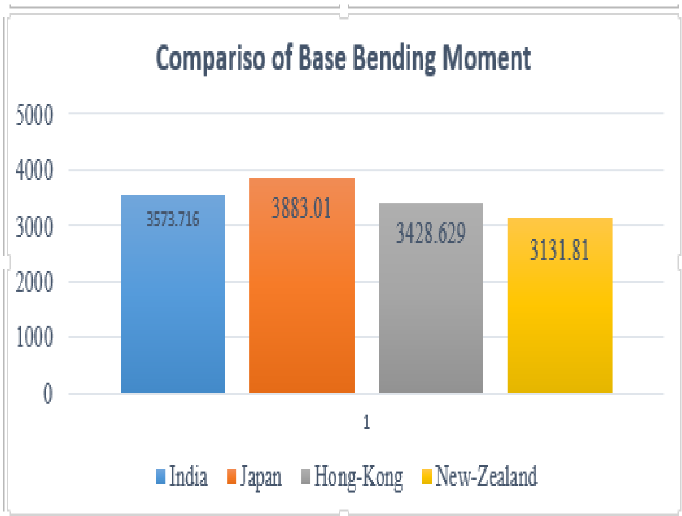

Fig: 8 Comparison of base Bending moment M of other codes with Indian Code

- Hong-Kong shows the value of M is 4.05% less than Indian code value
- New-Zealand shows 12.36% less value of M than Indian code value
- Japan have 8.65% higher value of M than Indian code value

VI. CONCLUSION

This paper presents a comparative analysis of parameters in along wind direction (wind direction is along 70m face) of a tall building. Parameters are design wind velocity and design wind pressure at different height of the building, base shear and base bending moment.
The value of base shear and base bending moment, according to Japan wind loading code show the highest value in comparison to other wind loading code and New-Zealand show the least value. India and Hong-Kong show nearly equal results. The mean value of base shear three codes (Japan, Hong-Kong and New-Zealand) is 31746 .24 this is only 4.4% less than Indian code. The mean value of base bending moment three codes (Japan, Hong-Kong and New-Zealand) is 3481.15 this is only 2.6% less than Indian code. The mean value of base shear and base bending moment is near equal to base shear and base bending moment calculated by the Indian wind loading code.

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