

Significance of k_1 Factor on Elevated Hoardings in the City Limits of Five Wind Zones of India

Santhosh Kumar B^{1*}, Balaji KVG², Chandan Kumar Patnaikuni², Ramesh, B²

¹D.E.E, Department of Water Resources, Vizianagaram, 532201, Andhra Pradesh, India

²Department of Civil Engineering, Gandhi Institute of Technology and Management (GITAM), Visakhapatnam, 530045, Andhra Pradesh, India

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Abstract In recent years, hoarding design has been a source of major concern in city limits, since the damage can be risky to life and property. The handbook of wind loads (IS 875(Part3):1987&2015 codes) recommended the hoarding as a temporary structure with 5 years design life period risk factor. The recent developments in India expanded the tremendous outdoor picturesque advertisement hoardings in the city limits for the dissemination of the broadcasting information. The failure of hoarding can be high degree hazard resulting in the loss of human life, but the wind code cannot define the structure even as a low hazard class of structure. Hence this paper addressed the risk associated with 10, 15, 20 and 25 years of design periods in city limits of terrain category 2 of the five wind zones of India. The five wind zones comprise 33 m/s, 39 m/s, 44 m/s, 47 m/s and 50 m/s have been considered because most of the populated cities have been geographically located in all the wind speed zones. To ascertain the influence of the above parameters, 15m × 6m steel elevated hoarding mounted on G+7 storey building is analysed in SAP 2000 version software. The associated risks are interpreted in terms of the variation of drag force, shear force and overturning moments. It can be highlighted when risk factor varied from 6% to 29%, the drag force, and overturning moments varied from 13% to 65%. Similar results were also obtained with cyclonic factor.

Keywords Hoarding, Design Life, Risk Factor, Wind Zones, Internal Parameters

1. Introduction

Hoardings, also known as Bill Boards in the USA, are outdoor picturesque advertising structures typically found in high traffic areas alongside busy roads and on the terrace of the buildings in the city limits. These are designed to provide road direction or dissemination of Information. They usually consist of primarily rectangular signboards or an enclosed rectangular box with simple support in the form of a mono-pole or a truss. Post-disaster investigations have reported that many damages and failures to large scale hoardings are occurring because of High wind speeds [1].

In the Indian context, the design guidelines of wind loads assumed the 5 years design life period risk factor for hoarding design [2, 3, 4]. This risk factor is generally considered for temporary sheds, and structures used in the formwork and false works structures category. With the new generation technology, the picturesque advertisement has gained the moment during the last couple of years. This event has flourished in the city limits. The failure of hoardings in these areas is hazardous in nature and causes the loss of property and life. This is attributed to the low-risk factor application.

In the cyclonic region, recognizing the likelihood of

cyclonic wind speeds is often exceeding the design wind speeds in a coastal region, IS 875 (Part3): 2015 code presented the cyclonic wind importance factor for computation of design wind speeds. Further, many hoardings have failed during the past couple of cyclones. The specified cyclonic factor for the design of hoardings in the cyclonic region was not recommended in IS 875 (Part3):2015 hence both 1.15 and 1.30 cyclonic importance factors are adopted in this study.

The commonly adopted maximum size of the 15 m × 6m (Height and Width) hoarding size mounted on a terrace of twenty-four-meter height (G+7 storey) building is selected to examine the variation of drag force, shear force and overturning moment for different design life periods 10,15,20 and 25 years in the five wind damage risk zones including cyclonic wind region. All the models are simulated in SAP2000 (v 4i) software programme [5].

Wind loads are predominant design loads on hoardings. Non engineered hoardings are prone to windstorm damage. The available literature review indicated that limited research work was carried out to find the force/drag coefficients in Wind tunnel testing's only [6, 7, 8].

The lack of further reliable data and increasing use of new materials and innovative techniques applied to design and construction of wind sensitive fences and hoardings have created a need to further calibrate design data prescribed in the codes. Many building codes are therefore being updated with wind loading data on hoardings [9].

The explanatory handbooks for proposed IS 875 (Part3):2011 draft code on wind loads on buildings and structures and the explanatory handbook on IS 875(Part3):1987 assumed the mean probable design life of hoarding for five years only [10]. This design life may be considered as a temporary structural element only. In history, the hoardings were mainly used for site-specific dissemination of information for a small design period varies from one to three years. But the structures are currently gained popular in the urban areas.

However, lack of further reliable data and increasing use of new material and innovative techniques applied to design and construction of wind sensitive structures like hoardings in the urban areas, it is felt that there is a need to design, hoarding for the higher risk factor (more design life period) than specified in the code, because the failure of a structure might cause hazardous and dangerous.

In the recent past, the East Coast of India witnessed the higher cyclonic wind speeds by the Phalin and Hudhud Cyclones [11, 12]. Considering the fact of cyclonic wind speeds are often exceeding the design wind speed in coastal areas in India, the IS 875(Part 3):2015 presented the cyclonic wind speed factor for computation of design wind speeds in coastal areas.

Although intensive research efforts have been made to investigate the integrated wind loads on trusses, telecommunication towers and Transmission towers

[13-20] but no studies have been conducted to examine the specific design life periods associated with the risk factors on the hoardings in any wind zone. The relevant risk factors for the construction industry was described in [21].

Hence this paper examines the impact of risk factor associated with different design life periods and cyclonic important factors on a rectangular hoarding of size 15 m x6 m mounted on 24 m height of the building to know the variation of wind load, drag force and bending moment.

In this study, a typical commonly adopted rectangular double-sided hoarding of size 15 mx6m mounted on an eight-storey building (24 m height) with the structural steel channel and angle sections was selected to compute the wind load effects from Low damage wind risk zone (33 m/s) to very high damage risk Zone-B (50 m/s) for different risk factors of design life periods vary from 5 to 25 years. Subsequently, the cyclonic factor effects were also elucidated.

2. Methodology

The Indian standards IS 875 (Part 3): 1987 & 2015 illustrated that total wind load "F" acting on hoarding is computed from the "(1 to 4)". Where V_z = design wind speed at any height z in m/s; V_b is the basic wind speed for the zone. k_1 = risk coefficient, k_2 = terrain roughness (Category2) and height factor varies according to the height of a structure, k_3 = topography factor and k_4 = Importance factor for the cyclonic Region (1, 1.15 and 1.30), P_z = wind pressure at a height "z", in N/ sqm, P_d is the design wind pressure at a height "z", in N/sqm, K_a = the area averaging factor. K_d = wind directionality factor. C_f =drag coefficient, A =tributary area.

$$V_z = V_b \times k_1 \times k_2 \times k_3 \times k_4 \quad (1)$$

$$P_z = 0.6 \times V_z^2 \quad (2)$$

$$P_d = K_d \times K_a \times P_z \quad (3)$$

$$F = C_f \times A \times P_d \quad (4)$$

The risk coefficients for 5,10,15,20 and 25 years of design life are computed from the equation provided in IS 875 (Part3):2015 code. The variations of risk factors associated with the design life are depicted in the table1.

Because cyclonic wind speeds often exceeded the basic wind speeds the IS 875(Part3); 2015 code presented the cyclonic importance factor for computing the design wind speed according to the importance of structures.

This cyclonic factor has 1.15 for industrial structures, as economic consideration and 1.30 for post cyclonic importance structure. The IS 875(Part3):2015 code is silent about this factor for the design of hoardings. Hence, both values are considered in this study. These factors have found for improving the low rise buildings else ware [22].

3. Results and Discussions

The explanatory handbook of IS 875 (Part3):1987 and draft wind code 2011 explanatory handbook adopted the risk coefficient corresponding to the 5-year design life of hoarding. In the cyclone area, the basic wind speed cannot be greater than 50 m/s. The impact of the cyclonic factor was also not reckoned for the design of hoarding. In this study (commonly adopted) steel angle/channel supported hoarding with a maximum size of 15m width × 6 m height mounted on 24 m height of the building is considered.

The different parameters such as design wind loads, drag force, base shear force and overturning moments for A) different probable design life spans from 5 years to 25 years and B) Impact of a cyclonic importance factor in coastal areas are studied. Basic wind speeds 33,39, 44,47 and 50 m/s are classified as low damage risk zone, moderate damage risk Zone-B, moderate damage risk zone-A, high damage risk zone and very high damage risk Zone-B respectively.

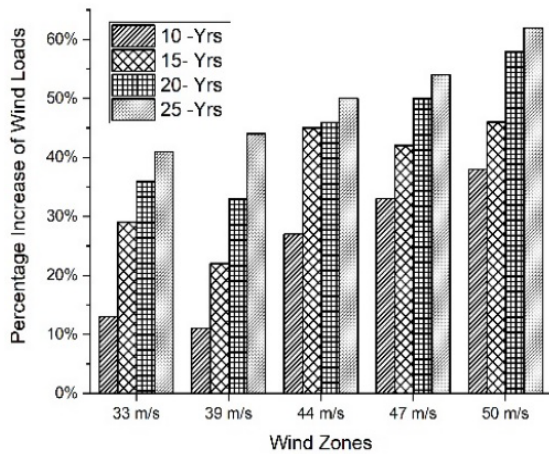


Figure 1. Wind load Variation

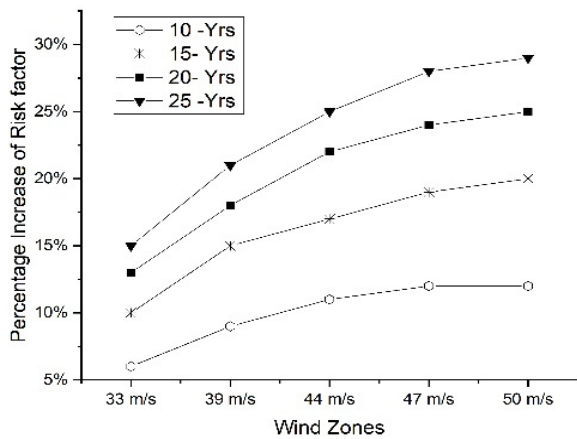


Figure 2. Variation of Risk factor

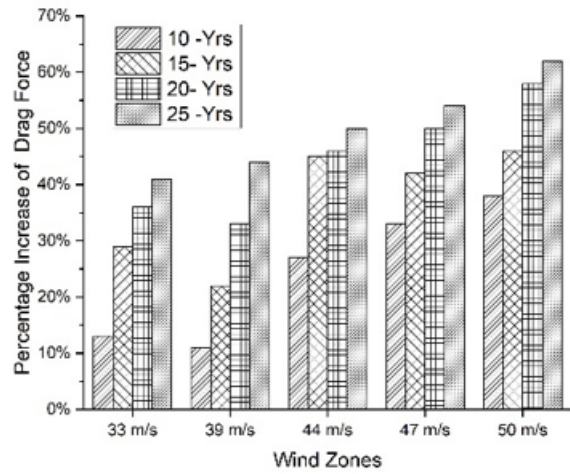


Figure 3. Drag Force Variation

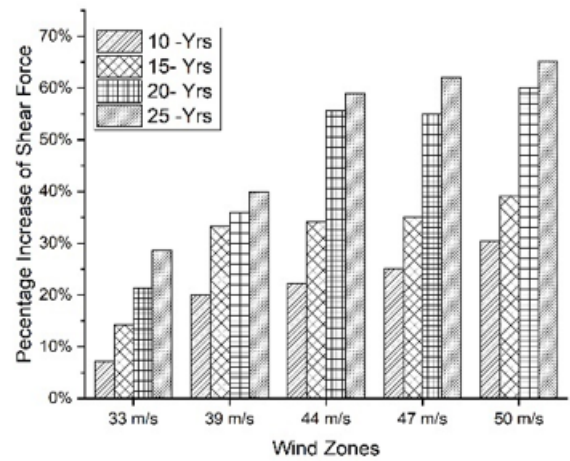


Figure 4. Variation of Shear force

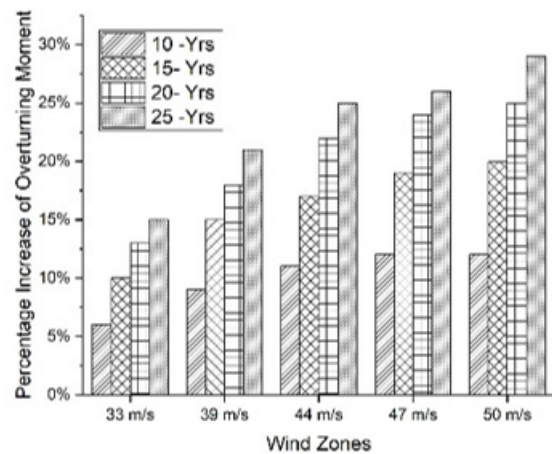


Figure 5. Overturning Moment Variation

Table 1. Risk factors (RF) and their percentage of increase variations in all wind zones

Wind zones Design Life (Yrs)	33 m/s		39 m/s		44 m/s		47m/s		50 m/s	
	RF	% Increase	RF	% Increase	RF	% Increase	RF	% Increase	RF	% Increase
5	0.82		0.76		0.73		0.71		0.70	
10	0.87	6%	0.83	9%	0.81	11%	0.80	12%	0.79	12%
15	0.90	10%	0.87	15%	0.86	17%	0.84	19%	0.84	20%
20	0.92	13%	0.90	18%	0.89	22%	0.88	24%	0.87	25%
25	0.94	15%	0.92	21%	0.91	25%	0.9	28%	0.90	29%

3.1. Discussion

The computed wind loads on 15 × 6 m (Width × Height) hoarding for all the wind zones with various design life period risk factors were simulated in SAAP 2000(v14) software for computation of internal forces such as drag force Shear force and Overturning moments. The variation of wind load has been shown in figure1. The variation of risk factor/ k_1 factor was depicted in Table 1 and figure 2. The internal parameter variations have been shown in figures 3-5.

The IS 875 (Part3):2015 specified the maximum basic wind speed in coastal areas shall not be more than 50m/s. However, IS 875 (Part3):2015 revised version specified the k_4 factor (Cyclonic importance factor) with 1.15 and 1.30 values for computing, the design wind speeds in industrial and post cyclonic importance structures in coastal areas. Hence the above hoarding modelled with k_4 factor values has been simulated for computing the various internal forces.

The variation of risk factors from the low damage risk zone (33 m/s) to very high damage, risk zone-B (33 m/s to 50 m/s) is in the range of 6% to 29%.

The variations of drag force and overturning moments for the low damage risk zone (33m/s) is 13 to 43% and 13 to 40% respectively.

The variation of drag force and overturning moments for moderate risk zone-A (39m/s) is in the range of 22 to 44% and 22 to 43%, respectively

The variations of drag force and overturning moments for moderate damage risk zone-A (44m/s) is in the range 27 to 50% and 36 to 50% respectively

The variations of drag force and overturning moments for the high damage risk zone (47m/s) is 33 to 54% and 38 to 54%, respectively.

The variations of drag force and overturning moments for very high damage risk zone-B (50m/s) is 38 to 62% and 43 to 65% respectively.

The variations of drag force and overturning moments for very high damage risk zone-B (50 m/s) with cyclonic importance factor 1.15(50m/s × 1.15)- are 15 to 71% and 19 to 124% respectively

The variations of drag force and overturning moments for very high damage risk zone-B (50 m/s) with cyclonic importance factor 1.30 (50m/s × 1.30) are 38 to 131% and

81 to 214% respectively.

From the Table 1, it is inferred that even though the risk factor for any design life of the structure is decreasing from low damage risk zone (33 m/s) to very high damage risk zone –B (50 m/s), the design wind load is increasing due to the specified regional wind speed only.

4. Conclusions

After simulating the wind loads in SAP 2000 (4i) version software on the hoarding of the low damage wind zone to high damage wind zones with different design life periods from 5 to 25 years, and secondly including the impact of cyclonic importance factor in the cyclonic region, the following conclusions can be drawn for 5 years of design life period with terrain category 3 only. Among the other internal parameters variations, the bending overturning moment parameter showed the highest increase.

The percentage increase of risk factors for the low damage risk zone (33 m/s) to very high damage, risk Zone-B (50m/s) for a design life period of 10 years to 25 years are 6% to 29%.

Whereas the variation of wind loads increased from 13% to 69%. It shows from the conclusion 1, the wind loads are varied more in comparison with the risk factor

The minimum increase of 13% overturning moment is obtained in wind speed zone 33 m/s and the maximum increase of 65% is observed in Wind speed zone 50 m/s.

For cyclonic wind region, 50m/s, when the cyclonic factor 1.15 is multiplied for basic wind speed, the wind load varies from 32 to 120%, the drag force, and overturning moments are varying from 15 to 77% and 19 to 124% respectively for a design life period of 10 to 25 years

For cyclonic wind region (50m/s) where the cyclonic factor of 1.30 is applied, the wind load varies from 69 to 181%, the drag force, and overturning moments are varying 38 to 131% and 81 to 214% respectively for a design life period of 10 to 25 years.

Since the various parameters viz., drag force, wind force and bending moment have shown significant effects on hoarding, because of applying higher design life

periods and cyclonic importance factor on the basic wind speed of IS 875(Part3):2015. It was concluded that there will be a substantial increase in the size of the hoarding members to be provided.

Since the hoarding size increases, the cost of material will also increase. Hence, increasing the risk factor for the design life period up to 25years shall lead to an enhanced hoarding section and escalation of cost. However, the code explicitly does not recommend the higher design life periods, this incorporation will reduce the substantial risk to life and property.

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