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Perception of k_4 Factor in Cyclonic Region of India

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Abstract**:** ***Even though 7% of global tropical cyclones are occurring as a medium intensity in the Northern Indian Ocean basin (in Bay of Bengal region) but their effect rendered a huge structural failures. There is a different opinion on the occurrence of cyclones from statistical, demographic and meteorological point of view but the financial loss was gradually increasing during the last decade. The cyclonic vulnerability map of India imparted the occurrence of various high speed wind cyclones in the different locations of the east coastal region. The post cyclonic damage reports revealed that the life line structures were also damaged. It indicated that the risk factor for 100 year design life of the structures was inadequate for safety of structures in coastal areas. Admitting the facts the revised IS 875(part3) 2015 recommended the cyclonic importance factor with 1.15 and 1.30 values for design of structures in coastal region. This recommendation cannot be suggested for hoarding design explicitly in the 2015 code.it is concluded from this analysis the hoardings cannot be treated as temporary structures and the design life must be considered up to a span of 25 years. Ultimately the necessity of k4 factor is highlighted in this paper.***

Keywords: ***Cyclone, Hoarding, IS 875(part3) 2015, K4 factor, static analysis***

I. INTRODUCTION

When compared to Atlantic and Pacific regions, the occurrence of tropical cyclones in North Indian Ocean (NIO) region is about 7% of the total global share [1] with a return period of 2 to 3 years with moderate to severe intensity. The NIO region consists of Bay of Bengal and Arabian Sea.

With the statistical analysis, 80% of cyclones in NIO region affects Andhra Pradesh and Orissa States. From the other point of view, the cyclonic damages in Andhra Pradesh state are due to concentration of population growth only [2].

Extensive structural damages have been reported in cyclones- Hudhdu'2012 [3], Vardah' 2016 [4] and Titly' 2018[5]. The common structural failure damages observed were Steel Roofs, roof claddings, Hoardings, Communication towers, transmission towers and electrical poles etc.

This attributed that the risk factor for 100 year design life recommended in the IS 875 (Part 3)-1987[6] for life line structures may not be adequate for design of structures in cyclonic region. Even respective peak factors specified in Gust factor method for computing the wind loads on towers, the code recommend the k4 factor for wind load calculation in Cyclonic region for towers. Considering these facts the IS 875 (PART-3) 2015[7] Code introduced the k4 factor /Cyclonic importance factor with three numerical values according to the structural importance. Numerical value 1.00 for general structures, 1.15 for industrial structures and 1.30 for post cyclonic importance structures.

This paper insight the effect of k4 factor on wind sensitive structures more particularly on hoardings. Analytical studies have been conducted on Hoardings for perception of this factor.

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II. LITTERATURE REVIEW.

Several conference papers such as Suresh kumar et al [8] and Hand book of wind load (HB2002) [9] on Asia Pacific region highlighted the large frequency of cyclonic damages in East Coastal region. The IS 15498-2004 code[10] also highlighted the same.

The conclusions made from the Lakshmanan et al (2009)[11] and Suresh kumar et al (8) that the basic wind speed specified in IS 875-1987[6] version is conservative, it means that there is no need to increase the basic wind speed in the East Coastal region.

The past cyclonic damage reports make known that there were many instances the cyclonic gale speeds exceeded the basic wind speed.

The IS 875(part3) 2015[7] version didn't change the basic wind speed in coastal region but suggested the k4 factor as an additional safety measure for computation of design wind speed in cyclonic region. The influence of k4 factor for various types of structures were analytically examined [12-15]

From this Literature, It is summarized that for computation of design wind speed in cyclonic region there is a need to multiply the k4 factor to the basic wind speed to minimize the structural failures associated with the cyclonic wind forces.

The IS 875(Part3)-2015 code implicitly recommend the risk factor for 5 years design life of the hoarding thus it has been assumed as a temporary structures. But due to adaptability of technology and change of Materials and due to increase of commercial activities in contemporary era, these structures have been fabricated on the green field and on building terraces in and around the metro Politian cities and even small towns also. The failure of these structures cause loss of life and property. With this instance, it is vital to perceive the k4 factor in this paper.

III. METHODS

The IS 875(Part3)-2015 code recommend the Force Coefficient method for computation of wind load on the hoardings based on the width to height ratios. The following equations1-4 are adopted from the code [7] for computation of design drag coefficient/ force coefficient in static analysis. In this regard, the size of 15m x6 m size on the 8 storey building is adopted to compute the variation of internal parameters and wind force with k4 factor. The hoarding failure on 3 storey building during Titly cyclone in Oct 2018 is shown in figure1.

1. Static analysis

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

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

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

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

Fig 1. Hoarding damage in Titly cyclone-2018

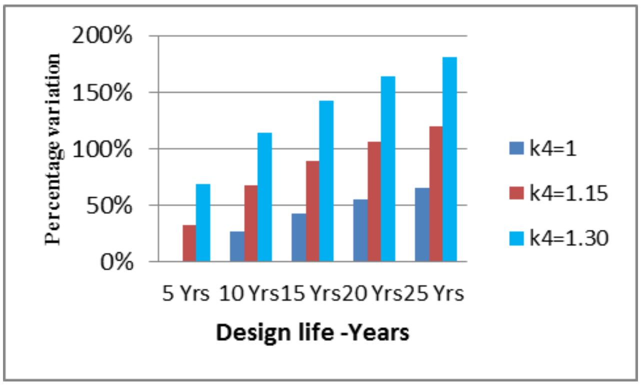

Fig 2. Variation of Wind loading for k4 factor values

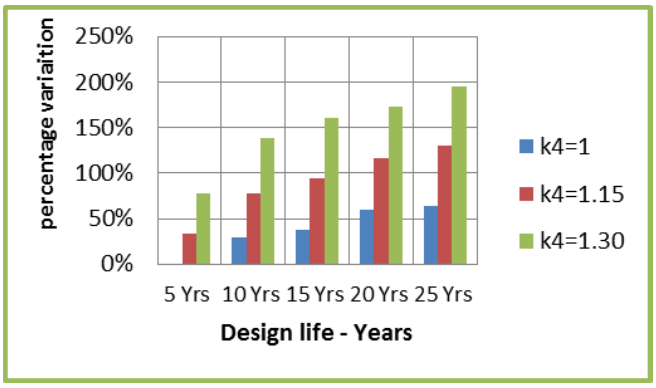

Fig 3. Variation of Shear Force for k4 factor values

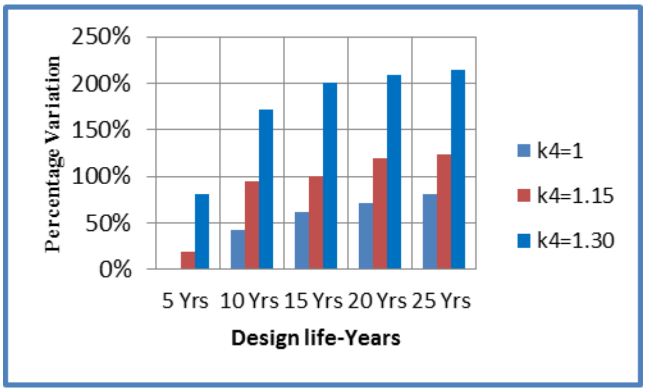

Fig 4.Variation of Bending Moment for k4 factor values

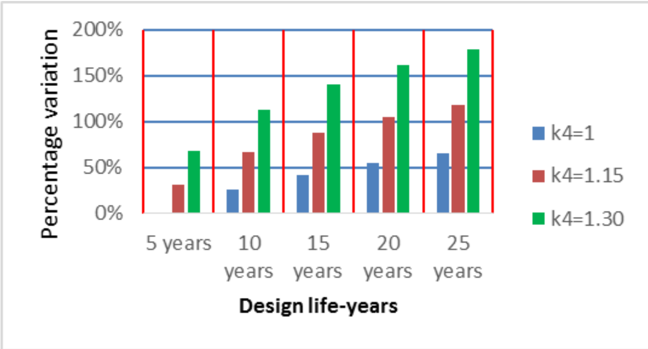

Fig 5.Variation of Displacements for k4 factor values

IV. RESULTS AND DISCUSSIONS

With the above methodology, the internal parameters are computed analytically with SAP software. In the cyclone area, the basic wind speed cannot be greater than 50 m/ s.

The impact of cyclonic factor was also not reckoned for the design of hoarding. In this paper steel hoarding a size of 15m width X 6 m height mounted on high rise building supported with channels is considered. The variations parameters such as design wind loads, bending moment, shear force and deflections for the k4 factor is explored.

Discussions

The computed wind loads on 15 X 6 m (Width X Height) hoarding were simulated in SAAP 2000(v14) software [16] for computation of internal forces such as drag force, Shear force, Bending moment and displacements. The results have been shown in fig 2-4.

The IS 875 (Part3)2015 [7] specified the maximum basic wind speed in coastal areas shall not be more than 50m/s. However IS 875 (Part3) 2015 [7] revised version specified the k4 factor with1.00, 1.15 and 1.30 values for computing, the design wind speeds for general, industrial and post cyclonic importance structures in coastal areas. Hence the above hoarding is modelled and simulated with k4 factor values.

When the design life is extended from 10 years to 25 years the wind loads are varying from 27 % to 66% with k4 factor value is 1.00; varies from 68% to 120% when k4 factor is 1.15 and varies from 115% to 181% when k4 factor 1.30.

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When the design life is lengthened from 10 years to 25 years the Shear force is varying from 29 %to 64% with k4 factor is 1.00; varying from 77% to 129 % when k4 factor is 1.15 and varies from 138% to 195% when k4 1.30 factor is 1.30.

When the design life is stretched from 10 years to 25 years the Bending moment varying from 43 %to 81% with k4 factor is 1.00; varies from95% to 124% when k4 factor is 1.15 and also varies from 171% to 214% when k4 factor 1.30.

With the design life is amplified from 10 years to 25 years, the displacements are varying from 26 %to 65% with k4 factor is 1.00value; are varying from 67% to 118% when k4 factor is 1.15 and 114% to 179% when k4 factor 1.30.

V. CONCLUSIONS

After simulating the wind loads in SAP 2000 (4i) version software on the hoarding with different design life periods from 10 to 25 years, including the impact of k4 factor, the following conclusions can be drawn.

I. It is a common insight from the past cyclonic damage reports, the hoardings cannot be treated as a temporary structure, However, the design life period can be considered up to 25 years.

II. From the above results and discussion, the perception of k4 factor in cyclonic region are as follows.

- ➢ The hoarding shall be designed for 25 years of design life with k4 factor value 1.00 for remote location where there is no damage to life and property.
- ➢ The hoarding shall be designed for 25 years of design life with 1.15 of k4 value for city/ town outskirts where there is a sparse population with minimum damage to property and life.
- ➢ The hoarding shall be designed for 25 years of design life with 1.30 of k4 value with in the city/ town limits where there is high risk to life and property when damages can anticipated be occurred within the city/town limits

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