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Structural behavior and design of concrete chimney due to revision of IS875 (part 3)

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ABSTRACT
There are very limited case studies available investigating about structural behavior of reinforced concrete chimney subjected to wind loads. An existing 65m high reinforced concrete chimney located at Oriental Yeast India ltd is considered for the present study. Although the chimney was designed in 2018 still it was designed by following the provisions of old code IS875 (part-3):1987 for wind loads. There are some changes in the revised code due to which the wind pressure increases which further leads to increase in the shear force, bending moments and deflection of chimney. In this study, reasons behind the increment of wind pressure is investigated by comparing the wind forces calculated from revised code IS875 (part 3):2015 & old code IS875 (part 3): 1987. The calculation work has been done manually in MS Excel.
Keywords - Reinforced concrete chimney, Design wind speed, Wind forces, IS875 (part 3):2015 & IS875 (part 3):1987.

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I. INTRODUCTION

Chimneys are very important industrial structures used to discharge various poisonous gases at higher elevation in the atmosphere. There are many Indian standards available for designing the chimneys such as IS4998 (part 1)-1992 for reinforced concrete chimney and IS6533 (part 2)-1989 for steel chimney. Reinforced concrete chimney is generally preferred due to its high flexural resistivity. It has been observed that height of chimneys are increasing since last few decades. The effect of wind forces increases with increase in the height of structure.

II. DETAILS OF EXISTING CHIMNEY

A self-supporting reinforced concrete chimney of height 65m and outside diameter of chimney shell throughout the height is 3.35m. The gas temperature inside the flue is 200deg.C and Basic wind speed at site is 39m/sec (Ref: IS875 [III]-1987). Concrete used in R.C. work is M25 grade for raft foundation and M30/M35 for chimney shell, corbels and platforms. There are two numbers of flue duct openings of size 1.25m by 1m and 1.1m by 0.6m. 115mm thick fire brick lining has been provided at upper 55m portion and 230mm thick AR brick lining provided in lower 10m portion.

III. COMPARATIVE STUDY ON DIFFERENT PARAMETERS

The comparative study has been carried out by calculating wind loads from IS875 (part-3):1987 and IS875 (part-3):2015. There are some variations in the revised code which are as discussed below.

Table 1: Comparing design wind speed formula from both the codes

	IS875 (part-3):1987	**IS875 (part-3):2015**
Design wind speed, V_z	$=V_b.k_1.k_2.k_3$	$=V_b.k_1.k_2.k_3.k_4$
Factor k_1	Same	Same
Factor k_2	Mentioned for different terrain categories and for different classes of buildings.	Mentioned only for different terrain categories not for different classes of buildings.
Factor k_3	Same	Same
Factor k_4	Didn't exist.	Mentioned according to the importance of the structure.

The existing chimney was designed according to previous code in which the chimney falls in class C type of structure because the vertical dimension of the chimney is greater than 50m. In the revised code basically the value of k_2 are of class A which is for all classes of structure. The values of k_2 for class C are lesser as compared to class A type building. The variation found in the value of k_2 is 1.158 to 1.218 at 65m level. The factor k_4 which is importance factor for cyclonic region is mentioned as 1.15 for industrial structures in revised code which was absent in the previous code. These changes in the parameters/factors leads to increase in the design wind speed which further increases the wind pressure on chimney.

Table 2: Comparing design wind speed (in m/sec) at different levels of the chimney

Level (in m)	**IS875 (part 3): 1987**	**IS875 (part 3): 2015**	**%age increased**
65	47.87	57.91	20.97
55	47.38	57.33	21.00
45	46.61	56.46	21.13
35	45.58	55.27	21.26
25	44.44	53.93	21.35
15	42.58	51.82	21.70
6.5	40.93	49.92	21.96
0	40.93	49.92	21.96

The table above clearly shows that the design wind speed by revised code is about 20-22% larger than the previous code.

Table 3: Comparing design wind pressures (in kN/m^2) at different levels of the chimney

Level (in m)	**IS875 (part 3): 1987**	**IS875 (part 3): 2015**	**%age increased**
65	1.375	2.012	46.33
55	1.347	1.972	46.40
45	1.304	1.912	46.63
35	1.246	1.833	47.11
25	1.185	1.747	47.43
15	1.088	1.611	48.07
6.5	1.005	1.495	48.76
0	1.005	1.495	48.76

The table above clearly shows that the value of design wind pressures by revised code is about 46-49% larger than previous code. This increment in the wind pressure leads to increase shear force, bending moments and deflection of the chimney.

IV. RESULTS

4.1. Shear Force

Shear force at any section is the multiplication of design wind pressure and projected area above that section. Shear force at different level has been calculated from revised code as well, the difference shows in tabulated form below-

Table 4: Comparing shear forces (in kN) at different levels of chimney

Level (in m)	**IS875 (part 3): 1987**	**IS875 (part 3): 2015**	**%age increased**
65	0	0	00.00
55	36	53	47.22
45	72	105	45.83
35	106	155	46.23
25	138	203	47.10
15	169	248	46.74
6.5	192	282	46.88
0	209	308	47.37

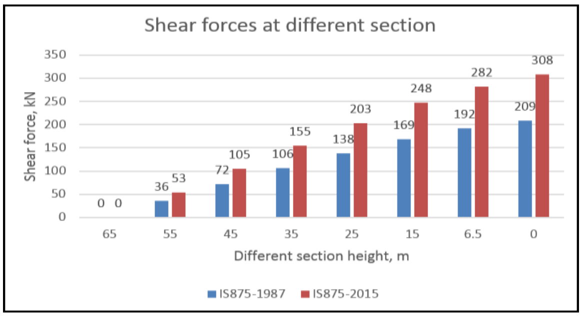

Fig. 1- comparison of shear forces at different section

4.2. Bending moments

Bending moment at any section is the summation of multiplication of the wind force and height of acting force. Bending moments at different levels is calculated by revised code as well, the difference is shows in tabulated form-

Table 5: Comparing bending moments (in kN-m) at different levels of chimney

Level (in m)	**IS875 (part 3): 1987**	**IS875 (part 3): 2015**	**%age increased**
65	0	0	00.00
55	182	267	46.70
45	725	1061	46.34
35	1614	2365	46.53
25	2836	4157	46.58
15	4372	6413	46.68

6.5	5904	8667	46.80
0	7208	10586	46.86

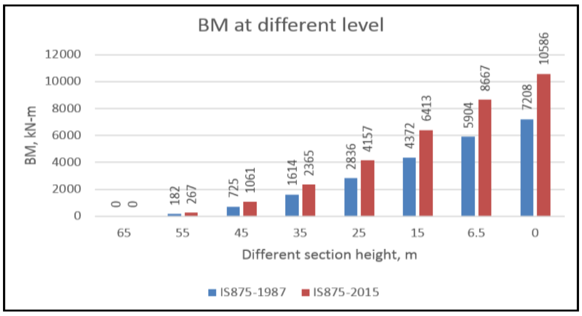

Fig. 2- comparison of bending moments at different section

4.3. Deflection

The deflection at different levels of chimney is also calculated from revised code, the difference shown in the table below-

Table 6: Comparing deflection (in mm) at different level of chimney

Level (in m)	**IS875 (part 3): 1987**	**IS875 (part 3): 2015**	**%age increased**
65	83	119	43.37
55	66	95	43.94
45	49	71	44.90
35	33	48	45.45
25	19	27	42.11
15	8	12	50.00
6.5	2	3	50.00
0	0	0	00.00

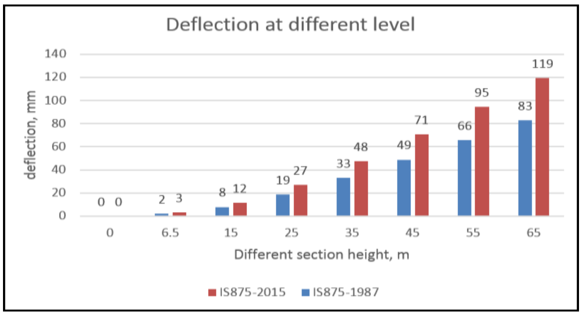

Fig. 3- comparison of deflections at different section

As per the results obtained the shear forces calculated from revised code are much larger than the previous code, the shear force at base by revised code is 47.37% more than the previous code. Similarly the difference between the bending moments calculated from both the codes are much larger, the maximum bending moment at base calculated from revised code is 46.86% more than the previous code. And the maximum deflection at 65m height is 83mm and 119mm calculated from previous code and revised code respectively. The maximum deflection calculated from revised code is 43.37% more than the maximum deflection calculated from previous code.

V. CONCLUSION

In the present study, comparison of wind forces on existing 65m high reinforced concrete chimney by IS875 (part 3)-1987 and IS875 (part 3)-2015. The results in terms of shear forces, bending moments and deflections obtained from revised code are much higher than the previous code. The changes in k_2 factor and introducing of k_4 factor in revised code causes the large differences in the results. The tall structures should be design as per the latest revised code for safe design.

REFERENCES

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