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Static and Dynamic Wind Force Analysis of Self Supporting Flare Base Circular Steel Stacks with Variable Height

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Abstract: This paper deals with the behaviour of Flare base circular steel stacks with variable height of 30m, 40m, and 50m respectively. The study aim is to find out the structural behaviour of Flare base steel stack under the equivalent static and dynamic wind forces. The static & dynamic wind analysis is done by using the Staad.Pro Vi8 ss5 software with assumptions as per IS 6533:1989(part1 & part2). The study parameter of static and dynamic forces, maximum deflection due to static & dynamic wind forces for flare base circular steel stacks for the different height with constant wind speed 47m/s (Location:- Agra, India) was compared.

Keywords— Steel stacks, Static wind force, Dynamic wind force, Maximum deflection and Variable height.

INTRODUCTION:

A steel stack is a vertical channel through which smoke and combustion gases pass out of a building. Steel stacks are used to emit and exhaust gases in atmosphere at higher elevation. Failure of steel stacks is prime issue in most of industries. The cause behind the failure is analyzed by the static & dynamic wind analysis of stacks. The steel stacks less than 80m are called short steel stacks. The first mode is sufficient for the analysis for the short circular steel stacks.

ANALYSIS OF STEEL STACKS:

Wind analysis include the effect of static and dynamic wind forces .Geometry of flare base is given in Table-1 as per accordance IS 6533 Part-1&2.

A. Geometry for flare base steel stacks:

Basic geometry of steel stacks is governed by top diameter (D_t), base diameter (D_b) and effective height (H_e). Following IS code are used for the analysis of steel stacks.

a) IS 6533 (part-1):1989, "Indian standard code of practice for design and construction of steel chimney –code of practice-Mechanical aspects."

b) IS 6533 (part-2):1989, "Indian standard code of practice for design and construction of steel chimney –code of practice-Structural aspects."

c) IS 875:1987(part-3) used for the wind force analysis.

Minimum top diameter of unlined chimney should be one twentieth of effective Height of chimney/stacks and minimum outside diameter at base should be equal to 1.6 times the top diameter of stack. (As per IS 6533(part2):1989(reaffirmed in 2003) cl.7.2.4 (b) &(c).

Table: 1 Geometry of Flare base steel stacks

Steel stacks	Total Height of stack (Meters) (H)	Basic wind speed (m/s)	Effective Height (He) = (2/3xH) (meter)	Top Diameter (Dt) = (H/30) (meter)	Bottom diameters (Db) = (1.6 * Dt) (meter)
1	30	47	20	1	1.6
2	40	47	26.67	1.33	2.128
3	50	47	33.33	1.66	2.656

PROBLEM -STATEMENT

Analyse the behaviour of self supporting flare base circular steel stacks under the static and dynamic wind forces of variable height as per Indian standard code of practice.

Detail of steel stack

- Type: self-supported unlined industrial flare base circular steel stacks with constant shell thickness as IS 6533 Part-1.
- Total 3 steel stacks (Wind speed constant with variable Height)
- Height of steel stack: 30m, 40m, and 50m.
- Top diameter for each stack is taken as minimum $h_e/20$ as per provision in IS 6533:1989.
- Variation in base diameter for each stack for fixed value of top diameter will be in following incremental ratio (ratio D_b/D_t) : 1.6
- Base condition : Rigid support at base
- Location of stack :Agra (L: 78*1'0", D: 27*10'0")
- Basic wind speed at location : 47m/s
- Shell thickness : 16mm (constant for all stacks)
- Materials for steel stack are conforming to IS2062:2006.

Results:

A. Static& dynamic wind Responses for Flare base circular steel stacks for 47m/s wind speed:

Deflection of FBC SS considering Static and dynamic wind force at basic wind speed 47m/s is given in table-2 & table-3.

Table: 2 Static wind responses for Flare base circular steel stacks for 47m/s wind speed

FBC SS	Height (m)	Top Diameter (m)	Bottom Diameter (m)	Static Wind Force (KN)	Maximum Deflection (mm)
30 m	10	1m	1.6 m	6.048	21.893
	20			6.408	
	30			5.880	
40m	10	1.33m	2.128 m	6.588	71.351

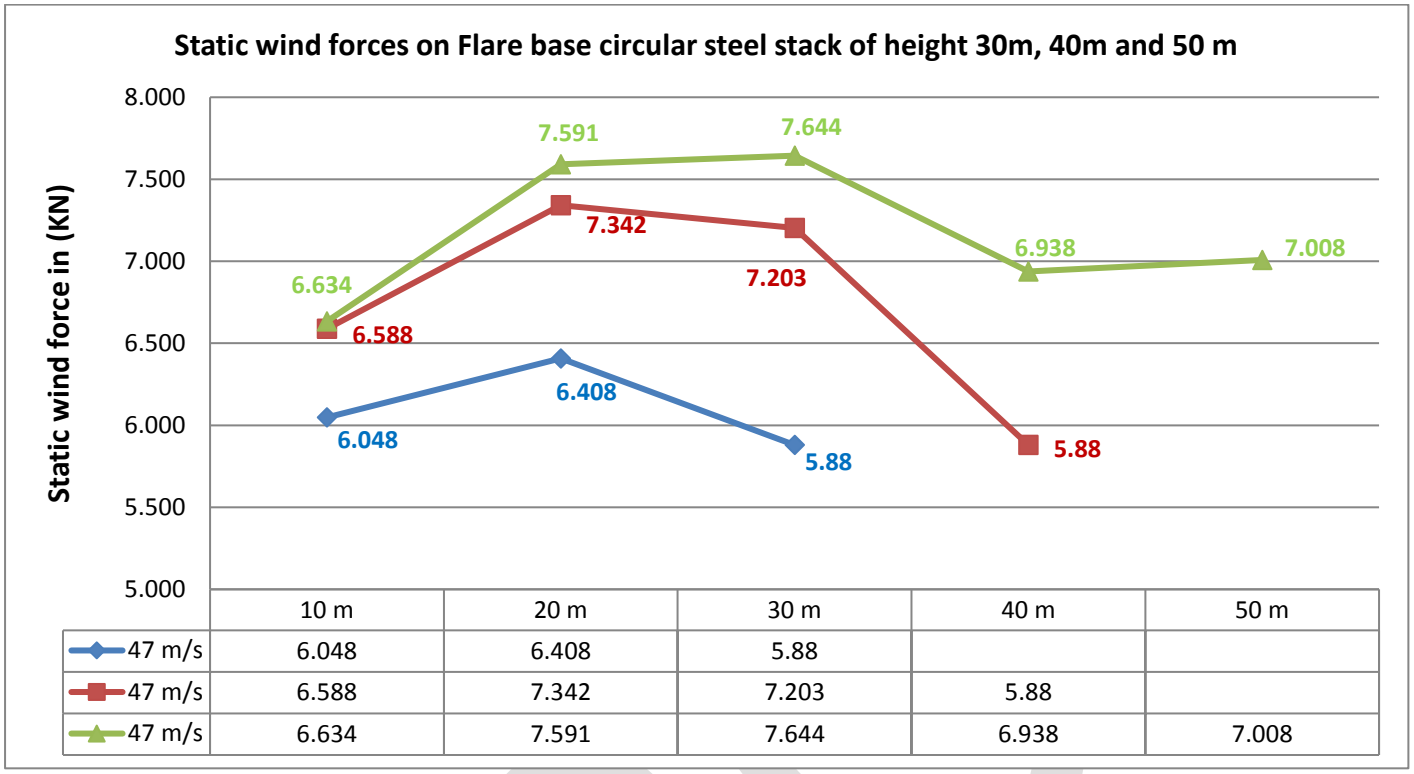
	20			7.342	
	30			7.203	
	40			5.880	
50 m	10	1.66m	2.656 m	6.634	116.233
	20			7.591	
	30			7.644	
	40			6.938	
	50			7.008	

Table: 3 Dynamic wind responses for Flare base circular steel stacks for 47m/s wind speed

FBC SS	Height (m)	Top Diameter (m)	Bottom Diameter (m)	Dynamic Wind Force (KN)	Maximum Deflection (mm)
30 m	10	1.00m	1.600 m	5.6461	25.411
	20			5.3753	
	30			5.6171	
40m	10	1.33m	2.128 m	8.1018	86.280
	20			7.1670	
	30			7.8879	
	40			7.8872	
50 m	10	1.66m	2.656 m	10.4716	141.123
	20			10.3180	
	30			9.8742	
	40			9.8716	
	50			11.0877	

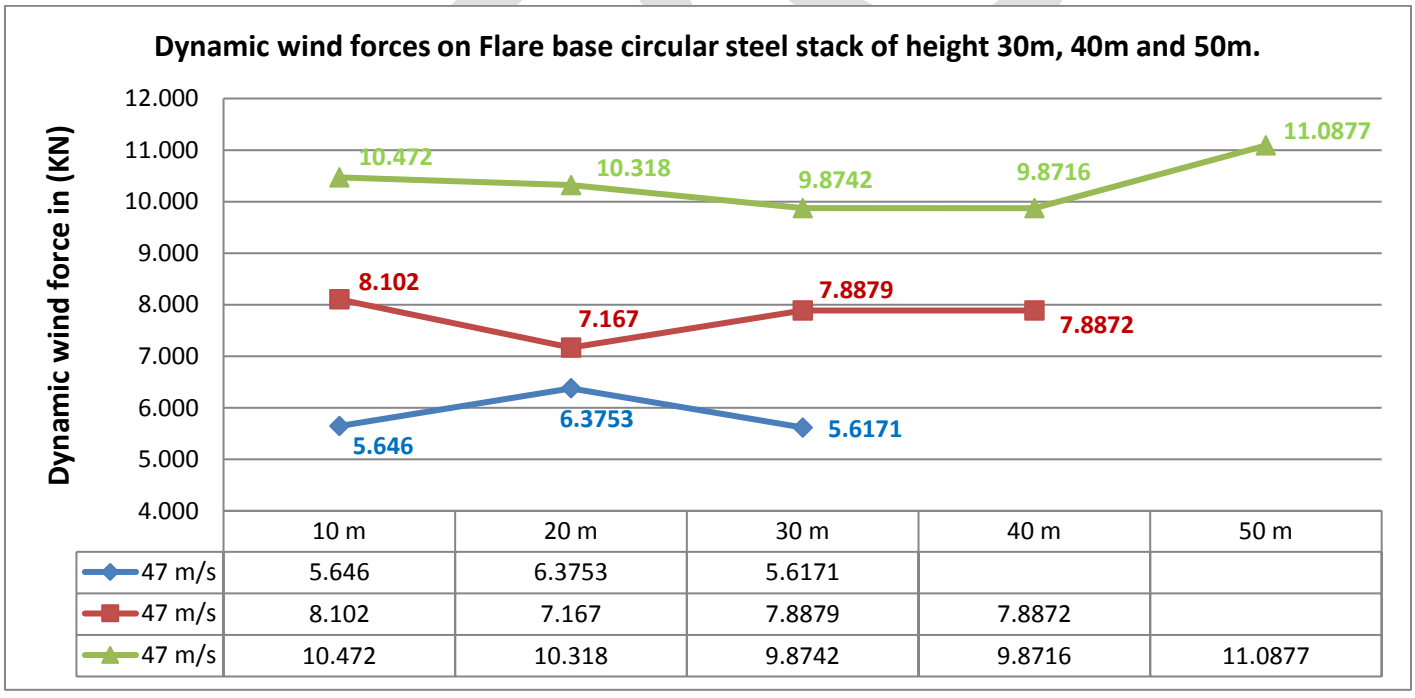
B. Graphical representation of static and dynamic wind Force:

The static and dynamic wind forces are given below in Fig-1 and Fig-2.



	10 m	20 m	30 m	40 m	50 m
47 m/s	6.048	6.408	5.88		
47 m/s	6.588	7.342	7.203	5.88	
47 m/s	6.634	7.591	7.644	6.938	7.008

Fig-1 Static wind forces on flare base circular steel stack of wind speed 47 m/s with height (30m, 40m and 50m)



	10 m	20 m	30 m	40 m	50 m
47 m/s	5.646	6.3753	5.6171		
47 m/s	8.102	7.167	7.8879	7.8872	
47 m/s	10.472	10.318	9.8742	9.8716	11.0877

Fig-2 Dynamic wind forces on flare base circular steel stack of wind speed 47 m/s with height (30m, 40m and 50m)

C. Maximum deflection due to static and dynamic wind responses:

Maximum deflection due to static and dynamic wind forces increases along the increment in height. Maximum deflections at variable height (30, 40 & 50m) are given in figure -3.

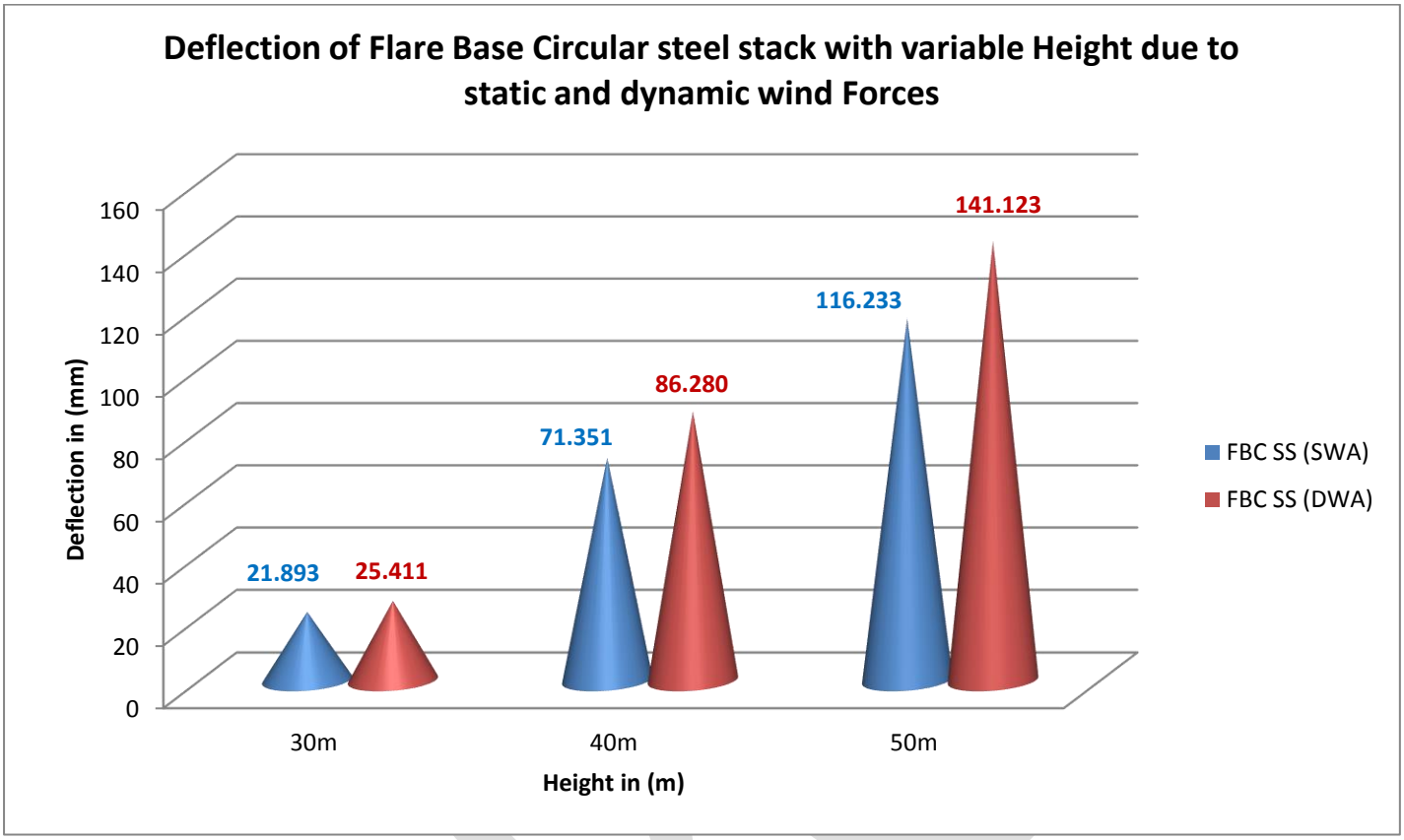


Fig-3 Maximum Deflection due to Static wind response with variable height (Basic mode)

CONCLUSION:

Following results are obtained from all above graphical representations:

1. Maximum deflection due to static wind force increase with the increase in height of steel stacks. At 30m, 40m and 50m height maximum deflection are 21.893mm, 71.351mm and 116.233mm respectively.
2. Maximum deflection due to dynamic wind force increase with the increase in height of steel stacks. At 30m, 40m and 50m height maximum deflection are 25.411 mm, 86.280mm and 141.123mm respectively.
3. Maximum deflection is more due to dynamic wind force as compare with static wind force at their respective height.
4. Maximum deflection difference is increasing due to static and dynamic wind force with the increase in height of steel stacks. At 30m, 40m and 50m height maximum deflection difference are 3.518mm, 14.929mm and 24.890mm respectively.

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