International Journal of Engineering Research and General Science Volume 4, Issue 4, July-August, 2016
ISSN 2091-2730

Response of Flare base Self supporting Steel stack

Under the static & dynamic wind loads with variable wind speed

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Abstract— This paper deals with the behaviour of Flare base steel stacks with variable Wind speed of 44m/s, 47m/s, and 50m/s respectively. The study aim is to find out the structural behaviour of Flare base steel stack under the Equivalent static and dynamic wind loads. 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 steel stack for the three different wind speeds with constant height & shell thickness was compared.
Keywords— Steel stacks, static wind force, dynamic wind force, Maximum deflection.

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.

B. *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.

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

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

f) 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 (H_e) (2/3xH) (meter)	Top Diameter (constant) (H_e/20) (m)	Varying top to bottom diameters ratio (D_b/D_t) ratio (m)
					1.6
	H		H_e	D_t	D_b
1	30	44	20	1	1.6

2	30	47	20	1	1.6
3	30	50	30	1	1.6

PROBLEM -STATEMENT

Analyse the behaviour of self supporting Flare base Steel stack under the static and dynamic wind loads for variable wind speed as per Indian standard code of practice.

Detail of steel stack

- Type: self-supported unlined industrial circular steel stacks with constant shell thickness as IS 6533 Part-1.
- Total 3 steel stacks (Height constant with variable wind speed)
- Height of steel stack: 30m
- 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
- Wind speed : 44m/s,47m/s,50m/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 steel stack for (44m/s) wind speed:

Static and dynamic wind force increases with increment in wind speed. Static and dynamic wind force at wind speed 44m/s is given in table-2&table-3.

Table: 2 Static wind responses for Flare base steel stack for (44m/s)

FBC SC	Basic wind Speed (m/s)	Height (m)	Top Diameter (m)	Bottom Diameter (m)	Static Wind Pressure P_z (KN/m^2)	Static Wind Force (KN)	Max. Maximum deflection (mm)
30 m	44	10	1m	1.6 m	0.63	6.048	19.207
		20			0.78	7.488	
		30			0.86	8.256	

Table: 3 Dynamic wind responses for Flare base steel stack for (44m/s)

FBC SC	Basic wind Speed (m/s)	Height (m)	Top Diameter (m)	Bottom Diameter (m)	Dynamic Wind Force (KN)	Max. Maximum deflection (mm)
30 m	44	10	1	1.6	6.0782	181.145
		20			7.5327	

		30			8.3051	

B. *Static wind Response for Flare base steel stack for (47m/s) wind speed:*

Static and dynamic wind force increases with increment in wind speed. Static and dynamic wind force at wind speed 47m/s is given in table-4&table-5.

Table: 4 Static wind responses for Flare base steel stack for (47m/s)

FBC SC	Basic wind Speed (m/s)	Height (m)	Top Diameter (m)	Bottom Diameter (m)	Static Wind Pressure P_z (KN/m^2)	Static Wind Force (KN)	Max. Maximum deflection (mm)
30 m	47	10	1	1.6	0.72	6.912	21.893
		20			0.89	8.544	
		30			0.98	9.408	

Table: 5 Dynamic wind responses for Flare base steel stack for (47m/s)

FBC SC	Basic wind Speed (m/s)	Height (m)	Top Diameter (m)	Bottom Diameter (m)	Dynamic Wind Force (KN)	Max. Maximum deflection (mm)
30 m	47	10	1	1.6	6.9486	208.271
		20			8.5984	
		30			9.4679	

C. *Static wind Response for Flare base steel stack for (50m/s) wind speed:*

Static and dynamic wind force increases with increment in wind speed. Static and dynamic wind force at wind speed 50m/s is given in table-6&table-7.

Table: 6 Static winds Response for Flare base steel stack for (50m/s)

FBC SC	Basic wind Speed (m/s)	Height (m)	Top Diameter (m)	Bottom Diameter (m)	Static Wind Pressure P_z (KN/m^2)	Static Wind Force (KN)	Max. Maximum deflection (mm)
30 m	50	10	1m	1.6	0.81	7.776	24.802
		20			1.01	9.696	
		30			1.11	10.656	

Table: 7 Dynamic wind responses for Flare base steel stack for (50m/s)

FBC SC	Basic wind Speed (m/s)	Height (m)	Top Diameter (m)	Bottom Diameter (m)	Dynamic Wind Force (KN)	Max. Maximum deflection

						(mm)
30 m	50	10	1	1.6	7.8195	234.158
		20			9.7614	
		30			10.7279	

D. Graphical representation of static and dynamic wind load:

Static and dynamic wind forces increase with increase in height of the steel stack and also increase with increment in wind speed.Fig-1 and Fig-2 shows the static and dynamic wind forces which is given below:

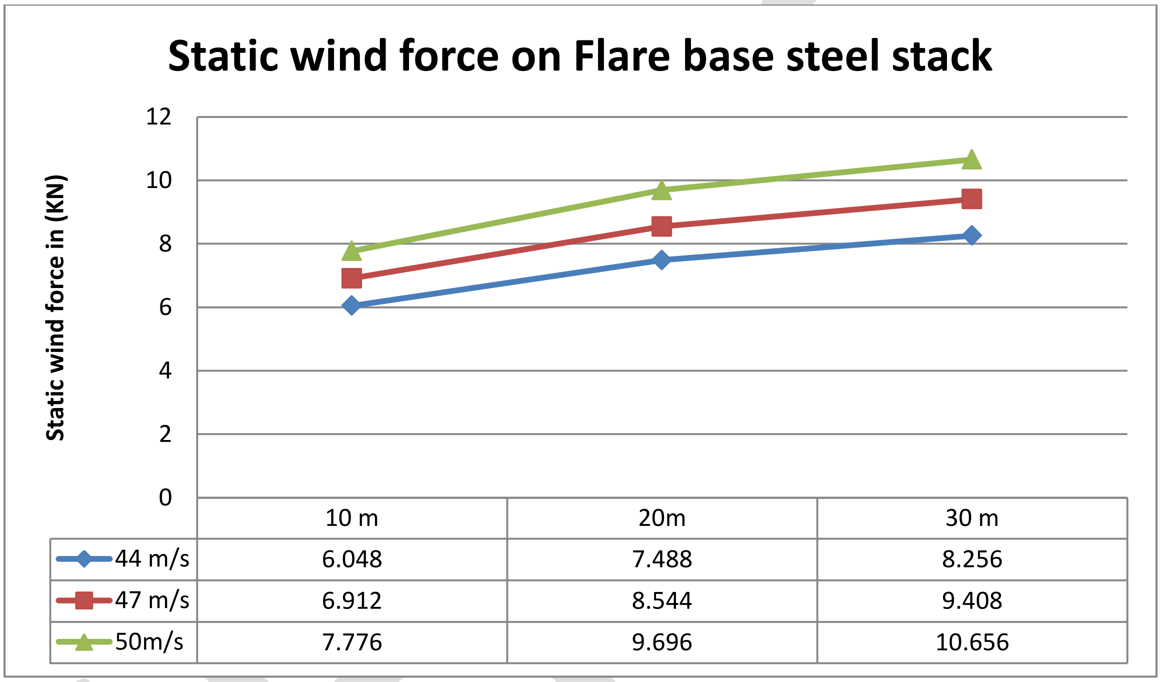

Fig-1 Static wind force on flare base steel stack of 30m with wind speed (44m/s, 47m/s, 50m/s)

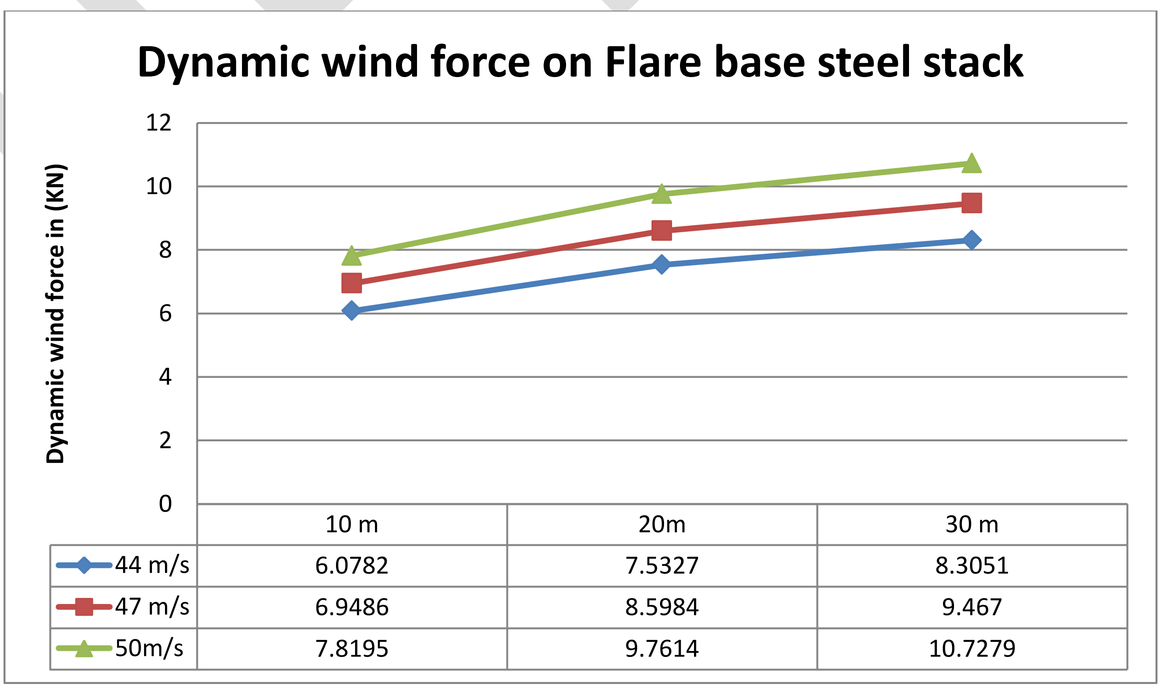

Fig-2 Dynamic wind force on flare base steel stack of 30m with wind speed (44m/s, 47m/s, 50m/s)

E. *Maximum deflection due to static and dynamic wind responses:*

Maximum deflection due to static and dynamic wind forces increases along the increment in wind speed. Maximum deflections at variable wind speed (44, 47 & 50m/s) are given in figure -3.

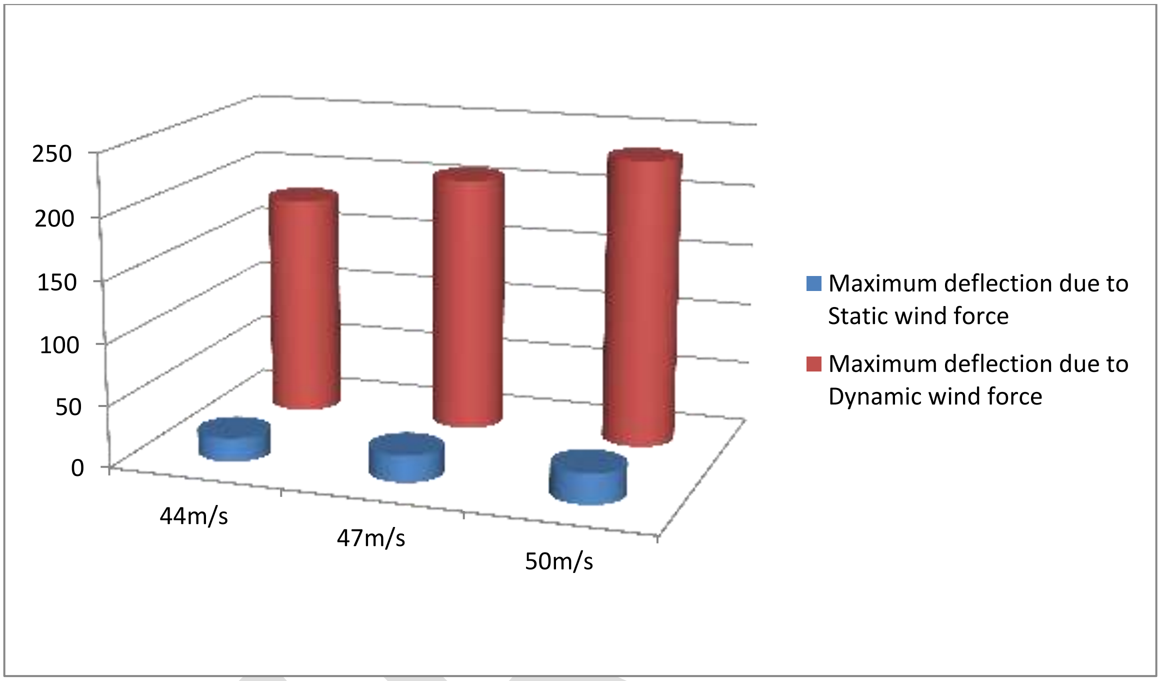

Fig-3 Maximum Deflection due to Static wind response with variable wind speed (for 1st mode)

CONCLUSION:

Following results are obtained from all above graphical representations:

1. Static & dynamic wind forces increases with the increment in wind speed (44, 47,50m/s).
2. Maximum deflection due to static wind force increases at 47m/s, 50m/s (14.45, 29.13%) as compare with wind speed 44m/s.
3. Maximum deflection due to dynamic wind force increases at 47m/s,50m/s (15.02, 29.32%) as compare with wind speed 44m/s.
4. Maximum deflections for wind speed (44,47 & 50m/s) due to static wind forces are (89.39, 89.49 ,89.41%) less as compare to maximum deflection due to dynamic wind force for (44,47,50 m/s) wind speed.

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