COMPARATIVE ANALYSIS OF WIND LOADS FOR INDUSTRIAL SHED STRUCTURES

Prabhat K Soni [1], P Sangamnerkar [2], S K Dubey [3]

1. Maulana Azad Natonal Institute of Technology Bhopal, India
2. M.P. Housing & Infrastructure Development Board Bhopal, India
3. Maulana Azad Natonal Institute of Technology Bhopal, India

ABSTRACT. The paper is related to analysis of wind load on structural members of industrial shed structures. The paper reviews the typified designs of steel roof trusses of SP-38(S&T); Handbook for typified designs for structures with steel roof trusses. Analysis of truss is done for different factors of terrain categories, class of structure, topography, height & structure size, permeability condition and calculated wind loads as per provisions of current Indian Standard Code. The paper presents comparative results of analysis to get optimum design of steel roof truss or industrial shed structure incorporating various factors, which helps to get economical sections or members of steel roof structure to enhance effectiveness of structural design and its economy through saving of material by optimization. The paper explores the scope of improvisation in typified designs given in the handbook and suggests that these factors for wind load calculation can be incorporated as per current Indian Standard Code to provide typified designs of common forms of industrial structures used in light engineering industries, warehouses, workshops, storage sheds, and to obtain economical designs under these conditions.

Keywords: Terrain category, typified design, topography, permeability.

Prabhat K Soni is a research scholar of civil engineering, Maulana Azad National Institute of Technology Bhopal (M.P.), India, has published on subject of Steel structures, Seismic Analysis.

Dr. Prakash Sangamnerkar is Assistant Engineer in M.P. Housing & Infrastructure Development Board, Bhopal (M.P.), India, His research area of interest includes Vibration Analysis, Steel Framed Structures and High Rise Structures.

Dr. S K Dubey is Professor in Civil Engineering, Maulana Azad National Institute of Technology Bhopal (M.P.), India and his main research areas of interest include Earthquake Engineering, R.C.C Structures and Composite Beams.

LITERATURE STUDY

Hamza et al. [10] worked on design optimization of a class of plane trusses called the N-shaped truss (NST) was addressed. The parametric model of NST presented was intended for real-world application, avoiding simplifications of the design details that compromise the applicability. They considered different topology, configuration and sizing of the truss and presented a challenging optimization problem. Aspects of such challenge include large search space dimensionality, absence of a closed form objective function and constraints, multimodal objective function

Togan et al. [6] studied to optimize the roof trusses under loads specified according to current Turkish code, TS 498. Wolfe [7] tested five full-scale truss-roof assemblies under simulated gravity loads.

Dubey et al. [8] analyzed the steel roof truss. Indian Standard Code IS: 875(Part 3)-1987 includes consideration for different conditions of class of structure, topography factor, enlarged provisions of permeability conditions, Terrain, height & structure size factor and various wind zones. These provisions of wind load calculations are different from the considerations used in SP 38(S&T):1987.

INTRODUCTION

An overview of SP 38(S&T):1987 [4]

The Department of Science and Technology set up an Expert Group on Housing and Construction Technology in 1972. As a result of this, the Planning Commission approved the Project B-8: Typification of Industrial Structures, which was assigned to the Bureau of Indian Standards (BIS) with the object to typify at national level the common forms of industrial structures used in light engineering industries, warehouses, workshops and storage sheds, and to obtain economical designs under these conditions. The purpose was to provide standard prefabricated designs so that the structures could be easily mass produced and made available to the user almost off the shelf. The Handbook is related to typification of structures with steel roof trusses (with and without cranes) having A-type as well as lean-to roof trusses supported on columns. In structures with cranes, crane columns are build-up cantilever columns to resist wind and transverse crane loads. The roof trusses which are the same for buildings with and without cranes have been designed both as angle trusses and tubular trusses.

An overview of IS 875:1987 [3]

It included the provisions for the basic design loads (dead loads, live loads, wind loads and seismic loads) to be assumed in the design of the buildings. In its first revision in 1964, the wind pressure provisions were modified on the basis of studies of wind phenomenon and its effect on structures, undertaken by the special committee in consultation with the Indian Meteorological Department. In addition to this, new clauses on wind loads for butterfly type structures were included; wind pressure coefficients for sheeted roofs, both curved and

sloping were modified; seismic load provisions were deleted (separate code having been prepared) and metric system of weights and measurements was adopted.

ANALYSIS

Design considerations as per IS 875:1987 PART I, II, III have been employed in calculating loads. A-type geometry is explored in the work.

Design Wind Speed (V_z)

Design Wind Speed depends upon (a) Risk level (b) Terrain roughness, height and size of structure; and (c) Local topography. It can be mathematically expressed as follows:

$$V_z = V_b.K_1.K_2.K_3 \quad (1)$$

Design Wind Pressure (P_z)

The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity:

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

Where, V_z = design wind speed at any height z in m/s, V_b = basic wind speed in m/s, K_1= probability factor (risk coefficient), K_2= terrain, height and structure size factor, K_3= topography factor, P_z = design wind pressure in N/m^2 at height z, V_z = design wind velocity in m/s at height z.

Wind Pressures and Forces on Buildings/Structures

For clad structures, it is necessary to know the internal pressure as well as the external pressure. Then the wind load, F, acting in a direction normal to the individual structural element or cladding unit is:

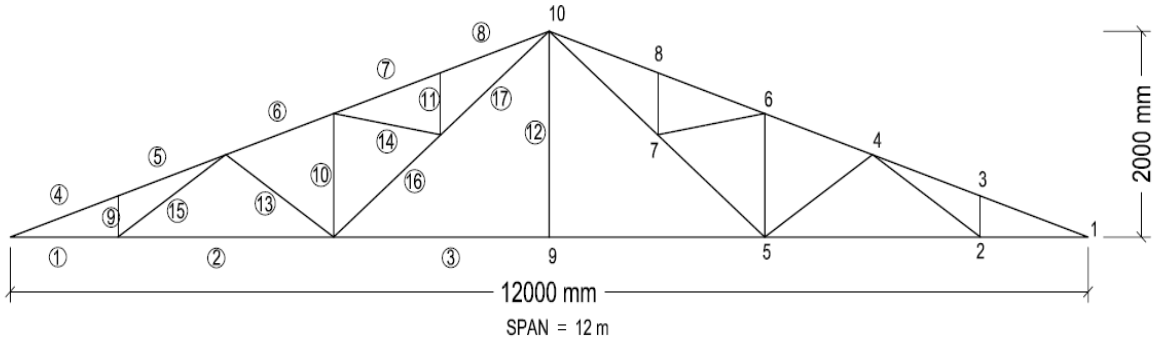
$$F = (C_{pe} - C_{pi}).A.P_z \quad (3)$$

Where, C_{pe} = external pressure coefficient, C_{pi} = internal pressure coefficient, A = surface area of structural element or cladding unit, and P_z = design wind pressure.

Design Parameters

Plan area = 12.0m × 42.0 m, Roof truss span = 12.0 m, Height of column = 9.0 m Type of roofing = A.C. Sheeting, Location of shed = Delhi, Type of truss = A-type, Spacing of trusses = 6.0 m, Truss Configuration =compound (c), Roof slope = 1 in 3, Basic wind pressure = 1.5kN/ m^2, Weight of roofing materials = 0.17kN/sq-m (including extra weight

due to overlaps and fasteners), Miscellaneous loads =0.035kN/ m^2, Live load = (75 – 2× ($18.435^0 – 10^0$)) = 0.58kN/m^2.



NUMBER WITHIN THE CIRCLE INDICATE THE MEMBER AND NUMBER WITHOUT THE CIRCLE INDICATE THE JOINT

Fig. 1

Table 1: Design forces on one panel point for zero permeability condition

M. No.	Tension +					Compression -			increment + decrement -		
	Coefficient for		Force in Member for DL+LL (kN)	DL +WL (as per sp:38) (kN)	(DL +WL) As per IS:875(part3) for Terrain Category-1(kN)				Percentage variation (in design forces) As compared to SP38		
					Class of structure				Class of structure		
	H	W			A	B	C		A	B	C
		W	5.7	W -2.68	W	-4.14	-3.9	-3.44			
		H	0	H 1.62	H	2.1	2.02	1.87			
1	0.50	13.50	76.95	-35.37	-54.84		-51.64	-45.51	55.05	46.00	28.67
2	1.00	12.00	68.40	-30.54	-47.58		-44.78	-39.41	55.80	46.63	29.04
3	2.50	7.50	42.75	-16.05	-25.8		-24.2	-21.13	60.75	50.78	31.65
4	0.00	-14.23	-81.12	38.14	58.92		55.5	48.96	54.48	45.52	28.37
5	1.05	-14.23	-81.12	39.85	61.13		57.63	50.93	53.40	44.62	27.80
6	1.05	-11.07	-63.11	31.38	48.05		45.31	40.06	53.12	44.39	27.66
7	2.47	-12.13	-69.12	36.49	55.38		52.27	46.33	51.77	43.24	26.97
8	3.52	-12.13	-69.12	38.20	57.59		54.4	48.3	50.76	42.41	26.44
9	0.33	-1.00	-5.70	3.22	4.84		4.58	4.07	50.31	42.24	26.40
10	0.50	-1.50	-8.55	4.84	7.27		6.87	6.11	50.21	41.94	26.24
11	0.33	-1.00	-5.70	3.22	4.84		4.58	4.07	50.31	42.24	26.40
12	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
13	0.60	-1.80	-10.28	5.81	8.73		8.25	7.33	50.26	42.00	26.16
14	-0.34	1.01	5.78	-3.28	-4.92		-4.65	-4.13	50.00	41.77	25.91
15	-0.60	1.80	10.28	-5.81	-8.73		-8.25	-7.33	50.26	42.00	26.16
16	-1.31	3.90	22.25	-12.58	-18.9		-17.86	-15.87	50.24	41.97	26.15
17	-1.74	5.21	29.68	-16.77	-25.2		-23.81	-21.16	50.27	41.98	26.18
Average percentage variation									49.23	41.16	25.66

Table 2 Design forces on one panel point for medium permeability condition

M. NO.	Tension (+)					compression (-)			Increment (+) decrement (-)		
	Coefficient for		Force in member for DL+LL (kN)	DL + WL (as per sp:38) (kN)	(DL +WL) As per IS:875(part3) for Terrain Category-4(kN)			Percentage variation (in design forces) As compared to SP38		
	H	W			Class of structure			Class of structure		
					A	B	C	A	B	C
			WH 5.70	WH -6.73	WH -3.78	-3.2	-2.01			
					WH 1.98	1.79	1.39			
1	0.50	13.50	76.95	-89.37	-50.04	-42.31	-26.44	-44.01	-52.66	-70.42
2	1.00	12.00	68.40	-77.79	-43.38	-36.61	-22.73	-44.23	-52.94	-70.78
3	2.50	7.50	42.75	-43.05	-23.4	-19.53	-11.6	-45.64	-54.63	-73.05
4	0.00	-14.23	-81.12	95.77	53.79	45.54	28.61	-43.83	-52.45	-70.13
5	1.05	-14.23	-81.12	98.90	55.88	47.43	30.07	-43.50	-52.04	-69.60
6	1.05	-11.07	-63.11	77.64	43.94	37.32	23.72	-43.41	-51.93	-69.45
7	2.47	-12.13	-69.12	88.93	50.72	43.22	27.8	-42.97	-51.40	-68.74
8	3.52	-12.13	-69.12	92.06	52.81	45.11	29.27	-42.64	-51.00	-68.21
9	0.33	-1.00	-5.70	7.72	4.44	3.8	2.48	-42.49	-50.78	-67.88
10	0.50	-1.50	-8.55	11.59	6.67	5.71	3.72	-42.45	-50.73	-67.90
11	0.33	-1.00	-5.70	7.72	4.44	3.8	2.48	-42.49	-50.78	-67.88
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.60	-1.80	-10.28	13.92	8.01	6.85	4.46	-42.46	-50.79	-67.96
14	-0.34	1.01	5.78	-7.84	-4.52	-3.86	-2.52	-42.35	-50.77	-67.86
15	-0.60	1.80	10.28	-13.92	-8.01	-6.85	-4.46	-42.46	-50.79	-67.96
16	-1.31	3.90	22.25	-30.15	-17.34	-14.83	-9.66	-42.49	-50.81	-67.96
17	-1.74	5.21	29.68	-40.19	-23.12	-19.77	-12.88	-42.47	-50.81	-67.95
				Average percentage variation				-40.58	-48.55	-64.92

Observations

Percentage variation in design forces for Zero Permeability, Terrain Category (1) can be observed from 25 to 50 percentages higher in case of calculations as per provisions of IS 875: 1987.percentage variation in design forces for Medium Permeability, Terrain Category (4) can be observed from 40 to 65 percentages lesser in case of calculations as per provisions of IS 875:1987.

CONCLUDING REMARKS

The analysis and results of typified structures with steel roof trusses have been presented for trusses having A-type truss span considering zero and medium permeability conditions, three different types of classes of structures (A, B&C), two different types of terrain categories (1&4).

There are highest values of wind forces in case of Terrain Category-1 for Class A type of structure. The forces are the lowest in case of Terrain Category-4, Class C type of structure with zero permeability condition. From the results of analysis, it can be observed that there are large variations in design forces obtained as per IS 875:1987 in comparison to calculations given in SP 38:1987. In some of the cases, the designs given in SP38 seem as uneconomic designs, on the other hand, in some of the cases, the designs given in SP38 are likely to be unsafe.

Hence, from the above observations, it can be concluded that designs of steel roof trusses for different wind zones given in SP 38:1987 are needed to be reviewed and analysis results obtained as per IS 875:1987 are required to be incorporated. Although, to fulfil the same objective, there is requirement of study and analysis work in comprehensive manner updating concerned data.

In addition to above, it is observed that the issue of separate documentations of typified designs for steel roof trusses matching the standard criteria for individual zones or permeability conditions can give more precise and effective designs

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