Research Paper

ANALYSIS OF STEEL ROOF TRUSS UNDER NORMAL PERMEABILITY CONDITION

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ABSTRACT

The main purpose of this study is to analyze the steel roof truss under the normal permeability condition of wind according to Indian Standard Code IS: 875(Part 3)-1987, in which, intensity of wind load is calculated considering different conditions of class of structure ,Terrain, height and structure size factor, topography factor, permeability conditions and compare the results so obtained with the calculations made in SP-38(S&T):1987; Handbook for typified designs for structures with steel roof trusses, in which there is no consideration for different conditions as mentioned above. Because of this, there are large variations in calculated results for wind loads and design forces in members of truss. Analysis of trusses called A-shaped truss is addressed

KEYWORDS: A shaped truss, roof terrain, topography permeability condition

INTRODUCTION

A roof truss is basically a framed structure formed by connecting various members at their ends to form a system of triangles, arranged in pre-decided pattern depending upon the span, type of loading and functional requirements .In industrial buildings, steel trusses are commonly used.

A-shaped truss*:* This is a type of truss that has a certain general shape resembling the letter "A".

The steel truss has been designed as simply supported on columns. The analysis of A-type truss has been done on the basis of relevant Indian Standards for the following different parameters:

- Span length of A-type trusses (metres) = 12
- Spacing between trusses (metres) = 6.0
- Roof slope=1 in 3,
- Column height = 9(metres)
- Wind zones = I, II and III
- Permeability = Normal
- Class of structure = A,B,C
- Terrain category = 1,2,3,& 4

Truss Configuration – A configuration which is compound of (a) Fink or fink fan, (b) N-truss has been used and A-type truss has been analyzed.

4. ANALYSIS

The steel trusses have been analyzed as simply supported on columns. The support at one end is assumed to be hinged and the other end on rollers for the purpose of analysis. The truss has been analyzed for dead load, live load and wind load according to IS: 875(Part 3)-1987.

5. METHOD

Wind load calculation according to IS: 875(Part 3)-1987

Design Wind Speed (Vz) - 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:

$V_Z = V_b.K_1.K_2.K_3$

Where,

Vz = design wind speed at any height z in m/s, Vb=basic wind speed in m/s

K_1= probability factor (risk coefficient) given in Table 1 of IS: 875(Part 3)-1987,

K_2= terrain, height and structure size factor and

K_3= topography factor.

Basic Wind Speed (V_b) - Basic wind speeds have been worked out for a 50 year return period.

TERRAIN, HEIGHT AND STRUCTURE SIZE FACTOR (K_2)

The buildings/structures are classified into the following three different classes depending upon their size:

Class A- Structures and/or their components such as cladding, glazing, roofing, etc, having maximum dimension (greatest horizontal or vertical dimension) less than 20 m.

Class B - Structures and/or their components such as cladding, glazing, roofing, etc, having maximum dimension (greatest horizontal or vertical dimension) between 20 and 50 m.

Class C - Structures and/or their components such as cladding, glazing, roofing, etc, having maximum dimension (greatest horizontal or vertical dimension) greater than 50 m.

Terrain: *Category* 1 - Exposed open terrain with few or no obstructions and in which the average height of any object surrounding the structure is less than 1.5 m.

Category 2 - Open terrain with well scattered obstructions having heights generally between I.5 to 10 m.

Category 3- Terrain with numerous closely spaced obstructions having the size of building-structures up to 10 m in height with or without a few isolated tall structures.

Category 4 - Terrain with numerous large high closely spaced obstructions.

TOPOGRAPHY FACTOR (K_3) - The effect of topography will be significant at a site when the upwind slope (θ) is greater than about 3^0, and below that, the value of K_3 may be taken to be equal to 1.0. The value of K_3 *is* confined in the range of 1.0 to 1.36 for slopes greater than 3^0. It may be noted that the value of K_3 varies with height above ground level, at a maximum near the ground, and reducing to 1.0 at higher levels.

Design Wind Pressure (Pz) - The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity:

$$Pz = 0.6\ V_z^2$$

Where,
P_z = design wind pressure in N/m^2 at height z, and
V_z = design wind velocity in m/s at height z.

WIND PRESSURES AND FORCES ON BUILDINGS/STRUCTURES

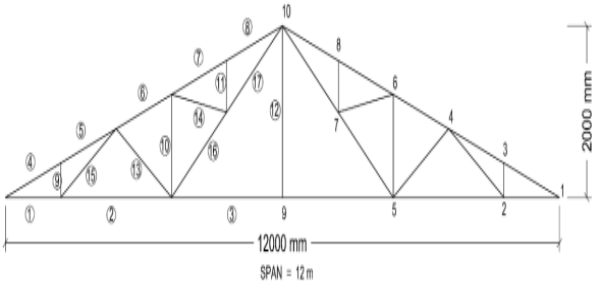
Wind Load on Individual Members – For clad structures, it is necessary to know the internal pressure as well as the external pressure. Then the wind load, F, acting in a direction normal to the individual structural element or cladding unit is:

$$F= (C_{pe} – C_{pi}).A.P_z$$

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

5. DESIGN EXAMPLE

Plan area = 12.0 m X 42.0 m
Roof truss span = 12.0 m
Roof slope=1 in 3
Height of column = 9.0 m
Type of roofing = A.C. Sheeting
Location of shed = Delhi
Type of truss = A-type
Permeability= Normal



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

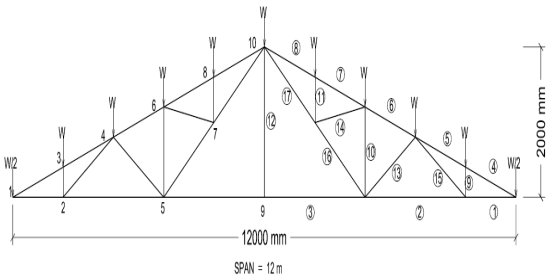
Fig. 1

TRUSS ANALYSIS

Analysis of truss according to wind load calculations given in SP: 38-1987:

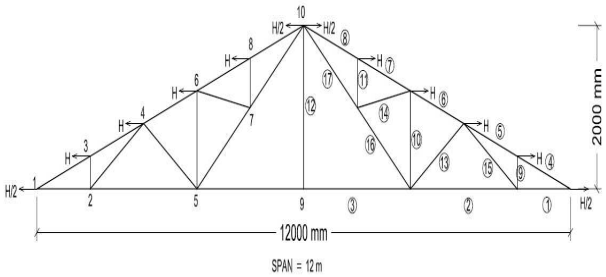
Basic parameters for the analysis are-

Spacing of trusses = 6.0 m
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)
The roof slope of 1 in 3 and spacing of 6.0 m give the minimum weight of truss as observed from Tables 148 to 150 of SP:38-1987
Governing wind pressure = (0.6 + 0.2) x 1.5
For design with normal permeability = 1.2kN/ m^2
Miscellaneous loads =0.035kN/ m^2
Live load = 75-2x (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. 2



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

Fig. 3

Load calculations

- Dead loads:
- (Calculated) Total Dead load =28.88kN
- No. of Panels= 10
- Load acting on one intermediate panel = 28.88/10 =2.89kN
- So, Dead load is taken as = 2.9kN/node.
- Live loads:
- (Calculated) Total live load = 27.9kN
- Load acting on one intermediate panel point = 2.79kN
- Wind loads:
- Total wind load = 1.2 x 6 x 6.32 x 2 = 91.01kN
- Load acting on one intermediate panel point = 9.10kN

Wind Load Calculations according to IS:875(Part 3)-1987

- Wind Load = $(C_{pe}-C_{pi}).A.P_z$
- Risk coefficients (K_1) = Topography factor (K_3) = 1.0
- Basic wind speed (m/s) V_b =47 (For Delhi), A =6*6.32*2
- Total wind load = $(C_{pe}-C_{pi}).A.P_z$
- Wind Load on one panel point = $\{(C_{pe}-C_{pi}).A.P_z\}/10$; no. of panels = 10

CONCLUSION

It is observed from Table (1) & (2) that in case of Terrain Category (1) and (2), calculated wind forces are greater than values as per SP38:1987. On other hand for Terrain Category (3) & (4) calculated wind forces are lesser than values as per SP38:1987.

In view of above results, it can be concluded that analysis made in SP38:1987 cannot be followed without considering various conditions of class of structures, risk coefficient, terrain conditions, topography factor, and permeability conditions.

Table: 1 Design forces on one panel point

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 Normal Permeability & Terrain Category-1 (kN)				Percentage variation(in design forces) As compared to SP38		
	H	W			Class of structure				Class of structure		
			W= (-)5.70 H=0.0	W= (-)4.30 H=2.16		A	B	C			
					W	-5.72	-5.41	-4.84	A	B	C
					H	2.63	2.53	2.33			
1	0.50	13.50	76.95	-56.97		-75.91	-71.77	-64.18	33.25	25.98	12.66
2	1.00	12.00	68.40	-49.44		-66.01	-62.39	-55.75	33.52	26.19	12.76
3	2.50	7.50	42.75	-26.85		-36.33	-34.25	-30.48	35.31	27.56	13.52
4	0.00	-14.23	-81.11	61.19		81.4	76.99	68.88	33.03	25.82	12.57
5	1.05	-14.23	-81.11	63.47		84.17	79.66	71.33	32.62	25.52	12.39
6	1.05	-11.07	-63.10	49.88		66.1	62.57	56.04	32.51	25.44	12.35
7	2.47	-12.13	-69.11	57.46		75.85	71.84	64.44	32.00	25.02	12.14
8	3.52	-12.13	-69.11	59.74		78.62	74.51	66.89	31.60	24.72	11.97
9	0.33	-1.00	-5.70	5.02		6.6	6.26	5.62	31.49	24.72	11.97
10	0.50	-1.50	-8.55	7.54		9.91	9.39	8.44	31.49	24.59	11.99
11	0.33	-1.00	-5.70	5.02		6.6	6.26	5.62	31.49	24.72	11.97
12	0.00	0.00	0.00	0.00		0	0	0	0.00	0.00	0.00
13	0.60	-1.80	-10.28	9.05		11.9	11.28	10.13	31.51	24.66	11.95
14	-0.34	1.01	5.77	-5.10		-6.7	-6.36	-5.71	31.40	24.73	11.98
15	-0.60	1.80	10.28	-9.05		-11.9	-11.28	-10.13	31.51	24.66	11.95
16	-1.31	3.90	22.25	-19.60		-25.76	-24.42	-21.94	31.42	24.58	11.93
17	-1.74	5.21	29.67	-26.13		-34.35	-32.56	-29.24	31.44	24.59	11.89
Average percentage variation									30.33	23.74	11.53

Table: 2 Design forces on one panel point

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 Normal Permeability & Terrain Category-2 (kN)				Percentage variation(in design forces) As compared to SP38		
	H	W			Class of structure				Class of structure		
			W= (-)5.70 H=0.0	W= (-)4.30 H=2.16		A	B	C			
					W	-4.98	-4.69	-4.02	A	B	C
					H	2.38	2.29	2.06			
1	0.50	13.50	76.95	-56.97		-66.04	-62.17	-53.24	15.92	9.13	-6.55
2	1.00	12.00	68.40	-49.44		-57.38	-53.99	-46.18	16.06	9.20	-6.59
3	2.50	7.50	42.75	-26.85		-31.4	-29.45	-25	16.95	9.68	-6.89
4	0.00	-14.23	-81.11	61.19		70.87	66.74	57.21	15.82	9.07	-6.50
5	1.05	-14.23	-81.11	63.47		73.38	69.16	59.38	15.62	8.97	-6.44
6	1.05	-11.07	-63.10	49.88		57.65	54.34	46.68	15.57	8.94	-6.42
7	2.47	-12.13	-69.11	57.46		66.26	62.52	53.83	15.31	8.80	-6.32
8	3.52	-12.13	-69.11	59.74		68.77	64.93	56	15.11	8.69	-6.26
9	0.33	-1.00	-5.70	5.02		5.78	5.46	4.71	15.16	8.78	-6.16
10	0.50	-1.50	-8.55	7.54		8.67	8.19	7.07	15.04	8.67	-6.19
11	0.33	-1.00	-5.70	5.02		5.78	5.46	4.71	15.16	8.78	-6.16
12	0.00	0.00	0.00	0.00		0	0	0	0.00	0.00	0.00
13	0.60	-1.80	-10.28	9.05		10.41	9.84	8.49	15.04	8.74	-6.18
14	-0.34	1.01	5.77	-5.10		-5.87	-5.54	-4.79	15.12	8.65	-6.06
15	-0.60	1.80	10.28	-9.05		-10.41	-9.84	-8.49	15.04	8.74	-6.18
16	-1.31	3.90	22.25	-19.60		-22.55	-21.3	-18.38	15.04	8.66	-6.23
17	-1.74	5.21	29.67	-26.13		-30.06	-28.39	-24.51	15.03	8.63	-6.21
Average percentage variation									14.53	8.36	-5.96

Table: 3 Design forces on one panel point

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 Normal Permeability & Terrain Category-3 (kN)				Percentage variation(in design forces) As compared to SP38		
					Class of structure				Class of structure		
	H	W	W= (-)5.70 H=0.0	W= (-)4.30 H=2.16		A	B	C	A	B	C
					W	-3.75	-3.36	-2.64			
					H	1.97	1.85	1.6			
1	0.50	13.50	76.95	-56.97		-49.64	-44.44	-34.84	-12.87	-21.99	-38.85
2	1.00	12.00	68.40	-49.44		-43.03	-38.47	-30.08	-12.97	-22.19	-39.16
3	2.50	7.50	42.75	-26.85		-23.2	-20.58	-15.8	-13.59	-23.35	-41.15
4	0.00	-14.23	-81.11	61.19		53.37	47.82	37.57	-12.78	-21.85	-38.60
5	1.05	-14.23	-81.11	63.47		55.44	49.77	39.26	-12.65	-21.58	-38.14
6	1.05	-11.07	-63.10	49.88		43.6	39.15	30.92	-12.59	-21.51	-38.01
7	2.47	-12.13	-69.11	57.46		50.33	45.31	35.96	-12.41	-21.15	-37.42
8	3.52	-12.13	-69.11	59.74		52.41	47.26	37.65	-12.27	-20.89	-36.98
9	0.33	-1.00	-5.70	5.02		4.41	3.98	3.18	-12.14	-20.71	-36.64
10	0.50	-1.50	-8.55	7.54		6.62	5.98	4.77	-12.16	-20.65	-36.71
11	0.33	-1.00	-5.70	5.02		4.41	3.98	3.18	-12.14	-20.71	-36.64
12	0.00	0.00	0.00	0.00		0	0	0	0.00	0.00	0.00
13	0.60	-1.80	-10.28	9.05		7.95	7.17	5.72	-12.14	-20.76	-36.79
14	-0.34	1.01	5.77	-5.10		-4.48	-4.05	-3.23	-12.14	-20.57	-36.65
15	-0.60	1.80	10.28	-9.05		-7.95	-7.17	-5.72	-12.14	-20.76	-36.79
16	-1.31	3.90	22.25	-19.60		-17.21	-15.53	-12.4	-12.20	-20.77	-36.74
17	-1.74	5.21	29.67	-26.13		-22.95	-20.71	-16.52	-12.18	-20.75	-36.79
Average percentage variation									-11.73	-20.01	-35.42

Table: 4 Design forces on one panel point

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 Normal Permeability & Terrain Category-4 (kN)				Percentage variation(in design forces) As compared to SP38		
					Class of structure				Class of structure		
	H	W	W= (-)5.70 H=0.0	W= (-)4.30 H=2.16		A	B	C	A	B	C
					W	-2.41	-1.96	-1.04			
					H	1.52	1.38	1.07			
1	0.5	13.50	76.95	-56.97		-31.78	-25.7	-13.5	-44.22	-54.77	-76.29
2	1.00	12.00	68.40	-49.44		-27.4	-22.1	-11.4	-44.58	-55.22	-76.92
3	2.50	7.50	42.75	-26.85		-14.28	-11.2	-5.13	-46.82	-58.10	-80.89
4	0.00	-14.23	-81.11	61.19		34.3	27.9	14.8	-43.94	-54.40	-75.81
5	1.05	-14.23	-81.11	63.47		35.9	29.35	15.93	-43.43	-53.75	-74.90
6	1.05	-11.07	-63.10	49.88		28.29	23.16	12.65	-43.29	-53.57	-74.64
7	2.47	-12.13	-69.11	57.46		32.97	27.17	15.25	-42.63	-52.72	-73.46
8	3.52	-12.13	-69.11	59.74		34.58	28.63	16.38	-42.12	-52.08	-72.58
9	0.33	-1.00	-5.70	5.02		2.92	2.42	1.4	-41.82	-51.79	-72.11
10	0.50	-1.50	-8.55	7.54		4.38	3.64	2.1	-41.88	-51.70	-72.14
11	0.33	-1.00	-5.70	5.02		2.92	2.42	1.4	-41.82	-51.79	-72.11
12	0.00	0.00	0.00	0.00		0	0	0	0.00	0.00	0.00
13	0.60	-1.80	-10.28	9.05		5.26	4.37	2.52	-41.87	-51.71	-72.15
14	-0.34	1.01	5.77	-5.10		-2.97	-2.47	-1.43	-41.75	-51.56	-71.95
15	-0.60	1.80	10.28	-9.05		-5.26	-4.37	-2.52	-41.87	-51.71	-72.15
16	-1.31	3.90	22.25	-19.60		-11.39	-9.46	-5.46	-41.89	-51.74	-72.15
17	-1.74	5.21	29.67	-26.13		-15.19	-12.6	-7.28	-41.88	-51.79	-72.14
Average percentage variation									-40.34	-49.90	-69.55

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