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Comparision of Member Forces in A-Type Truss Using IS875 and SP38

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***Abstract- In design of truss effect of wind forces is predominant to calculate the member forces. To achieve the economical mass production of trusses Indian government assigned some restrictions or parameters to production of industrial truss under the project of B-8. The paper presents comparative study between design of truss as per revised provisions of wind load calculations given in IS875:1987 with the design obtained as per calculations made in SP-38(S&T):1987; Handbook for typified designs for structures with steel roof trusses. The analysis is carried out on a 12m span A-type truss and the forces are calculated with the help of ANSYS 11.0. IS875:1987(part 3) considers terrain, class of structure, topography factor, different permeability condition depending on slope of structure which are not considered in SP-38(S&T):1987; Handbook for typified designs for structures with steel roof trusses. The calculations show that there is a considerable variation of member forces as the span of truss increases. The percentage variation of member forces in 24m span truss is nearly double that in 12m span truss*.**

Keywords ANSYS 11.0, SP 38 (S & T):1987, IS875:1987, Steel roof truss.

1. Introduction

Trusses are triangular frame works, consisting of essentially axially loaded member which are more efficient in resisting external loads since the cross section is nearly uniformly stressed. Trusses are extensively used, especially to span large gaps. These are used in roofs of single storey industrial buildings, long span floors and roofs of multistory buildings, to resist gravity loads. Trusses finds a substantial use in modern construction, for instance as towers, bridges, scaffolding, industrial buildings. Trusses are used to span long lengths in the place of solid web girders and they are light weight as compared any other system. Generally truss members are assumed to be joined together so as to transfer only the axial forces and not moments and shears from one member to the adjacent members. The joints of trusses are assumed to be pinned. Trusses are made up of different materials and different shapes. The loads on the truss are dead load, live load, wind load and earthquake load. The axial forces in members are calculated by taking different types of loading and their critical combination. In India the load should be taken as per IS 875:1987. The complexity of truss starts from the selection of truss [1,2]. There are various types of truss configuration; choice of truss depends upon many factors like purpose of that structure, atmospheric conditions, loading etc. The truss configurations distinguish between three categories namely Pitched roof trusses, Parallel chord trusses and Trapezoidal trusses. Design of truss depends upon factors like truss type, location, open category, wind exposure category, building category, required span, desired slope roof, building plans, fabrication and erection methods, transportation, fasteners etc. The primary goal of any structure is that it should be safe and durable for a required period. In truss the basic geometry is triangles which are naturally rigid geometric shapes that resist distortion.

Steel trusses supported on columns are one of the structural systems commonly used in industrial buildings. In a developing country like India, the capital expenditure under each five year plan towards setting up of industries and consequently construction of industrial buildings is very high. Therefore it is necessary that the various parameters of industrial buildings should be standardized on broad norms so that it will be feasible to easily adopt prefabricated members, particularly where repetitive structures could be used. It was understood by the department of science and technology who set up an expert group on housing and construction technology [3]. The planning commission approved typification of industrial structures under a project B-8. The object of project B-8 is 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 main objective of typication of industrial structures is to reduce the variety to the minimum and provide standard prefabricated designs so that structures could be easily mass produced and made available to the user almost off the shelf. The analysis and design are performed for different parameters and for two configurations as A-type and lean-to roof trusses. These are carried out considering economy associated with minimum weight and mass production of repetitive fabrication.

Zhong [4] have done the optimization of a steel truss calculating design forces for members of truss considering various permeability conditions. Togan and Durmaz carried out the optimization of roof truss by considering snow load [5].

2. Methodology

The analysis is carried out on a steel truss simply supported on columns. The truss is analyzed by taking dead load, live load and wind load as per IS 875:1987 [6] in a software ANSYS11.0 with 2D spar element. The parameters of a truss are kept as in SP-38(S&T):1987. The forces in members are calculated and compared with given forces in SP-38(S&T):1987. Design wind speed depends upon risk level,

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topography factor and terrain roughness and height of building. It is expressed as

$$V_z = V_b \times K_1 \times K_2 \times K_3$$

The coefficients K_1, K_2, and K_3 are Risk coefficient, terrain coefficient and topography factor respectively.

The design wind pressure at any height above mean ground level shall be obtained by following relation.

$$Pz = 0.6\ Vz^{2}$$

Wind load on each individual members calculated by considering internal as well as external pressure.

$$F = (C_{pe} - C_{pi}) \times A \times Pz$$

2.1 Design Example 1

The methodology is carried out on a 12 m span truss having tubular sections of a member. There are variations in member forces found by considering normal permeability condition of wind.

Plan area = 12 m× 42 m
Roof truss span = 12m
Roof slope 1 in 3
Height of column = 9 m
Type of roofing is A. C. sheeting
Type of truss = A-type
Permeability = Normal

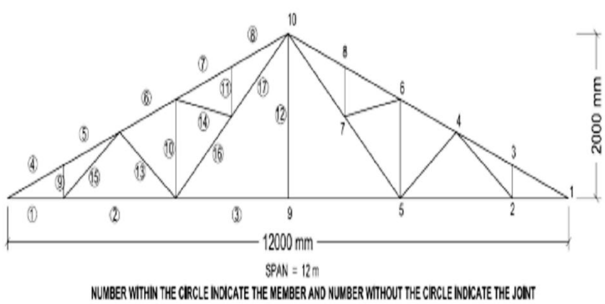

Figure 1 A-type truss having 12 m span

Load calculations as per SP-38(S&T):
Dead loads:
Total dead load = 28.88KN
Number of panels = 10
Load acting on one intermediate panel = 28.88/10 = 2.89 kN
So, dead load is taken as 2.9kN/Node.
Governing wind pressure = (0.6 + 0.2) x 1.5
For design with normal permeability = 1.2kN/m^2
Total wind load = 1.2×6×6.32×2 = 91.01 kN
Load acting on one panel point = 9.1kN
2) Load calculations as per IS 875:1987 (part 3):
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
Wind load = 9.65 kN

The analysis is carried out by modeling a steel truss in ANSYS 11.0. The DL+WL are resolved in two components along x-axis and y-axis as W and H and it is taken as 75% of the value. As per IS 875:1987 33% allowance is made for wind load combination.

W = 0.75(2.9 ï 9.1 COS (18.44)) = 4300N
H= 0.75 (9.1SIN (18.44)) = 2160N

The vertical component of load is placed on each node and its deflected shape is shown in figure 2. The element solution for this type of loading is shown in figure 3. It shows the maximum and minimum force members. The final results are presented in ref [2] and percentage of variation in member forces is tabulated in Table 1. Positive sign indicate tension and negative sign indicate compression in member.

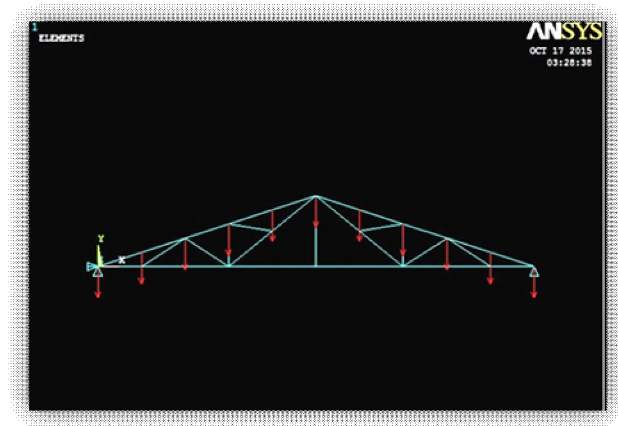

Figure 2 Vertical component of load and its deflected shape

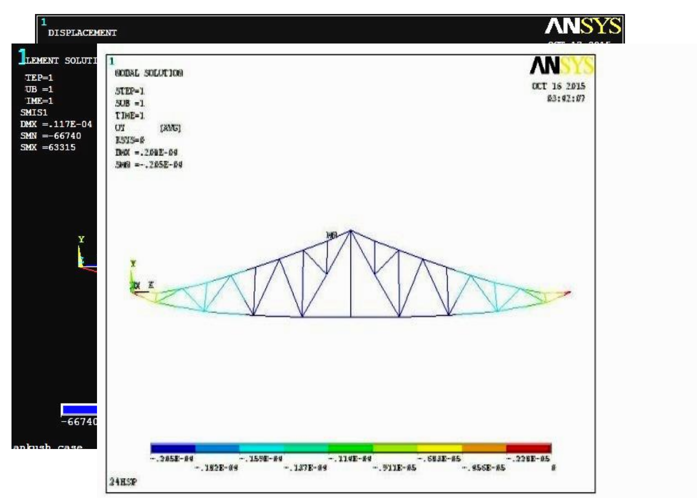

Figure 3 Element solution for a vertical load component

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2.2 Design Example 2

The steel truss is analyzed as simply supported on columns. Span length of A-type trusses (m) = 24
Spacing between trusses (m) = 4.5
Roof slope=1 in 3
Column height = 12(m)
Wind zones = II
Permeability = Normal
Class of structure = B
Terrain category = 2

Truss Configuration ï A configuration which is compound of (a) Fink or fink fan, (b) N-truss. The element solutions for vertical and horizontal component of member forces are shown in figure 4.

The calculated forces are compared to that with member forces obtained from SP38(S&T) and tabulated in Table 2.

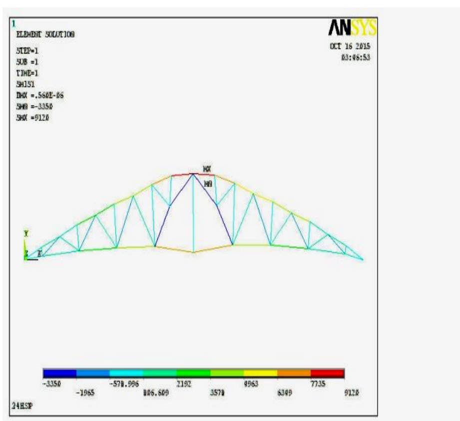

Figure 4 element solution of a 24m span truss

3. Conclusions

The result shows validation of 12m span of steel truss. It clearly shows that there is a large variation of forces due to the different wind load calculations as per IS875:1987(part 3) and SP38(S&T):1987. The maximum percentage variation of member force is 9.68 for 12m span truss. It proved the practical fact that for a different location the wind load is different which is not included in SP38:1987. Therefore wind force which depends of location, terrain and permeability of structure should be given due consideration in truss design. It shows that the various criteria of wind load calculations made in IS875:1987(part 3) should be incorporated in SP38:1987. For a 24m span truss results show a considerable variation in member forces having maximum percentage variation of member force is 19.60. Therefore it can be said that the percentage variation of member forces increases with the span of truss. Hence, for a long span roof trusses design should be based on IS875:1987.

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Table 1 Comparison of forces in Example 1

member	Length (m)	Forces in member[ref 2]		Forces in member [present study]		Percentage variations	
		SP:38	IS:875	SP:38	IS875	Ref(2)	Pr. study
1	1.20	-56.97	-62.17	-56.41	-61.59	9.12	9.18
2	2.40	-49.44	-53.99	-48.89	-53.41	9.20	9.25
3	2.40	-26.85	-29.45	-26.30	-28.87	9.68	9.76
4	1.26	61.19	66.74	61.74	67.34	9.07	9.06
5	1.26	63.47	69.16	64.01	69.75	8.96	8.96
6	1.26	49.88	54.34	50.42	54.92	8.94	8.92
7	1.26	57.46	62.52	57.98	63.08	8.80	8.79
8	1.26	59.74	64.93	60.26	65.50	8.68	8.69
9	0.40	5.02	5.46	5.01	5.45	8.76	8.66
10	1.20	7.54	8.19	7.52	8.18	8.62	8.67
11	0.60	5.02	5.46	5.01	5.45	8.76	8.66
12	2.00	0	0	1.44E-09	-1.6E-10	0	0
13	1.44	9.05	9.84	9.04	9.83	8.72	8.67
14	1.21	-5.10	-5.54	-5.08	-5.52	8.62	8.64
15	1.44	-9.05	-9.84	-9.04	-9.83	8.72	8.67
16	1.56	-19.60	-21.30	-19.59	-21.29	8.67	8.66
17	1.56	-26.13	-28.39	-26.12	-28.39	8.64	8.66

member	Length	SP38(S&T)	IS875	Percentage variation
1	1.33	77.51	64.64	16.60
2	2.66	74.09	61.88	16.48
3	2.66	66.14	55.44	16.17
4	2.66	58.81	49.52	15.80
5	2.66	47.73	40.56	15.02
6	1.40	-81.65	-68.09	16.60
7	1.40	-79.80	-66.35	16.84
8	1.40	-70.11	-58.28	16.87
9	1.40	-68.22	-56.51	17.15
10	1.40	-58.62	-48.51	17.23
11	1.40	-56.78	-46.79	17.59
12	1.40	-47.35	-38.92	17.78
13	1.40	-46.69	-38.15	18.28
14	1.40	-44.96	-36.52	18.77
15	0.44	-2.25	-1.81	19.33
16	1.33	-2.10	-1.69	19.52
17	2.22	-2.29	-1.85	19.31
18	3.11	-3.46	-2.80	19.28
19	1.55	-2.65	-2.14	19.12
20	4	0	0	0
21	1.60	-5.12	-4.15	18.81
22	2.22	-6.15	-4.97	19.16
23	2.98	-8.42	-6.80	19.13
24	1.73	1.53	1.23	19.15
25	1.60	4.10	3.30	19.34
26	2.22	6.14	4.97	19.14
27	2.98	8.03	6.49	19.19
28	2.40	13.20	10.67	19.16
29	2.40	15.25	12.32	19.16