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Comparison of Different Roof trusses Under Wind Load

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***Abstract:*— 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 used in roofs of single storey industrial buildings and multi storey industrial buildings. The loads on the roof truss are dead load, live load, wind load and earthquake load. Trusses are also used to support long span floors of multi storey building to resist gravity load. The axial forces in members are calculated by taking these loadings and their critical combinations.For design of trusses, effect of wind force is predominant to calculate the member forces. SP 38(S&T):1987-provides designing for structures with steel roof trusses and their weight comparison. It gives details of specific roof truss configuration. This Paper represents analysis and design of roof trusses whose configuration are other than that specified in SP 38(S&T):1987. However their span to depth ratio is same as the truss configuration given in SP 38(S&T):1987. The trusses which has been analyzed having span 12m, 18m and 24 m and angle section has been used for design purpose. The analysis has been done for three basic wind pressure 100 kg/m2, 150 kg/m2 and 200 kg/m2, So that we can compare the weight of these trusses with A-type roof truss of having same span which is specified in SP 38(S&T):1987.The purpose of this study is to suggest the most feasible truss section, when longer span roof sheets are used. Now a days roof sheets of longer span are available in market. So we can use the configuration which have less number of purlins or wider panel. The truss configurations are distinguished between three categories namely Pitched roof trusses, Parallel chord trusses and Trapezoidal trusses. The advantages and disadvantages of different truss configuration are discussed in detail.**

***Key word:*-- Truss, SP 38(S&T):1987, Span, Configuration**

I. INTRODUCTION

Wind effect should be considered for both tall, slender structures as well as Low rise structures. From material point of view steel structures which are light are highly susceptible to wind loading compared to the heavy massive reinforced concrete structures [10]. The components like cladding units, walls window panels etc., are also affected by wind. Firstly wind load should be assessed properly. For resisting these wind loads on steel structures various arrangements are done like providing proper openings to flow wind freely (permeability) and providing good system of bracings which will work for the lateral loads coming into picture. And claddings should be properly connected with the purlins which if failed causes adverse effects on the structure. The factors like wind characteristics, wind-structure interaction (aerodynamics), and structural characteristics etc. play important roles in wind load assessment [10].

Trusses find a substantial use in modern construction, for instance as towers, bridges, 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.

There are various type of truss configuration are available. The problem is that which type of truss configuration should be selected for the structure. This depends upon the various factors like type of loading, atmospheric condition and purpose of the structure [6].

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 [6]. 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

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that it will be feasible to easily adopt prefabricated members, particularly where repetitive structures could be used.

II. METHODOLOGY

Wind Load on Individual Members –For clad structures, it is necessary to know the internal pressure as well as the external pressure [5]. 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.

Further wind load is divided in horizontal and vertical component.

Dead Load is found by summing up self-weights of various components and ISMC 125 is assumed as Purlin section [3, 6].

Imposed Load is calculated by using the formula, $IL= \{750-2*(\theta-10)\}$ where θ is roof angle in degrees [4].

The analysis has been done using SAP 2000.

For the design load combination [5] used are 1.5(DL+LL), 1.5(DL+WL), 1.2(DL+LL+WL) and 0.9DL+1.5WL.

Where, DL-Dead load, IL-imposed load, WL-Wind load.

III. ANALYSIS AND DESIGN

Analysis and design of three types of roof truss configuration has been done for 12m, 18m and 24m span which are not specified in SP 38(S&T):1987.The analysis has been done for three basic wind pressure 100 kg/m2, 150 kg/m2 and 200 kg/m2 .These three basic wind pressure are applied on each configuration. Each truss are having slope 1in 3 and spacing of truss 6.0 m. The purpose of analysis is to find out the section which is less in weight and are frequently in use.

Design Example 1:

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

Type of truss=Howe type

Permeability=Normal

Spacing of trusses=6m

Basic wind pressure=100 kg/m_2,

150 kg/m_2,200kg/m_2

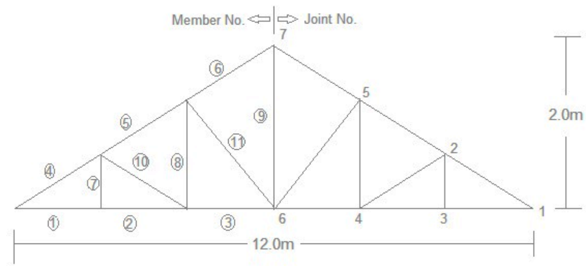

Fig. 1: Howe type roof truss

Fig. 1 shows Howe type roof truss. Truss configuration have span of 12 m and purlin spacing is 2.10 m. Number within the circle indicates member and number without circle indicates joints. Total number of member in this configuration are 22.Each panel loads are applied on the joints.

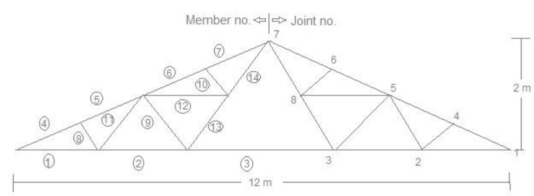

Fig. 2: Compound fink roof truss

Fig. 2 shows compound fink roof truss. Truss configuration have span of 12 m and purlin spacing is 1.58 m. Number within the circle indicates member and number without circle indicates joints. Total number of member in this configuration are 27.Each panel loads are applied on the joints.

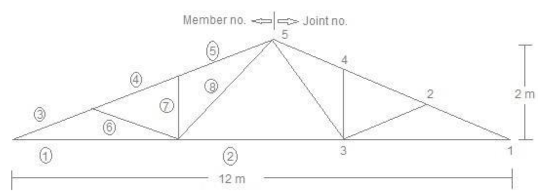

Fig. 3: Fan type roof truss

Fig. 2 shows Fan roof truss. Truss configuration have span of 12 m and purlin spacing is 2.10 m. Number within the circle indicates member and number without circle indicates joints. Total number of member in this configuration are 15.Each panel loads are applied on the joints.

Comparison of the weight of the trusses

The comparison of weight of trusses which are analyzed and designed above are given in table below. Weight are given in kg and the basic wind pressure are in kg/m2.

Table 1: weight comparison of trusses

Basic wind pressure	Weight of truss(kg)		
	Howe truss	Fan truss	Compound fink truss
(kg/m²)			
100	352.85	409.46	307.93
150	388.07	480.77	375.47
200	440.28	548.09	419.38

Observation:

From the above analysis it has been seen that per panel member dead, load live load and wind load is increasing as number of panel is decreasing. When decreasing the number of panel number of member in in the configuration is also decreasing and forces in the member is increasing. If member forces are increasing then design of section is becoming heavier. Because number of member are less than previous configuration but heavier so total weight of configuration is more. Weight of compound fink truss is less for all three basic wind pressure and fan truss have highest weight for all basic wind pressure.

Design Example 2:

Three type of roof trusses of 18 m span has been analyzed. These configuration are Howe roof truss, Compound fink roof truss and Fink Fan roof truss. Howe roof truss having 44 members, 12 panel and purlin spacing is 1.58 m. Compound fink roof truss having 30 members, 8 panel and purlin spacing is 2.37 m and Fink Fan roof truss having 40 members, 14 panel and purlin spacing is 1.35 m. Basic wind pressure 100 kg/m2, 150 kg/m2 and 200 kg/m2 is applied at each configuration.

Plan area = 18.0 m X 42.0 m
Roof truss span = 18.0 m
Roof slope=1 in 3
Height of column = 9.0 m
Type of roofing = A.C. Sheeting
Permeability=Normal
Spacing of trusses=6.0 m
Comparison of the weight of the trusses
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below. Weight are given in kg and the basic wind pressure are in kg/m2.

Table 2: weight comparison of trusses

Basic wind pressure	Weight of truss(kg)		
	Howe truss	Fan truss	Compound fink truss
(kg/m²)			
100	1179.24	862.76	798.03
150	1237.92	1189.86	930.56
200	1389.12	1385.31	1185.66

Observation:

Weight of compound fink truss is less for all three basic wind pressure and fan truss have highest weight for all basic wind pressure. Like design example 1 for 18 m span per panel member dead, load live load and wind load is increasing as number of panel is decreasing. When decreasing the number of panel number of member in in the configuration is also decreasing and forces in the member is increasing. If member forces are increasing then design of section is becoming heavier. Because number of member are less than previous configuration but heavier so total weight of configuration is more.

Design consideration 3:

Three type of roof trusses of 24 m span has been analyzed. These configuration are Howe triangular roof truss compound fan roof truss and Pratt triangular roof truss. Howe roof truss having 46 members, 12 panel and purlin spacing is 2.10 m. Compound fan roof truss having 52 members, 18 panel and purlin spacing is 1.33 m and and Pratt triangular roof truss having 36 members, 10 panel and purlin spacing is 2.52 m. Basic wind pressure 100 kg/m2, 150 kg/m2 and 200 kg/m2 is applied at each configuration.

Plan area = 24.0 m X 42.0 m
Roof truss span = 24.0 m
Roof slope=1 in 3
Height of column = 9.0 m
Type of roofing = A.C. Sheeting
Permeability= Normal
Spacing of trusses = 6.0 m
Comparison of the weight of the trusses
The comparison of weight of trusses which are analyzed and designed above are given in table
below. Weight are given in kg and the basic wind pressure are in kg/m2.

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Table 3: weight comparison of trusses

Basic wind pressure	Weight of trusses(kg)		
	Howe truss	Compound fan truss	Pratt truss triangular
(kg/m²)			
100	1467.06	1447.77	1460.78
150	1844.21	2001.82	1922.77
200	2039.33	2115.71	2098.31

IV. CONCLUSION

From the above analysis it has been seen that per panel dead load live load and wind load is increasing as number of member is decreasing. If member forces are increasing then design of section will be heavier. For 24 m span truss weight of Howe triangular truss is less for all three basic wind pressure and fan truss have highest weight for all basic wind pressure. Now these days different type of roof sheets of longer span are available in market so that we can increase the panel length of the truss. When we are using the configuration which have wider panel, number of purlin required is less. So weight of purlin is reducing. But for all three span 12 m, 18 m and 24 m weight of truss is increasing when we are using configuration of wider panel. Number of purlin is less so per panel load is increasing and also other member forces are increasing. Member forces are more so that section is becoming heavier.

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