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Analysis and Design of Conventional Industrial Roof Truss and Compare it with Tubular Industrial Roof Truss

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Abstract

Many of the steel building are made up with orthodox sections of steels which are designed and built by conventional approaches. This directs to weighty or too expensive structures. Tubular steel is the best possible alternatives to the conventional with their comparatively better specifications. Dead weight is tending to be decreased for many structural members so it is clear that because of the tube section, it helps in reducing overall economy. This is regarding the economy, load carrying capacity of all members and their relative safety measures. Economy is the main goal of the present work including comparison of conventional structures with tubular structure for given conditions. Results show that up to 15 to 25% saving in expense is accomplished by using tubular sections. Analysis of shed's elements was carried out by Staad Pro V8i computer software, with manually applying Indian Standards. Several excel sheets for various structural elements like Purlin, Roof Truss, compression member, Tension member etc. were carried out using Microsoft office excel. Lastly estimation sheet is prepared for each Conventional Roof Truss section as well as Tubular roof truss section.
Keywords: Conventional Steel truss, Tubular section, Staad Pro V8i, AutoCAD, IS 800 and IS 806

I. Introduction

Industrial sheds are low rise steel buildings generally used as workshops, factories or industries in absenteeism of interior walls. Any building used by the industry to stock raw materials is known as an industrial building. Roof truss and portal frame is used to cover and shelter the area of an industrial building. As per the requirement of an industrial building the suitable kind of roof truss and portal frame is utilized. There are three kinds of truss namely Pitched roof truss, Parallel chord truss, and Trapezoidal truss. Roof truss are designed for dead load, live load, wind load and their combinations as per Indian Standards. An economy of an industrial building depends on the configuration of structure, type of roof truss and portal frame utilized, forces acting on building and selection of steel sections needed as per force employed. Steel sections are categorized namely as conventional steel section (channel, angle, rolled etc.), and Hollow steel section (square hollow section, rectangular hollow section, circular hollow section).

The Present work includes designing Roof truss components for an industrial building using conventional steel sections and Tubular steel sections (circular hollow section) and selecting most suitable section according to its advantages and disadvantages..

A. *Advantages of Tubular sections:*

- Economy is achieved as strength to weight ratio is more.
- Compressive strength and torsional. Because of that Tubular sections behave more efficiently than conventional steel section.
- Ease of maintenance.
- Free from sharp edges.
- Ease in fabrication and erection compared to conventional steel section.

From the point of view of corrosion, the tubes are subjected to corrosion on the other surface only, because of having the ends sealed. So, protection by means of paints and other processes involve a lesser surface area on the outside face only which is reflected in the code of practice allowing less wall thickness for tubes than in conventional sections.

II. LITERATURE REVIEW

A. *M.G.Kalyanshetti, G.S.Mirajkar, "Comparision between Conventional Steel Structures and Tubular Steel Structures" International Journal of Engineering Research and Application (Ijera) Vol. 2, Issue 6, November- December 2012*

This research involves the economy, load carrying capacity of all structural members and their corresponding safety measures. Economy was the main goal of this study involving comparison of conventional sectioned structures with tubular sectioned structure for given requirements. For study purpose superstructure-part of an industrial building is considered and comparison is made. Research reveals that, up to 40 to 50% saving in cost is achieved for square and rectangular tubular sections.

B. *Trilok Gupta, Ravi K. S Harma, "Analys Is of Industrial Shed using Different Design Philosophies" International Journal of Research In Advent Technology, Vol.1, Iss Ue 5, Dec Ember 2013*

The research involves various kinds of industrial roof trusses by using computer software. It also involves the knowledge regarding steel roof trusses and the design philosophies with worked examples. From the observations they concluded that, the sections designed using limit state methods are more economical than the sections using working stress method. It was observed that the tubular section designed by limit state method was the most economical among the three sections which were used

C. *Vaibhav B. Chavan, Vikas N. Nimbalkar and Abhishek P. Jaiwal " Economic Evaluation of Open and Hollow Stuctural Sections in Industrial Trusses", Aci Structural Journal, March-April 1990*

This research's objective was to estimate the economic importance of the Hollow Sections in contrast with conventional sections. This paper was carried out to find out the percentage economy accomplished using Hollow Sections so as to understand the importance of cost efficiency. The technique used in order to reach the objective involves the comparison of various profiles for different combinations of height and material cross -section for given span and loading conditions. The analysis and design phase of the project was done utilizing STAAD PRO V8i. The results of STAAD analysis were validated with the results of Manual analysis.

III. MODELING

A truss is fundamentally a triangulated system of straight interlocked structural components. The common use of trusses is in structures, where assist to roofs, the floors and inner loading such as services and suspended ceilings, are willingly arranged.
A truss is basically a triangulated system of straight correlated structural components; it is sometimes also mentioned as an open web girder. The individual components are connected at joints; the links are often assumed to be nominally pinned. The outer forces applied to the system and the outcomes at the supports are usually applied at the joints. When all the members and applied forces are in a similar plane, the system is a plane or 2D truss.
The main force in every component in a truss is axial tension or compression.

A. *Uses of Trusses in Structure*

Trusses are consumed in a wide range of structures, chiefly where there is a necessity for long spans, such in airport terminals, aircraft hangers, sports stadium roofs, auditoriums and other buildings. Trusses are also utilized to carry hefty loads and are sometimes utilized as transfer buildings. This article emphases on typical single story industrial structures, where trusses are extensively utilized to assist two main functions:

- To carry the roof load
- To arrange horizontal stability.

B. *Types of Trusses:*

The Most common type of roof trusses are pitched roof trusses wherein the top chord is provided with a slope in order to facilitate natural drainage of rainfall and clearance of dust or snow accumulation. There are various types of trusses used in industrial buildings are shown below:
1) Pratt truss
In Pratt trusses web members are organized in such a way that under gravity load the longer diagonal members are under tension and the shorter vertical members are under compression. This allows for efficient design, since the short members are under compression. However, the wind uplift may cause reversal of stresses in these members and nullify this benefit.

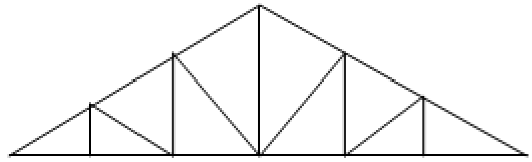


Fig. 1: Pratt Truss

2) Howe truss

William Howe, from Massachusetts, USA. Patented his design in 1840, and extended it in 1850 with improvements. The Howe Truss was formerly designed to combine compression members and tension members. Though, the Howe Truss was far along utilized in steel bridges. Its remarkable strength over lengthy spans contributed to its popularity in railroad bridges.

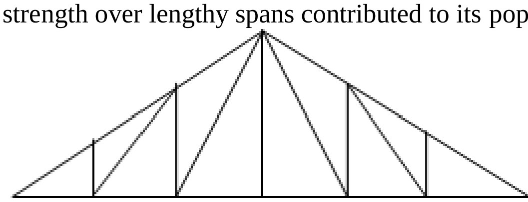


Fig. 2: Howe Truss

3) Fink truss

The Fink truss gives economy in terminologies of weight for short span high pitched roofs as the components are segmented into shorter parts. Fink trusses are utilized for long spans having high pitch roof, since the web members in truss are sub-divided to obtain shorter members.

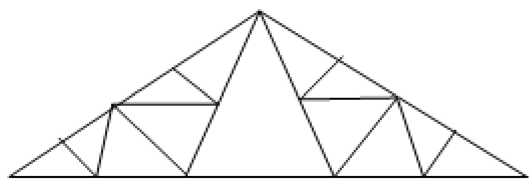


Fig. 3: Fink Truss

4) Fan truss

Fan trusses are format of Fink roof truss. In this, top chords are subdivided in smaller spans to supply supports for purlins which won't come at joints in Fink type roof trusses. It will be useful for spans from 10-15m.

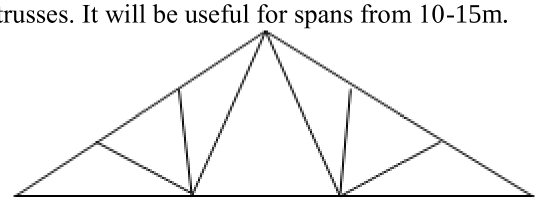


Fig. 4: Fan Truss

TO CLARIFY THE USEFULNESS OF TUBULAR STEEL SECTION OF AN INDUSTRIAL SHED, ANALYSIS AND DESIGN PROCEDURE IS CARRIED OUT WITH CONVENTIONAL STEEL SECTION AND TUBULAR STEEL SECTION WITH THE HELP OF STAAD PRO V8I AND MICROSOFT EXCEL. COST COMPARISON IS MADE FOR BOTH CONVENTIONAL AND TUBULAR SECTIONS.

IV. APPROACH

1) Dead load analysis is carried out referring IS 875 (Part1) with the assistance of STAAD Pro V8i.
2) Live load analysis is carried out referring IS 875 (Part2) with the assistance of STAAD Pro V8i.
3) Wind load analysis is carried out referring IS 875 (Part3) with the assistance of STAAD Pro V8i.
4) Designing is carried out referring IS 800 for conventional steel section and IS 806 for Tubular steel section with the assistance of Microsoft EXCEL.

The trusses have been analyzed for dead load, live load and wind load referring to IS: 875. Dead load includes the self-weight of the structure, weights of roofing material, weight of purlins. The wind load, F, acting in a direction normal to the individual structural element or cladding unit is:

$$F = (Cpe - Cpi).A.Pz$$

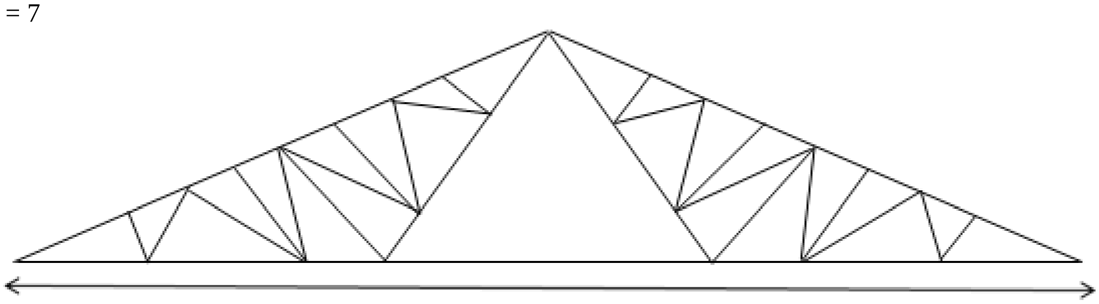
Where, Cpe = external pressure coefficient,
Cpi = internal pressure coefficient
A = surface area of structural element
Pz = design wind pressure

IV. DESIGN PROBLEM

To determine the effectiveness of tubular sections an industrial shed is considered Analysis and design is carried out using conventional steel sections and tubular steel sections. In tubular circular, rectangular and square shapes are considered. Cost comparison is made for all above sections.
Following data is considered for analysis and design of industrial shed.

A. Data for Industrial building

Plan area around: - 1125 sq.m.
Roof truss- Double Fink type
Geometry of truss- span 25 m, θ = 19.79˚
Location- Vallabh Vidyanagar, GIDC Area, Gujarat, India.
Spacing of purlins = 1.31 m.
No of trusses = 7



25 M
Fig. 5: Geometry of truss

B. Load Calculations:

Table – 1
Load calculations for truss

Loads	*Pressure*	*Load on each intermediate panel point*	*Load at end point*
DL	*0.410 N/m²*	*3.98 KN*	*1.99 KN*
LL	*0.514 N/m²*	*3.46 kN*	*1.73 kN*
Wind normal to ridge (windward side)	*-1.598 kN/m²*	*-12.32 kN*	*-6.16 kN*
Wind normal to ridge (leeward side)	*-1.44 kN/ m²*	*-12.32 kN*	*-6.16 kN*
Wind parallel to ridge (windward side)	*-1.87 kN/ m²*	*-11.50 kN*	*-5.75 kN*
Wind parallel to ridge (leeward side)	*-1.63 kN/ m²*	*-11.50 kN*	*-5.75 kN*

V. ANALYSIS

The different analyses have been made using STAAD Pro V8i, a computer program. The various load combinations considered in the analysis are as follows:
1.5 DL + 1.5 LL
1.2 DL + 1.2 LL +1.2 WL
1.2 DL + 1.2 LL - 1.2 WL

The outcome of different analyses for different geometries and section specifications are compared for optimization of roof truss design.

Utilizing data, design is made for required load carrying capacity. Ideal sections are selected for truss members. Analysis is carried out for total shed area of 1125 sq.m. Consisting 7 numbers of trusses. Cost comparison is made for various elements of truss. Results are presented in tables [4], [5] and [6]. Project work shows that significant saving in cost can be achieved by using tubular sections.

VI. RESULT AND DISCUSSION

Total weight of one roof truss components in Kg was calculated for Top chord members, Bottom chord members and other members of conventional steel section as well as Tubular steel section. From the results, total weight of all seven roof trusses components was carried out. Comparison is made between both type of sections and from the results of weight of roof truss members cost estimation sheet is carried out. That helped us to witness advantages of Tubular steel section over Conventional steel section.

Table - 2
Weight calculations for conventional steel section

Type Of Truss	Member configuration	Section used	Length Of Member	Nos	Weight In Kg
Double Fink	Top chord member	2-ISA 75 x 75 x 8	13.3	2	473.4649
	Bottom chord member	2-ISA 70 x 70 x 6	25	1	316.355
	Other Members	ISA 65 x 65 x 6	1.82	2	456.49
			1.03	2	
			1.51	2	
			2.87	2	
			2.21	2	
			2.23	2	
			4.0	2	
			4.48	2	
			3.3	2	
			2.45	2	
			2.85	2	
			1.71	2	
			1.07	2	
			1.8	6	
			4.5	1	

Table - 3
Weight calculations for Tubular steel section

Type Of Truss	Member configuration	Section used	Length Of Member	Nos	Weight In Kg
Double Fink	Top chord member	(TUB ED- 130 ID- 119.2)	13.3	2	439.556
	Bottom chord member	(TUB ED-75 ID- 65.2)	25	1	211.752
	Other Members	(TUB ED-49 ID- 55.8)	1.82	2	380.408
			1.03	2	
			1.51	2	
			2.87	2	
			2.21	2	
			2.23	2	
			4.0	2	
			4.48	2	
			3.3	2	
			2.45	2	
			2.85	2	
			1.71	2	
			1.07	2	
			1.8	6	
			4.5	1	

VII. COST COMPARISION

Weight in kilograms of all section that has been used in designing of Conventional Industrial roof truss as well as in designing of Tubular Industrial roof truss was worked out and with the information of current market rates Cost comparison between Conventional and Tubular Industrial roof truss was carried out.

Table – 4
Weight calculation of Conventional Industrial roof truss

Description	Weight in Kg
TOP CHORD	473.464

BOTTOM CHORD	*316.355*
TIE MEMBER	*456.49*
TOTAL	*1246.309*

Table -5
Weight calculation of Tubular Industrial roof truss

Description	*Weight in Kg*
TOP CHORD	*439.556*
BOTTOM CHORD	*211.752*
TIE MEMBER	*380.408*
TOTAL	*1031.716*

Table – 6
Cost comparison of Roof trusses

TOTAL WEIGHT	*COST*
CONVENTIONAL INDUSTRIAL ROOF TRUSS	
1246.309 Kg(for one)	*62,315 Rs.*
1246.309×7=8724.163 Kg	*4,36,208 Rs.*
TUBULAR INDUSTRIAL ROOF TRUSS	
1031.716 Kg(for one)	*51,586 Rs.*
1031.716×7=7222.012 Kg	*3,61,100 Rs.*

VIII. CONCLUSION

Above work shows that Tubular section has proved to be more economical. Saving of 10,729 INR per one roof truss is achieved with assigning Tubular steel sections instead of conventional steel roof truss. Which came down to total saving of 75,108 INR for all seven roof truss of an industrial shed? Overall 18% saving has been achieved during this project work.

From the present study and results we can conclude that, the structural members having larger span length can be designed with tubular sections which will be benefitted in overall economy. For smaller span lengths one would have to design roof truss with minimum sections for both conventional steel sections and tubular steel sections which would affect overall economy due to larger initial cost. Even if cost for tubular sections is more compared to conventional sections, but because of comparatively less dead weight it has proved more economical for the industrial roof truss as well as for other steel structures.

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