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Comparative Study Between Hollow Steel Structures and Conventional Steel Structures

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Abstract— This study report showing the comparative study carried out between Conventional Steel Section (CSS)/open section and Hollow Steel Sections (HSS). The aim of the study is to evaluate economic importance of HSS in contrast with CSS. The approach used in order to accomplish the objective to which includes comparison of industrial building frame for various combinations of span, crane loads and material cross-section for given loading conditions. Design and analysis of industrial shed with truss and supporting column and check for both sections is made with draft code IS 800:2007 for LSM of given problem. The analysis and design phase of the project was performed using STAAD PRO V8i. The sample results of STAAD analysis were validated with the results of Manual analysis.

Index Terms— Hollow Steel Sections, Conventional Steel sections, STAAD PRO V8i, Tubular Sections ,Open Section

I. INTRODUCTION

Steel structures are built-up with conventional sections of steels which are designed and constructed by conventional methods. This leads to heavy or uneconomical structures. Hollow steel sections are the best replacements to the conventional ones with their useful and comparatively better properties. It is obvious that due to the profile of the tube section, dead weight is likely to be reduced for many structural members, which derives overall economy. This study is regarding the economy, load carrying capacity of all structural members and their corresponding safety measures. Economy is the main objective of this study involving comparison of conventional sectioned structures with hollow sectioned structure for given requirements.

II. STRUCTURAL CONFIGURATION

For this study and industrial building frame is considered of different span and loading conditions using HSS and CSS. Steel trusses, supported on columns, are one of the structural systems commonly used in industrial buildings. The steel trusses have been designed as simply supported on columns and subjected to loads (dead, live, crane, wind and earthquake loads) applied through the purlins and gantry girders. The columns have been designed as cantilevers tied.together resisting wind load and other loads acting perpendicular to the ridge, in addition to axial load. The analysis and design results are given for purlins, steel roof trusses and columns made by made of Conventional Sections and Hollow Steel sections. The typified designs have been presented for the following different parameters:

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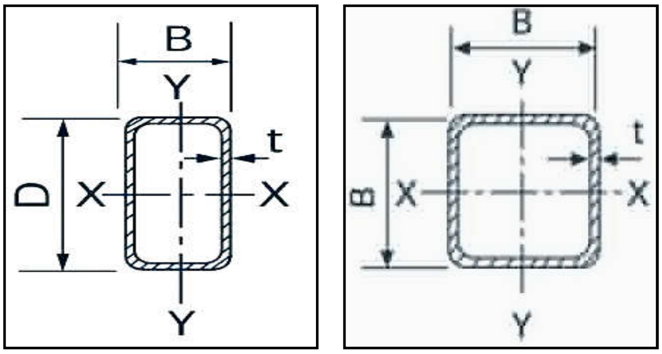
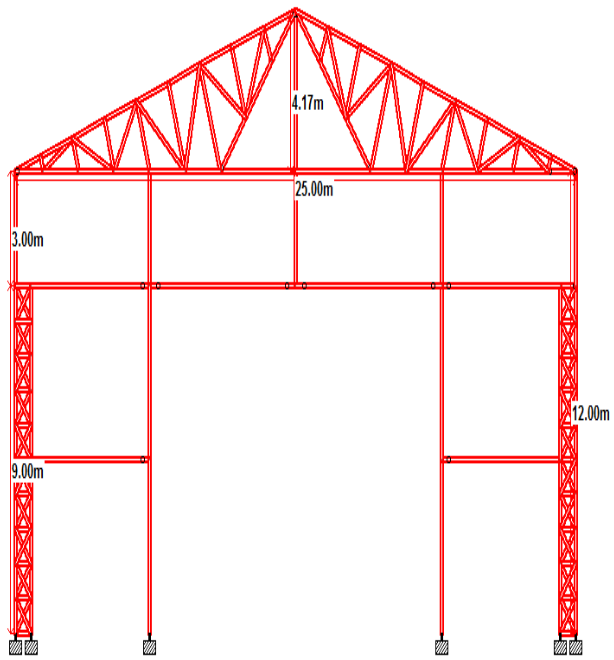
S.	Parameters	Units
1.	Span Length of Trusses	20m, 25m, 30m and 35m
2.	Spacing between trusses	5 m.
3.	Roof Slop	1 in 3
4.	Column Height	9m
5.	Crane Column Height	3 m.
6.	Crane Capacity	5Ton,10Ton,15Ton and20 T
7.	Minimum Clear Head Room	4 m
8.	Wind Zone	III
9.	Permeability	Normal



"Fig. 1"a.Rectangular & Square Hollow Section



"Fig. 2" Framing System for Conventional and Hollow Steel Structure

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III. DESIGN PROBLEM

Table 1. Structure Configuration Details

Location	:	Mumbai
Length	:	45m
Width	:	25m
Eave Height	:	9m (clear)
Wind Speed	:	44 m/sec
Wind terrain category	:	category 2
Wind Class	:	III
Life Span	:	50 years
Slope of roof	:	1 in 3
Crane Capacity	:	20Ton
Important Factor	:	1
Purlin Spacing	:	1500 mm

Dead Load Calculation, Dead load calculation includes the weight calculation of sheeting, purlins and material as follows in Table [2].

Table 2. Calculation of Dead Load

Sheeting weight Sheets)	:	0.171 kN/m^2(1.6 mm thick AC
	:	5 x 0.171 kN/m (Purlin 1.5m Spacing)
	:	0.855 kN/m
Purlin weight	:	16.4/1.5
	:	10.93 kg/m^2 = 01093 kN/m^2
Purlin weight	:	5 x 0.1093
	:	0.5 kN/m

Live Load Calculation, Calculation of live loads includes consideration of live loads according to Indian Codes as follow in Table [3]

Table 3. Calculation of Live Load

As per IS: 875(part-2) – 1987 – Table – II Since the slope of the roof is 18.435° the live load for non accessible roof of 0.75 kN/m2 is reduce to 0.581 kN/m2 by 0.02 kN/m2 for every degree increase in slope over 10°. With the Bay spacing of 5m Intensity of load on the rafter = 5 x 0.581 = 2.9 kN/m

Crane Load Calculation, Crane load calculation includes the vertical and horizontal reactions coming on the column C1 and C2. Reactions for crane load 20 T span 25m are given in Table [4]

Table 4. Calculation of Crane Load

Type of Crane	:	EOT Crane
Crane Capacity	:	200 kN
Span of the crane between rails	:	23.6m
Span of Gantry Girder	:	5m
Approach Length (a)	:	1.2m
Wheel Base (b)	:	4m
Summary of crane load:		
Dead load on column C1	:	345 kN
Vertical load due to impact C1	:	85kN
Total load on Column	:	430 kN
Horizontal Load on C1	:	33 kN
Dead load on column C2	:	183 kN
Vertical load due to impact C2	:	45kN
Total load on Column C2	:	228 kN
Horizontal Load on C1	:	18 kN

Wind Load Calculation, Wind load calculation is done according to Indian IS code: 875(part-2)-1987- Cl. 5.3, as follows in Table [5]

Table 5. Calculation of Wind Load

Wind speed (Vb)	:	44 m/sec
Risk coefficient (K1)	:	1
Probability factor (K2)	:	1.05
Topography factor (K3)	:	1.0
	:	K1*K2*K3*Vb
Design wind speed	:	1*1.05*1*44
	:	46.2
	:	0.6*(Vz)^2
	:	0.6 * 46.2^2
Design wind speed (Pz)	:	1.28 kN/m^2

IV. METHODOLOGY

Roof Trusses, Purlins, and supporting columns. for industrial sheds are analyzed and designed with open sections and cold finished RHS/SHS Specified in IS4923:1997. Industrial shed frame including pitched roof trusses for rectangular clad buildings of 4 different spans for 4 different crane loads for wind zone III, (as mapped by Bureau of Indian Standards) and each span having slopes 1 in 3 for trusses have been considered to cover various practical combinations of roof systems and existing manufacturing practices in the country. Truss configurations for different spans have been arrived at after trial and error, considering overall economy in terms of savings in weight and ease of manufacturing. However, other configurations may also be tried. Trusses have been analysed assuming rigid member to member connections except at ridge and hanger joints.

The designs have been prepared for simply supported conditions and reaction values have been tabulated accordingly. Trusses have been analysed for Dead Load, Superimposed Load, Wind Load and combinations therefore according to IS: 875-97. Only nodal loads have been considered for the purlins to be located strictly at node points, based on the maximum allowable span of A.C sheeting. For other roofing material allowing longer spans, suitable changes in truss configurations should be tried. For Wind Load combinations, allowable stresses have been increased by 33.33% as per provision of IS:806. Effective length of each member has been assumed to be 0.85 times the node to node distance. In case of compression loading, member has been designed against buckling in and out of plane of truss. Maximum slenderness ratio for compression member has been restricted to 180. Maximum deflection of mid span node of truss has been restricted to "span/325". As RHS/SHS are still considered non conventional sections, typical fabrication detailing for different spans have been incorporated, so that practising structural engineers may find it helpful as a ready reference.

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V. DESIGN SUMMARY

1) Conventional Steel Frame

For 25 meter span with 20 tons crane load

Member	Section
Laced Column	ISMC 250
Column lacing members	ISA 65X65X8
Column supporting truss	ISMB 200
Principal Rafter	2 ISA 90X900X8
Bottom chord	2 ISA 100X100X10
Struts and Ties	ISA 80X80X10
Purlin	ISMC 100
Footing Size	3.5m x 1.8m x 0.4m

2) Rectangular Hollow Steel Frame

For 25 meter span with 20 tons crane load

Member	Section
Built up Column	RHS 200X100X6
Column lacing members	RHS 66X33X4.5
Column supporting truss	RHS 145X82X4.8
Principal Rafter	RHS 145X82X4.8
Bottom chord	RHS 145X82X4.8
Struts and Ties	ISA 96X48X4
Purlin	ISMC 120X60X4.5
Footing Size	2.5m x 1.6m x 0.4m

VI. RESULT COMPARISON

The comparison of cost and steel quantity for different crane loads in Ton is shown in graphical format between the conventional steel structure, Rectangular Hollow Steel Structure and Square Hollow Steel Structure.

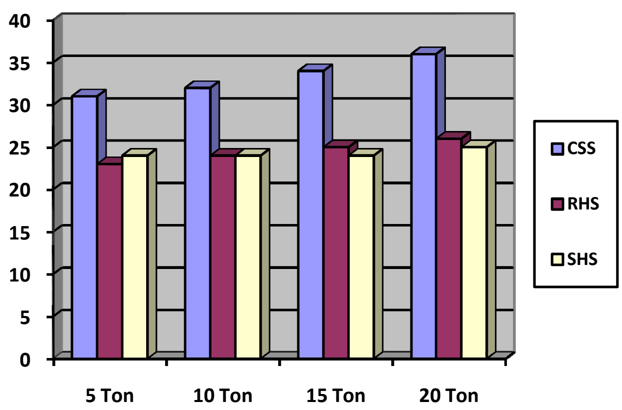

Fig 3. Comparison of Steel Quantity for Span 20m

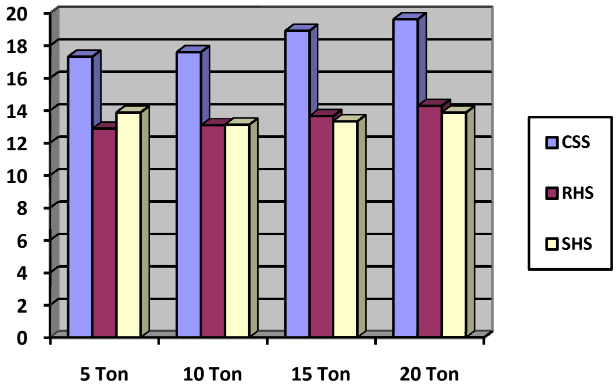

Fig 4. Comparison of Cost (in Lac) for Span 20m

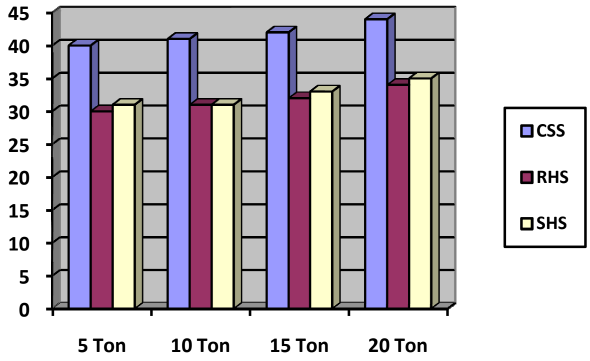

Fig 5. Comparison of Steel Quantity for Span 25m

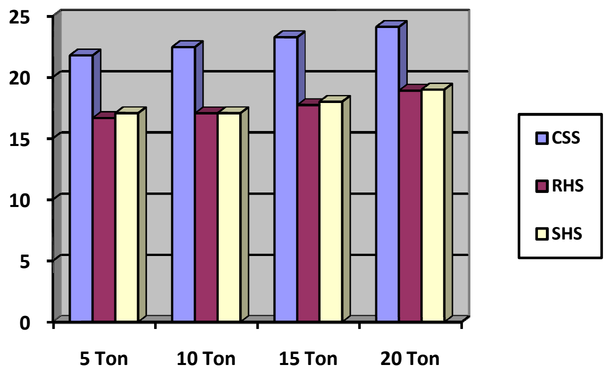

Fig 6. Comparison of Cost (in Lac) for Span 25m

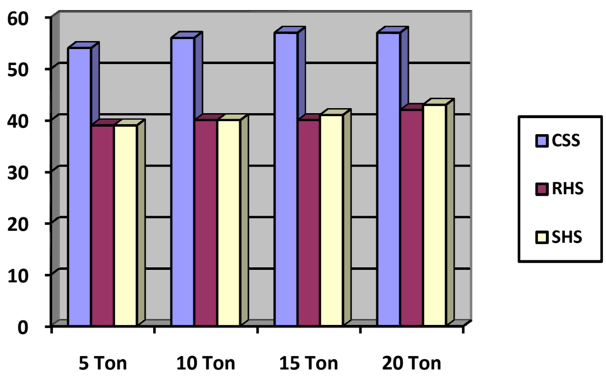

Fig 7. Comparison of Steel Quantity for Span 30m

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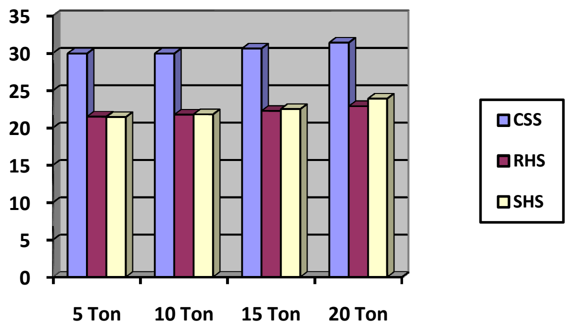

Fig 8. Comparison of Cost (in Lac) for Span 30m

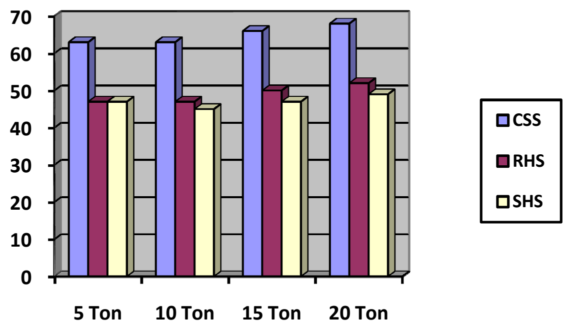

Fig 9. Comparison of Steel Quantity for Span35m

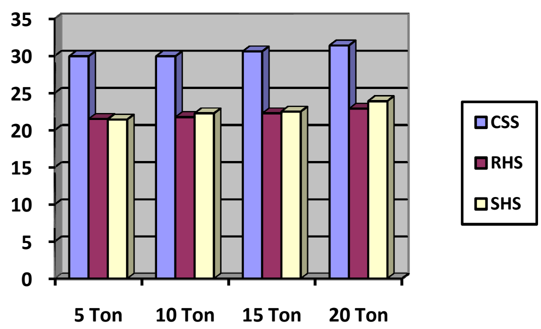

Fig 10. Comparison of Cost (in Lac) for Span35m

VII. OBSERVATION AND CONCLUSION

From the detail calculation and summary it is seen that the comparison between Conventional Steel Portal and Hollow Steel Portal shows following results on an average

Parameters	Reduction
Steel Quantity	21 – 25 %
Concrete Quantity	35 – 40 %
Cost	21 – 25 %

VIII. CONCLUSION

All the above results conclude that the consumption of steel of whole industrial building can be reduced by deciding appropriate geometry of truss and by using hollow steel section with compare to conventional steel section. Hollow steel sections can create large reduction of steel required of truss geometry as well as for the total geometry of structure if used. It is found that hollow steel sections saves 20% to 30% from total cost of building as per geometry of truss is used. Truss can be designed by hollow sections for the sustainable development of whole industrial building.

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