RESEARCH ARTICLE   **OPEN ACCESS**

Cost Optimization of a Tubular Steel Truss Using Limit State Method of Design

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ABSTRACT
Limit state method helps to design structures based on both safety and serviceability. The structures are designed to withstand ultimate loads or the loads at which failure occurs unlike working stress method where only service loads are considered. This leads to enhanced safety. Also unlike the working stress method, the structures are economical. It is also better than ultimate load method as serviceability requirement is also taken care of by considering various safety factors for all the load types and structures do not undergo massive deflection and cracks. For tubular sections, higher strength to weight ratio could result in upto 30% savings in steel .Due to the high torsional rigidity and compressive strength, Tubular sections behave more efficiently than conventional steel section This study is regarding the economy, load carrying capacity of all structural members and their corresponding safety measures.
Keywords: IS (800-2007),IS(4923-1997),IS 806,IS 875, Tubular sections.

I. INTRODUCTION

Comparison of various structural elements in terms of Safety,Economy and Load carrying Capacity is done in paper Comparison Between Conventional Steel Structures and Tubular Steel Structures By Prof. M.G . Kalyanshetti and G.S.Mirajkar (myself) [11]. Experimental and theoretical studies have been carried by, S. Poonaya, U.Teeboonma, C.Thinvongpituk [9] regarding plastic collapse analysis of thin walled circular tubes subjected to bending. Design of circular steel arch with hollow sections is presented by C.A. Demopoulos, C.J.Gantes [10], they have suggested that Tubular sections are an economical, efficient and strong alternative to conventional sections used in steel structure A hollow section shall be designated by its outside dimensions and its thickness in millimeters and shall be further classified into CF or HF depending upon whether it is cold formed or hot formed.

a) A hot formed square hollow section with outside dimensions of 50 mm square and 2.90 mm thickness is designated as50 x 50 x 2.90 HF SHS.
b) A cold formed square hollow section without side dimensions of 50 mm square and2.90 mm thickness is designated as 50 x 50x 2.90 CF SHS.
Strength of HF steel in N/mm^2

Grade	Yield Stress	Tensile Strength
YST 210	210	330
YST 240	240	410
YST 310	310	450

Classification of section as a plastic, compact, semi-compact section is as per clause 3.7.2 and 3.7.4 of IS 800-2007

1.1 Tensile Strength: The design strength of a member under a tensile loading depends on the cross-sectional area and the design yield stress
Factor Design strength shall be minimum of , T_{dg} T_{dn} ,T_{db} . (Clause: 6.2, 6.3&6.4)

Where,
T_{dg} =Strength in axial
Tension governed by
Yielding of gross section
$A_g . f_y / \gamma_{m0}$
T_{dn} =Strength of plate in
Axial tension governed by Rupture of net cross
Sectional area at holes $0.9 A_n fu / \gamma_{m1}$
T_{dn} =Rupture strength of an angle connected through one leg governed by rupture at net section
$0.9 A_{nc} f_{u} / \gamma_{m1} \beta A_{go} f_y / \gamma_{mo}$

T_{db} = strength of connection governed by block shear at an end connection of plates and angles=

$A_{vg} f_y /(\sqrt{3} \gamma_{mo}) + 0.9 A_n f_u / \gamma_{m1}$

(OR)
$[0.9 A_{vn} f_u / \sqrt{3} \gamma_{m1+} A_{tg} f_y / \gamma_{m0}]$ Where,
f_y = yield stress of material
A_g =gross area of cross
     Section
γ_{m0} =partial safety for failure in tension by yielding=1.10
$\gamma_{m1=}$partial safety factor for failure at ultimate

stress=1.25

f_u= ultimate stress of the material

A_{nc} =net area of the connected leg

gross area of the outstanding leg

A_{go}= gross area of the outstanding leg.

L_C=length of the end connection

A_{vg}, A_{vn}=minimum gross and net area in shear along bolt line parallel to external force respectively

1.2 compressive strength, $P_d = A_c f_{cd}$

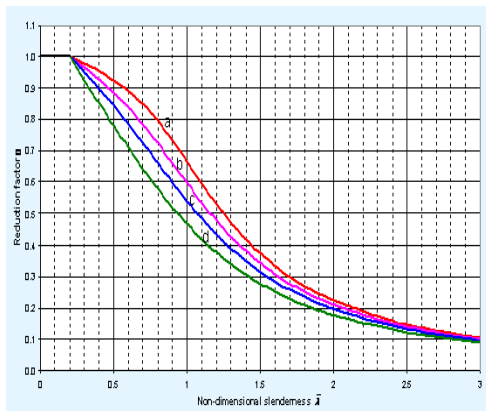value of f_{cd} depends upon buckling curves (clause:7.1.2)IS 800-2007

Figure1:. Geometry of truss

The selection of the buckling curve (i.e. a, b, c,d) depends on the cross section type.

For Hot Rolled Section: Buckling Class :a

1.3 Flexural strength: Clause: IS 800

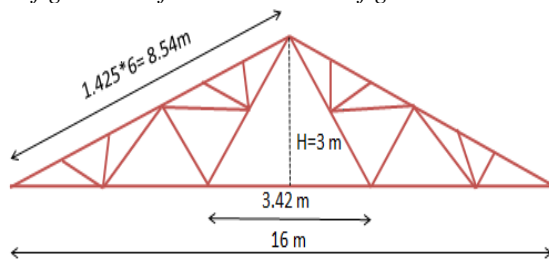## II. PROBLEM.

Configuration of truss is shown in fig 1.

Figure2: Geometry of truss

1) Plan area around:- 550 sq.m.

2) Location: - Solapur, MIDC Area, Maharashtra –India.

3) Roof truss:- FAN type

4) Geometry of truss:- span 24 m,θ=16.26˚,

5) 10 panel Points spacing of purlins 1.425 m.

6) Length of sheet=3.05m, sloping length=12.5m.

7) Spacing of truss = 5m, No of trusses = 811

III. APPROACH

1. Dead load analysis is done according to IS 875 (Part1) with the help of STAAD-PRO

2. Live load analysis is done according to IS 875 (Part2) with the help of STAAD-PRO

3. Wind load analysis is done according to IS 875 ((part 3) with the help of STAAD-PRO

4. Designing is done according to IS 800,IS806 and STAAD PRO

Conventional design is carried out as per IS 800-2007 and tubular sectioned design is carried out as per IS 806.

A)Total Dead Load.

1) On central purlin =2.411 kN

2) On intermediate purlin=2.411 kN

3) On end purlin=2.411 kN

B) Total Live Load

1) On central purlin =1.755 kN

2) On intermediate purlin=1.755 kN

*3) On end purlin=1.755kN*

C) Total Wind Load

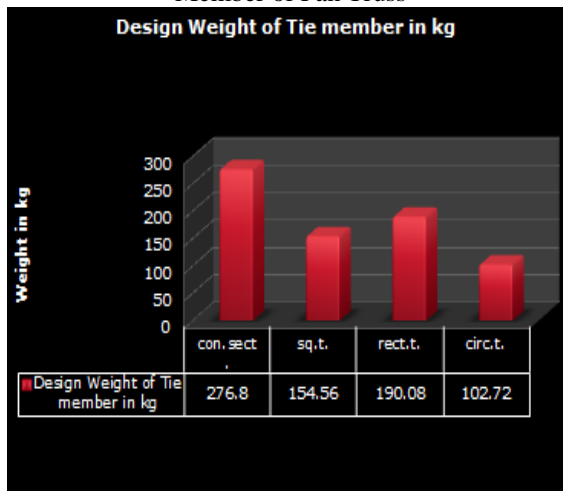*1) On central purlin= -6.722 kN*

2) On intermediate purlin=-6.722 kN

3) On end purlin=-6.722 kN

Using above results design is carried out for required load carrying capacity. Optimum sections are assigned to truss members and purlin members. Comparison is made for self-weight and cost of various elements of truss such as principalrafter,tie member, strut member, sling member, purlin member. Results for single truss are presented graphically in graph 1 to graph 5. These results shows that considerable amount of saving is achieved using Tubular sections Also analysis is carried out for total shed area of800 sq.m. Consisting 8 numbers of trusses. In this case also comparison is made for various elements of truss. Results are presented in tabular form i.e. Table 1 to table 5. Study reveals that considerable saving in cost can be achieved by using tubular sections
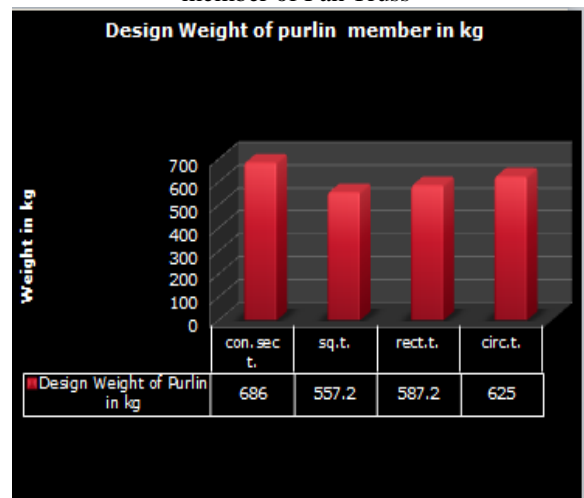
Graph 1. variation of design weights for Principal Rafter of Fan Truss
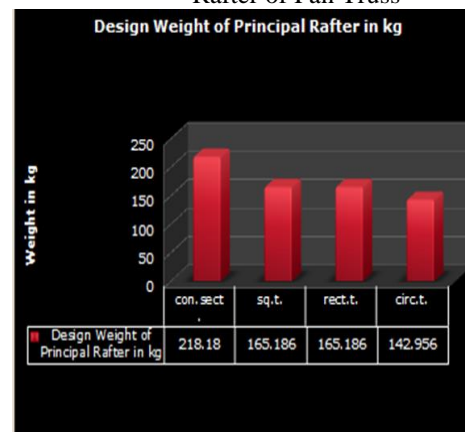
Graph 2. variation of design weights for Tie Member of Fan Truss

Graph 3. variation of design weights for Strut member of Fan Truss

Graph 4. variation of design weights for Sling member of Fan Truss

Graph 5. variation of design weights for Purlin member of Fan Truss


IV. TOTAL COST
Table 1: Sections Assigned:

section	conventional	Square Tube	Rect.tube	Circ. tube
Prin .Rafter	2 ISA 55X55X8	72X72X4.8	96X48X4.8	OD 88.9,NB=80,t=4
Tie member	2ISA 100X100X10	72X72X4.8	96.48X4.8	OD 88.9,NB=80,t=4
strut	ISA 65 X45X6	ISA 50X50X2.9	ISA 60X40X2.9	NB=40,OD=48.3,t=4
Sling	ISA 70X50X8	50X50X2.9	60X40X2.9	NB 40,OD48.3,t=4
purlin	ISA 125 X95X12	113.5X113.5X4.8	145X82X4.8	OD139.7,NB125,t=4.5

Total cost for modified Fan truss truss using conventional sections: Rs 3,31,558
Total cost for modified Fan truss using square tube sections: Rs 2,48,118 /-. (% saving in cost =25.16%) .
Total cost for Fan truss using rectangular tub tubee sections: Rs 2,62,008 /- (/% saving in cost=20.9%) .
Total cost for modified Fan truss using circular tube sections: Rs 2,10,554 /- (% saving=36.4%)
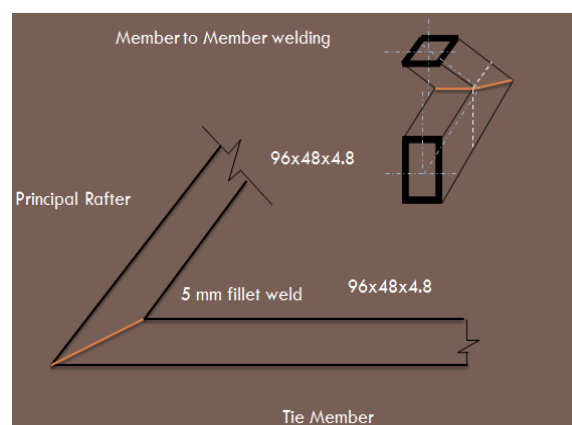
Figure3.Connection

V. CONCLUSION

Above study reveals that tubular sections proves to be economical. Total saving of almost 20 % to 40 % in cost is achieved. Out of circular, square and rectangular shapes, due to connection difficulties of circular tube sections, it is suggested to adopt rectangular or square tube sections. This study is for a given area of 550 sq.m. and truss of Fan type. Effectiveness of Tubular section can be verified for different plan areas for various types of trusses.

From above observations and results one can conclude that, the structural members having larger unsupported lengths can be assigned tubular sections which will derive overall economy. For smaller unsupported lengths one will have to assign minimum sections for both conventional and tubular sections so that economy is not considerably achieved. In such cases due to larger initial cost it becomes uneconomical. Initial cost for tubular sections is more however ,due to reduction in total dead weight, it is overall economical not only for industrial buildings but also for various steel structures like transmission towers, bridge structures etc

REFERANCES

[1]. IS 800-1984, Code of practice for general construction i in steel.
[2]. IS 875-1987(part-1) Code of practice for design loads (other than earthquake) for buildings and structures.
[3]. IS 875-1987(part-2) Code of practice for design loads (other than earthquake) for buildings and structures
[4]. IS 875-1987(part-3) code of practice for design loads (other than earthquake) for buildings and structures
[5]. IS 806-code of practice for use of steel tubes) for buildings and structures.
[6]. Design of steel structure by S.K. DUGGAL.
[7]. Design of steel structure by Ashok Kumar Jain.
[8]. Broucher of Tata steel structures.
[9]. "Plastic collapse analysis of thin walled circular tubes subjected to bending" by S. Poonaya, U.Teeboonma, C.Thinvongpituk, 15 th may 2008.
[10]. "Design of circular steel arch with hollow sections" by C.A. Demopoulos, C.J. Gantes_Department of Civil Engineering, National Technical University of Athens, Greece , 10 June 2007.ic
[11]. "Comparison Between Conventional Steel Structures And Tubular Steel Structures" by Prof.M.G.Kalyanshetti,G.S.Mirajkar,Nov-Dec 2012.