COMPARATIVE STUDY ON ANALYSIS AND DESIGN OF TRUSS USING MANUAL CALCULATIONS AND STAAD-PRO

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Abstract - Due to the rise in demand in steel structures in recent years, there are number of software that are available in engineering field for design of steel structures.

This study deals with comparison of manual methods and software to find the accurate design of the structure. In this study the design of truss is first done by manual calculation and second by the use of STAAD-Pro.

The results obtained are then compared to obtain the best and most efficient truss for steel structure.

Key words: **Design, Analysis, Fink Truss, Design, STAAD-PRO, Steel take-off**

1. INTRODUCTION

In all parts of the world steel industry is rising rapidly. Steel roof trusses have a broad range of application in industry involving of good load transfer mechanism without negotiating with the structural appearance.

Now a days, number of application software are available in market for designs in civil engineering field. software's are developed on basis of advanced analysis which includes the effect of loads, earth quake effects etc. in the present work, to study the efficiency of certain civil engineering application software an attempt was made.

The study of this paper reviews to analysis and design of steel member /section to be used in construction of steel structure, and its comparative study of properties using software and manual calculations.

2. OBJECTIVE

1. To design an economical truss.

2. To study the properties of designed truss.

3. To compare the results of design of truss from STAAD PRO and manual calculations.

3. SCOPE OF THE PROJECT

- Increase the load carrying capacity of truss without optimizing the materials used
- Modification in design methods which help in easy design of Truss
- Decrease the materials and change in design used without optimizing the load carrying capacity of truss.

4. MANUAL DESIGNS

4.1 *Methodology in Manual design*

1] Truss configuration
2] Loads Configuration
3] Member forces
4] Reactions
5] Resultants

4.2 *Description of data in manual design*

Rise of truss	1/4 of span
Self-weight of Purlins	318N/m
Roofing	Asbestos cement sheet (dead weight = 171N/m^2)
Height of Building	11M
C/C Spacing of truss	8M
Width of Building	16M

4.3 Truss Configuration

Let α Be the Inclination of The Roof with The Horizontal
Tan α = 4/8 = ½
α= 26°34′ = 26.566°
Length Of the Rafter

$$= \sqrt{[\frac{16}{2}]^2 + 4^2} = 8.94m$$

Length Of Each Panel = 8.94/4 = 2.235M

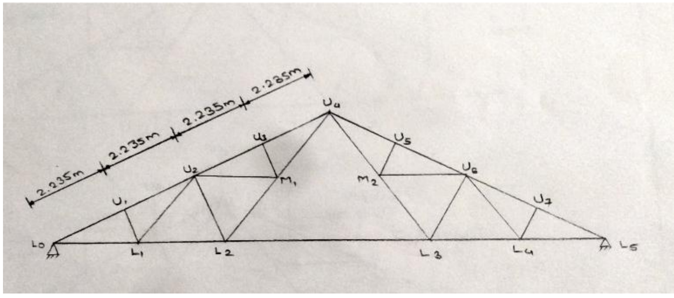


Fig No. 1 Truss Configuration

4.4 Loads on Panel Points

1]Dead Load

Assume Weight of Bracing= 12 N/M²
Dead Weight of Ac Sheet Sheets = 171 N/ M²
Self-Weight of Purlin= 318N/M²
=318x8 = 2544 N
Panel Length = 2.235m
The Panel Length in Plan
= 2.235 Cos 26⁰ 34' = 2.00 m.
Load On Each Intermediate Panel Due to Dead Load
= (12 + 171 + 110) X (8 X 2) + 2544 = 7232N
≅ 7.4 KN
Load On End Panel Points of the Rafter
= 7.4/2 = 3.7 KN

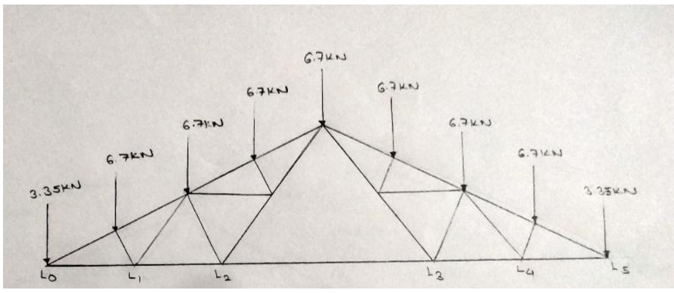


Fig No. 2 Dead Loads on Truss

2] Live Load

α= 26° 34' = 26.566°
Assume No Access Provided to The Roof. The Live Load Is Reduced By 20N/M²
For Each One Degree Above 10° Slope
Live Load= 750- 20 X (26.566-10)
= 418.68N/M²
The Load On Each Intermediate Panel
= 418.68*8*2
= 6698.88N = 6700N = 6.7KN
The Load On Each Panel Point
= 6700/2 = 3350N = 3.35KN

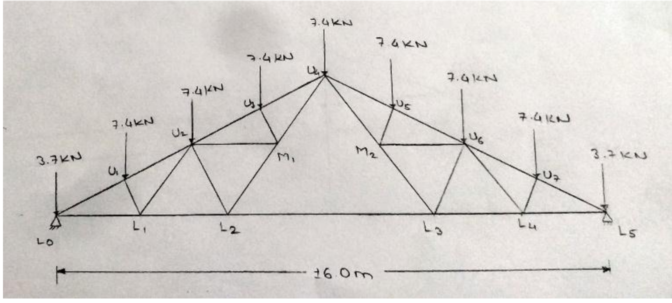


Fig No. 3 Live Loads on Truss

3] Wind Load

Expected The Life of the Industrial Building is 50 Years and The Land is Plain and Surrounded by number Small Building

$K_1 = 1.0$

$K_2 = 0.89$

$K_3 = 1.0$

$V_b = 47\ M/S$

Design Wind Speed $V_z = K_1 * K_2 * K_3 * V_b$

$= 1.0*0.89*1.0*47$

Design Wind Pressure, $P_d = V_z^2$

$= 0.6 * 41.83^2 = 1049.8\ N/M^2$

Height Of Building Column Above Ground Level, H= 11m

Width Of Building, W= 16m

$$\frac{h}{w} = \frac{11}{16} = 0.6875 \qquad [\frac{1}{2} < \frac{h}{w} < \frac{3}{2}]$$

In This Present Example the Roof Angle A Is 26.566° For Which the Coefficients Are Tabulated Below

The Wind Force Is Given By

$$F = (C_{pe} - C_{pi})\, p_d\, A$$

The Values of Coefficient C_{pe} for Various Conditions in The Table Have Been Calculated by The Interpolation for Appendix Xv Is 800- Part III

1) *Windward Side*

$F_1 = (C_{pe} - C_{pi})\, p_d\, A = (-0.8-0.2) X 1.05 X (8 X 2.235) = -18.77 \cong -18.8kn$

F_2 = -18.8/2 = -9.4 KN [Intermediate Panel Points]

2) *Leeward Side*

$F_3 = \left(C_{pe} - C_{pi}\right) p_d\, A$ = (-0.731-0.2) X 1.05 X (8 X 2.235) = -17.48≅-17.5kn

F_4 = -17.5/2= -8.75 KN [Intermediate Panel Points]

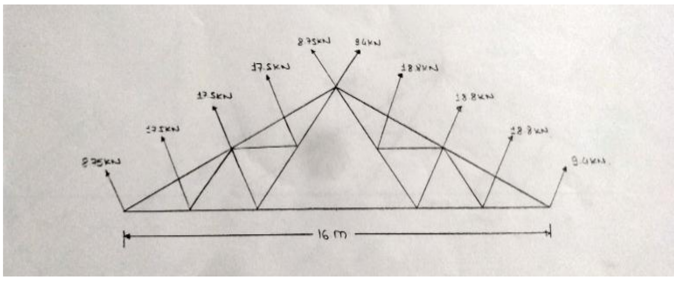


Fig No. 4 Wind loads on Truss

4.5 Reactions

The truss is symmetrical and therefore, the dead load and live reactions will be the same on both supports but the reactions due to wind load will be different on the two supports

Dead Load Reaction

Taking Moment at L_0
7.4 X 2 + 7.4 X 4 +7.4 X 6 + 7.4 X 8 + 7.4 X 10 + 7.4 X 12+ 7.4 X 14 + 3.7 X 16 = R_{15} X 16
R_{l0} = 29.6KN
By Symmetry, $R_{l0} = R_{l5}$= 29.6KN

Live Load Reactions

Taking Moment at L_0
6.7 X 2 + 6.7 X 4 +6.7 X 6 + 6.7 X 8 + 6.7 X 10 + 6.7 X 12+ 6.7 X 14 + 3.35 X 16 = R_{15} X 16
R_{l0} = 29.6kn
By Symmetry, $R_{l0} = R_{l5}$= 29.6 KN

Components of results

Force: *70.0 KN*
Vertical component
= 70.0 cos 26.566° =62.60kN ↑
Horizontal component
= 70.0 sin 26.566° =31.30 KN ←
Force: 75.2kN
Vertical component
= 75.2 cos 26.566° = 67.26 KN ↑
Horizontal component
= 75.2sin 26.566° = 33.63 KN →
Net horizontal component
= 33.63- 31.30 = 2.33kN →
Horizontal force at each face shoe *= 2.33/2 = 1.165kN →*

5. Truss design on STAAD-PRO

Methodology used in design on STAAD

1] Snap node/beam
2] Supports
3] Properties
4] Loading [DL, LL, WL]
5] Load Envelope
6] Steel Design- Apply IS codes
7] Steel Take-off
8] Analysis of loads
9] Results
STAAD Design:

Use of figures has been done to explain the design process

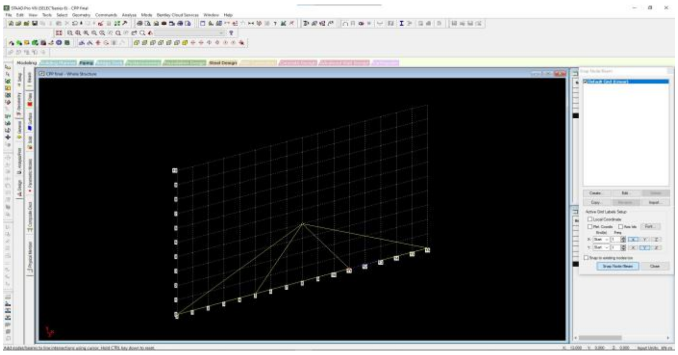


Fig no 5 Assigning Node/beam

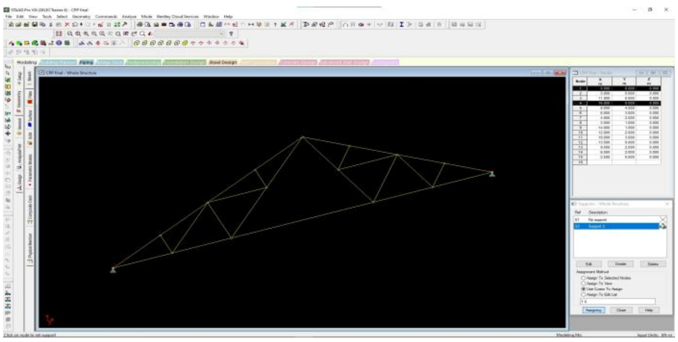


Fig No. 6 Assigning Supports

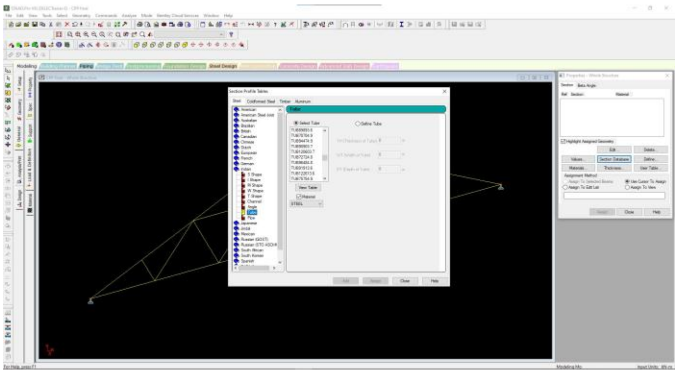


Fig No. 7 Selection of materials

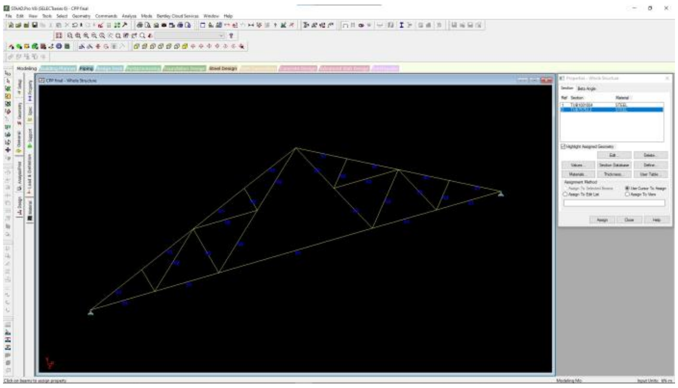


Fig No. 8 Assigning of materials to the truss

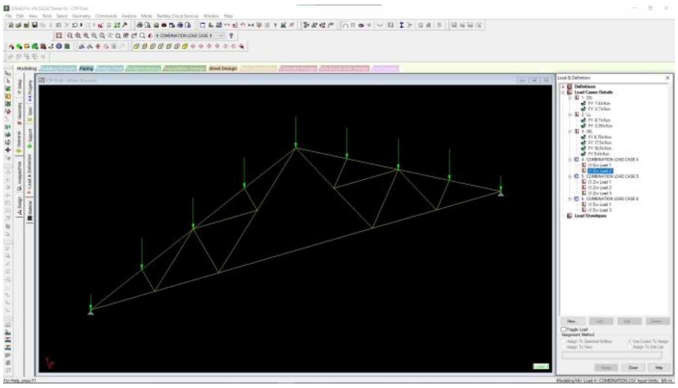


Fig No. 9 Assigning of Loads

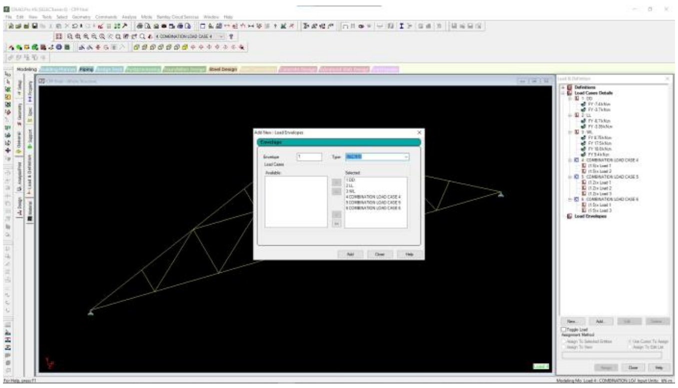


Fig No. 10 Load Combinations

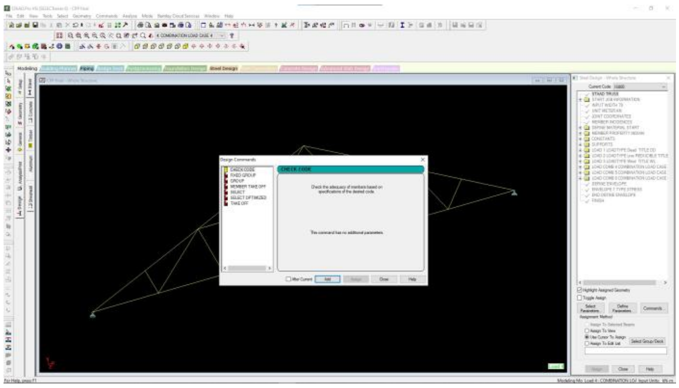


Fig No. 11 Selection of IS Codes

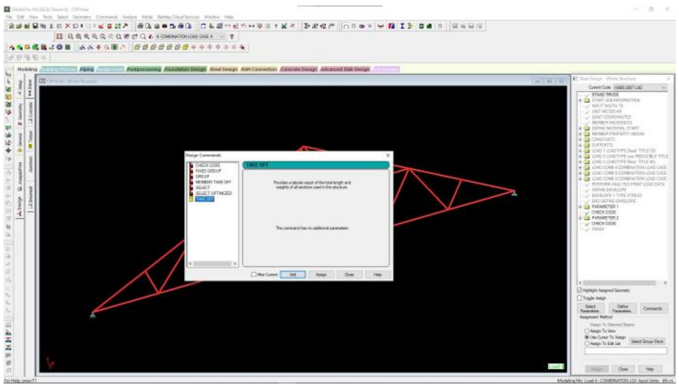


Fig No.12 Assigning Steel take off command

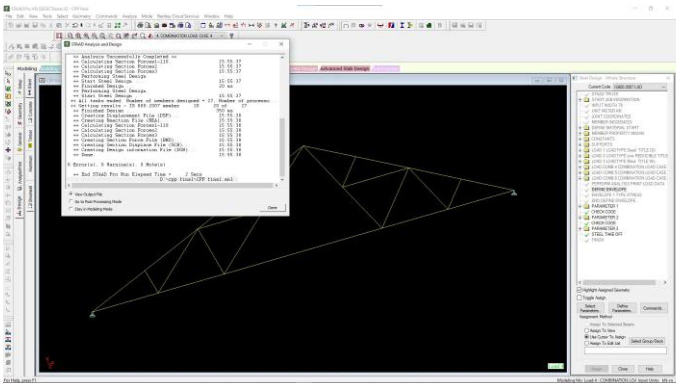


Fig No13. Analysis

Results From STAAD-PRO and manual design

**NOTE: HIGHLIGHTED SECTIONS ARE RESULTS BASED ON MANUAL DESIGN REULTS WHILE THE NON-HIGHLIGHTED ARE RESULTS FROM STAAD- PRO*

STRESS Rafter	DL	LL	WL
L_0U_1	-58	-52.5	125.8848
10	-38.869	-35.192	93.870
U_1U_2	-56	-50.3	125.8848
9	-36.648	-33.181	88.617

U_2U_3 8	-51.4	-46.5	125.8848
	-34.426	31.170	-83.365
U_3U_4 5	-48	-43.5	125.8848
	-32.205	-29.159	78.112
U_4U_5 15	-48	-43.5	125.8848
	-32.205	-29.159	79.868
U_5U_6 14	-51.4	-46.5	125.8848
	-33.350	-30.195	82.775
U_6U_7 13	-55.6	-50.3	125.8848
	-36.648	-33.181	91.154
U_7U_5 4	-58	-52.5	125.8848
	-38.869	-35.192	96.796

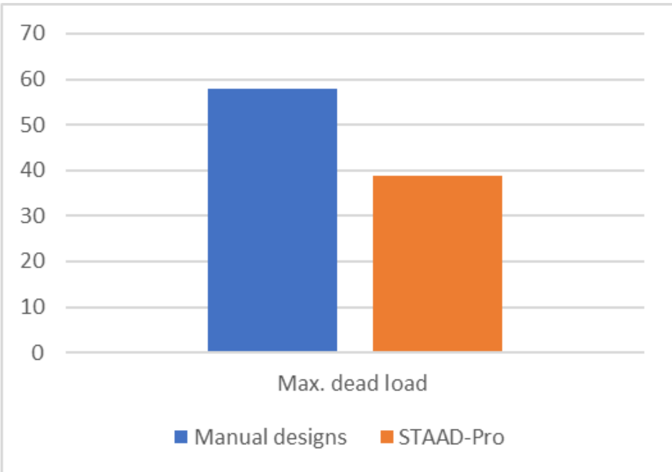
STRESS Minor Slings	DL	LL	WL
U_2L_1 19	7	6.3	-23.688
	7.4	6.7	-17.5
U_2M_1 21	6	5.4	-23.688
	7.4	6.7	-17.5
U_6M_2 24	6	5.4	-23.688
	7.4	6.7	-18.8
U_6L_4 26	7	6.3	-23.688
	7.4	6.7	-18.8

STRESS Main tie	DL	LL	WL
L_0L_1 *1*	52	47	-115.5072
	10.637	9.631	-24.141
L_1L_2 *17*	45	40.7	-92.2704
	3.237	2.931	-6.641
L_2L_3 *2*	31.1	28.2	-44.8944
	11.563	10.469	-28
L_3L_4 *3*	45	40.7	-92.2704
	3.237	2.931	9.241
L_4L_5 *16*	52	47	-115.5072
	22.20	20.10	-52.5

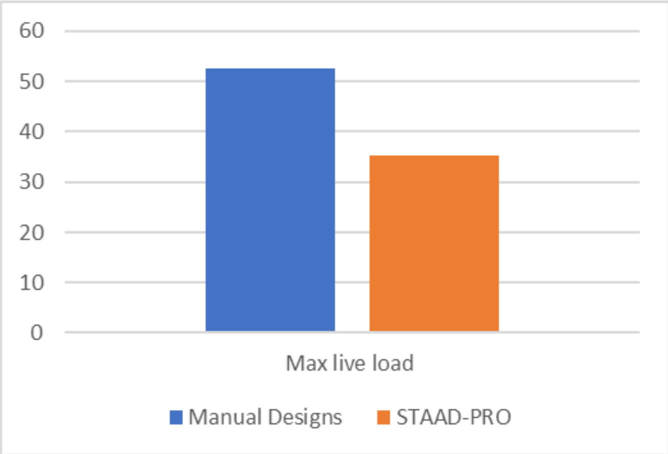
STRESS Minor Slings	DL	LL	WL
U_4M_1 11	20.3	18.4	-71.064
	54.605	49.439	-135.819
L_2M_4 6	13.8	12.5	-47.376
	14.8	13.4	-35.0
U_4M_2 7	20.3	18.4	-40.9464
	22.20	20.10	-56.400
L_3M_2 12	13.8	12.5	-47.376
	51.295	46.443	-129.411

STRESS Struts	DL	LL	WL
U_1L_1 18	-6.2	-5.6	21.2064
	-6.619	-5.993	15.652
U_2L_2 20	-12.4	-11.2	42.128
	-13.238	-11.985	31.305
U_3M_1 22	-6.6	-6	21.064
	-6.619	5.993	15.652
U_3M_2 23	-6.6	-6	21.064
	-6.619	5.993	16.815
U_6L_3 25	-12.4	-11.2	42.4128
	-13.238	-11.985	33.630
U_7L_4 27	-6.2	-5.6	21.2064
	-6.619	5.993	16.815

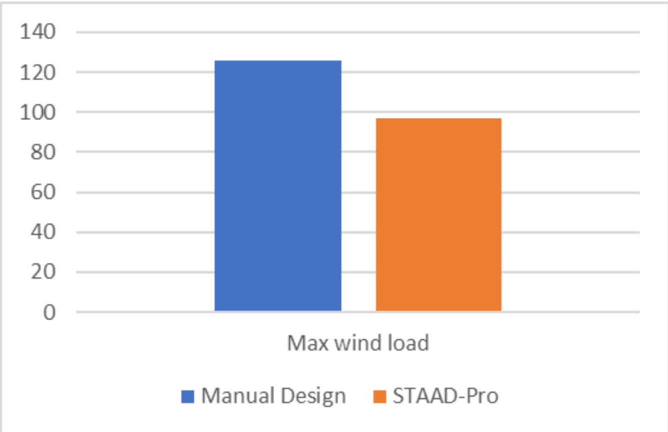
Graphical representation of loads on Rafters



Graph 1- Max Dead load on Rafters

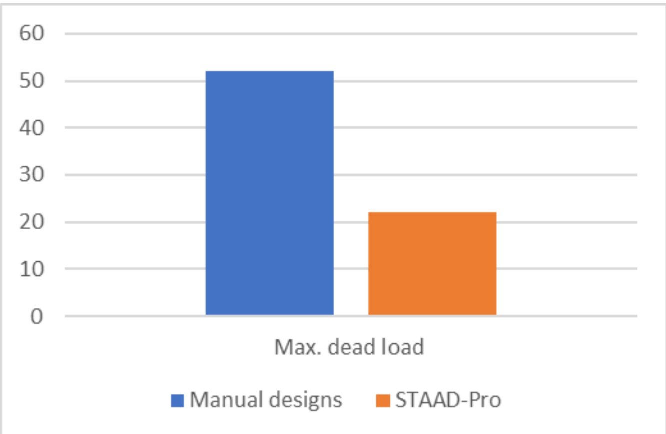


Graph 2- Max live Load in Rafters

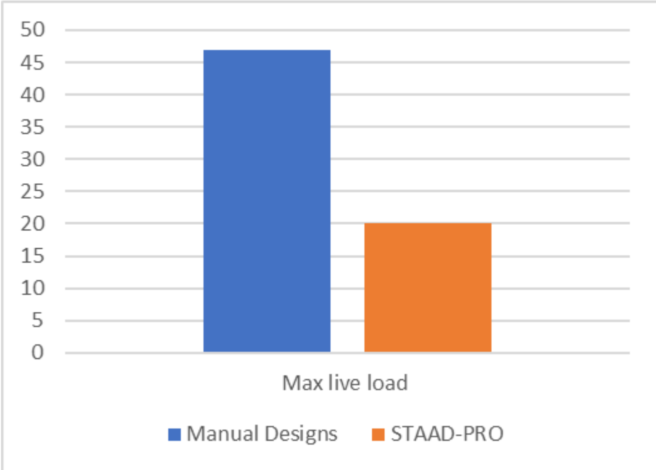


Graph 3 – Max wind load on Rafters

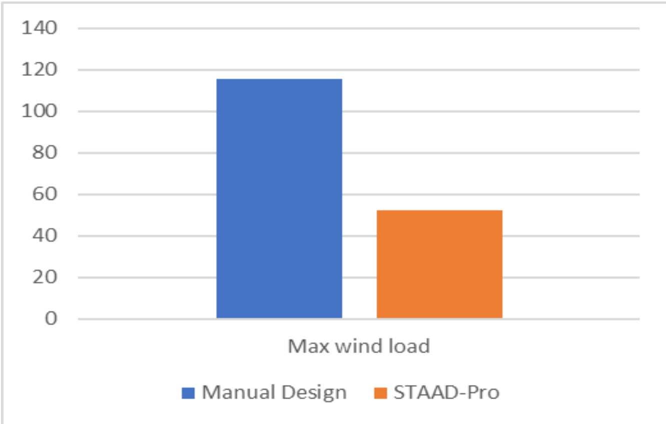
Graphical representation of load on Main Ties



Graph 4- Max Dead load on main ties

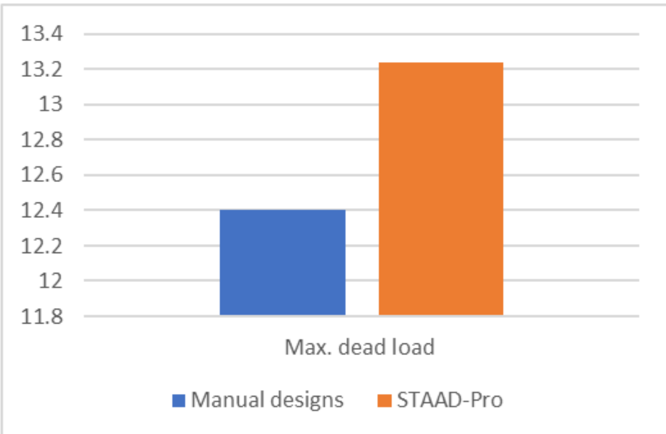


Graph 5- Max live Load on Ties

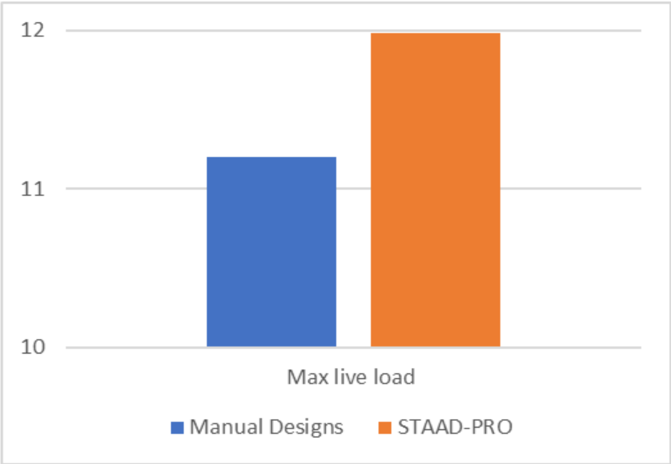


Graph 6 – Max wind load on main ties

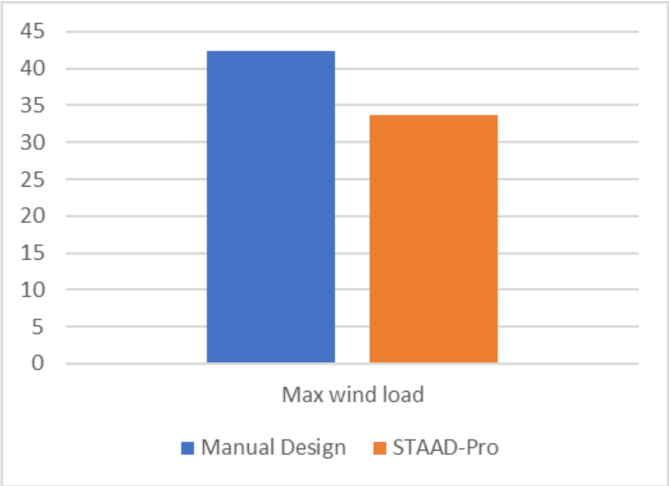
Graphical representation of load on Struts



Graph 7- Max Dead load in Struts

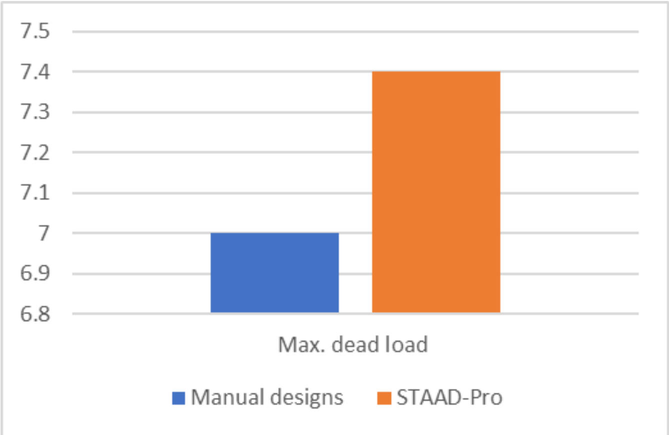


Graph 8- Max live Load in Struts

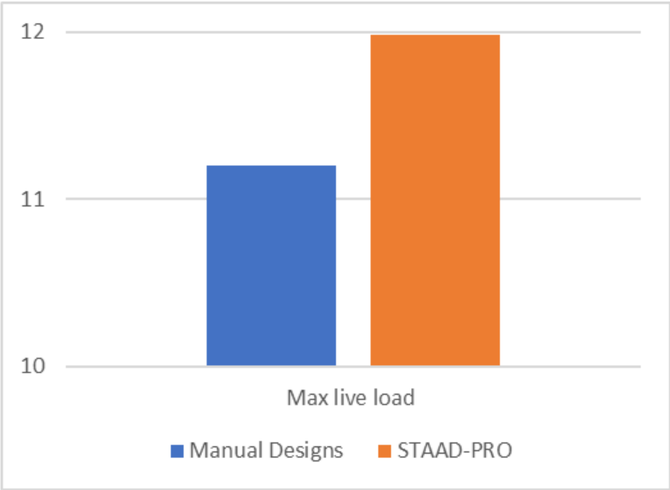


Graph 9–Max wind load on struts

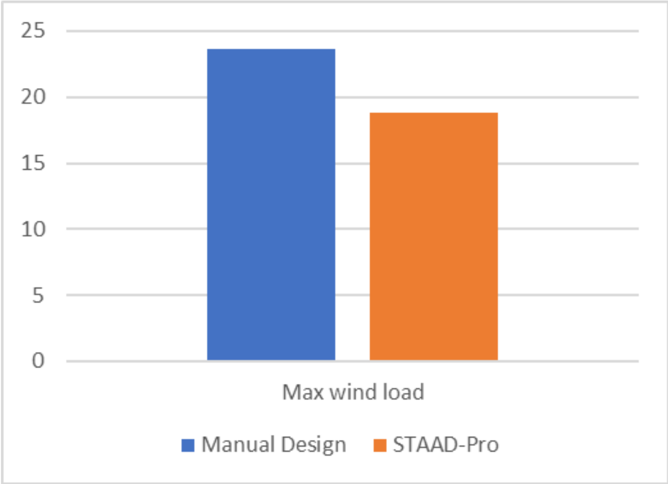
Graphical representation of load on Minor Slings



Graph 10-Max Dead load in Slings

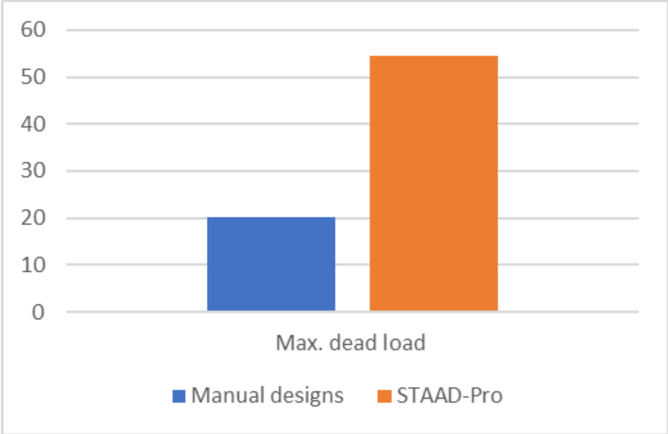


Graph 11-Max live Load in Slings

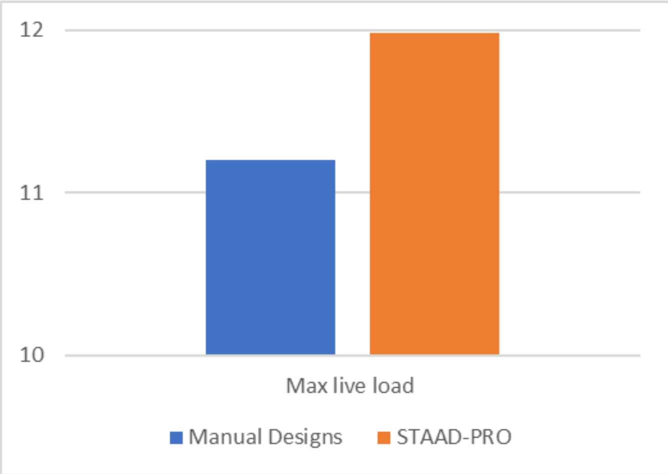


Graph 12–Max wind load on Slings

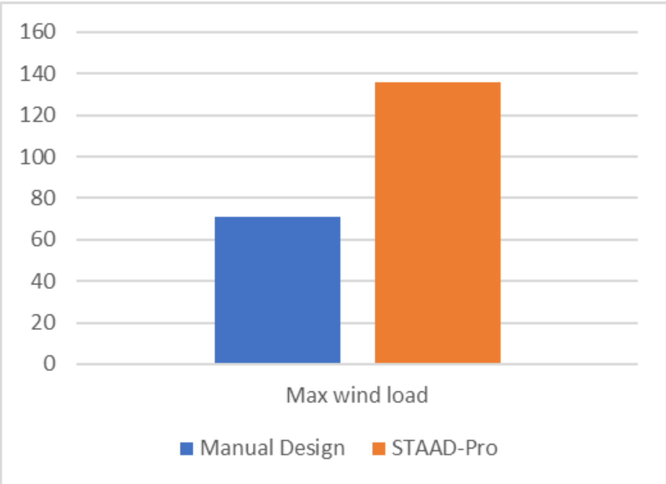
Graphical representation of load on Minor Slings



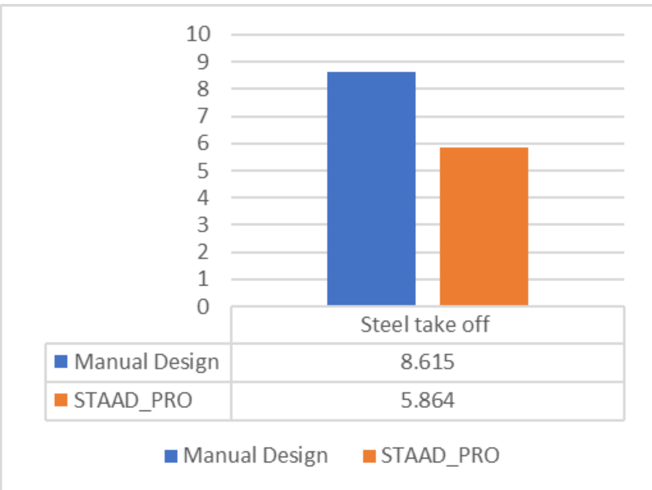
Graph 13-Max Dead load in Slings



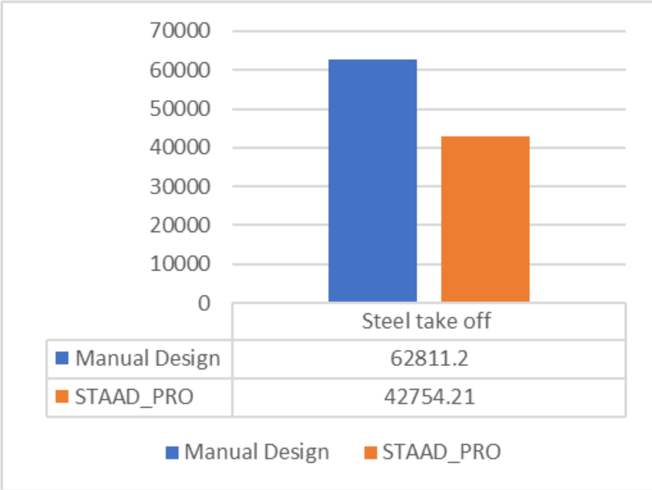
Graph 14-Max live Load in Slings



Graph 15–Max wind load on Slings



Graph no. 16-Steel take-off



Graph NO. 17-Cost Comparison

CONCLUSION

1. From the above results we conclude that the axial forces in MANUAL DESIGN are more as compared to STAAD-PRO.

2. From the above results we conclude that the STAAD-PRO is more economic to use as less forces are required.

3. From the above results we conclude that STAAD-PRO model is more economical and suitable for building as less material are required as can resist a greater number of forces than manual design

REFERENCES

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[2] IS CODE 875- PART 1 -1987 -CODE PRACTICE FOR DESIGN LOADS

[3] IS CODE 875 – PART 2 -1987- (LIVE LOADS)

[4] IS CODE 875 – PART 3- 1987- (DEAD LOAD)