International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 06 | June 2022 www.irjet.net p-ISSN: 2395-0072

Typified design of modified compound fink truss based on IS 800:2007 and IS 875(part 3):2015

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Abstract - *Steel is the most common building material and has been utilized in the construction industry for a long time. Steel has been a popular material choice due to its low cost as well as its versatility, sustainability, and flexibility. Steel is often regarded as a "green" commodity because it is completely recyclable. Steel structure design necessitates a thorough understanding of the fundamental principles behind the analyses of steel structural elements and their linkages. The iterative nature of steel structural element design necessitates rigorous calculations involving mathematical formulae to estimate various forces, moments, stresses, strains, deflections, and so on. As a result, developing such designs takes time and effort.*

This research project has been proposed to assist structural designers involved in steel pitched roof truss design, with the goal of providing a simpler, faster approach to steel truss design in terms of handbooks, i.e., ready-to-use steel truss designs as per limit state method and latest Indian standards. In this study, a modified compound fink truss with changing characteristics such as span, pitch, truss spacing, and wind zone is used. Purlin spacing is maintained at 1.4m, while column height up to the eaves is maintained at 10m.

The truss layout was developed after numerous trials to produce an optimal design with the least amount of structural weight utilizing steel hollow sections in accordance with IS800-2007 and IS875 part-3 2015.

Key Words: Truss, Steel, Design, Industrial Shed, Roof, Structure

1. INTRODUCTION

The research focused on developing a design aid for a typical design of steel pitched roof truss (Modified compound fink Truss) with varied spans and other changeable parameters, employing hollow sections that can be easily employed in steel industrial projects.

The scope of work was to prepare a handbook for different iterations of modified compound fink truss using hollow sections for all the types of members required to build a truss. The members are Upper chord, lower chord, purlin, tie runner, and struts.

In the study, analysis and design of the truss were carried out considering the following parameters:

- Truss spans L : 10m, 15m, 20m, 25m
- Different truss spacing : 4m, 5m, 6m
- Pitch of truss : 1 in 3, 1 in 4, 1 in 6
- Wind speed : 33 m/s, 39 m/s, 44 m/s, 47 m/s, 50 m/s, 55 m/s
- Thickness of roof sheet : 0.5mm, 0.7 mm, 1.0 mm
- Column height : 10m
- Purlin spacing : 1.4m

1.1 Truss Configuration

Figures depict optimized designs for a 10 m spans truss. The truss layout is designed for a certain pitch and span. There are a total of 12 variants with 3 pitches and 4 spans. The principal load instances analyzed, as well as the load combinations used, are also stated. The methodology for analysis and software validation is also presented.

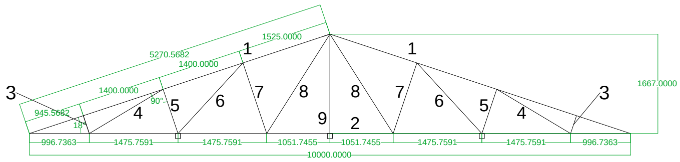

Fig -1: Truss Configuration No.1; span 10m, pitch 1 in 3

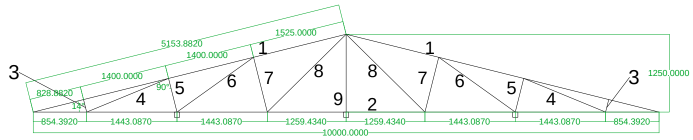

Fig -2: Truss Configuration No.1; span 10m, pitch 1 in 4

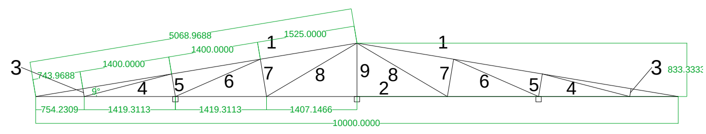

Fig -3: Truss Configuration No.1; span 10m, pitch 1 in 6

2. LOAD CALCULATIONS

1) DEAD LOAD CALCULATION:

Roofing sheet (0.5 mm thick. GC sheet)	= 3.80 kg/m^2	TATA Shaktee Brochure
Dust load	= 5.00 kg/m^2	Assumed
Fixtures	= 5.00 kg/m^2	Assumed
Bracing	= 2.50 kg/m^2	Assumed
Self-weight of purlin	= 6.71 kg/m	96x48x3.2mm RHS

2) LIVE LOAD CALCULATION:

Angle of roof	= 18^0	
Live load (IS:875 (Part-2), 1987) (Table 2)	= 0.75- 0.02 (θ-10)	= 0.59 kN/m^2
Live load (IS:875 (Part-2), 1987) (Cl 4.5.1)	= =2/3*(0.59*4)	= 1.60 kN/m

3) WIND LOAD CALCULATION:

V_b	= 33	Design wind speed at any height, applicable 10m above ground level, m/s	(IS:875 (Part-3), 2015) (Figure 1)
K_1	= 1	Probability Factor, Risk Coefficient	(IS:875 (Part-3), 2015) (Table 1)
K_2	= 1	Open Terrain, height, and structure size factor	(IS:875 (Part-3), 2015) (Table 2)
K_3	= 1	Topography factor (Terrain Category 2)	(IS:875 (Part-3), 2015)
K_4	= 1	Importance factor for cyclone region	(IS:875 (Part-3), 2015)

3. ANALYSIS AND DESIGN RESULTS

3.1 Load Combinations

Load combinations are in accordance with Is 800:2007. From 201 to 213, the limit state of strength load combinations used for member design is described.

Table 1: Load combination for Design

Sr. No.	Load Cases
201	1.5(DL+LL)
202	1.5(DL+W1)
203	1.5(DL+W1)
204	1.5(DL+W1)
205	0.9(DL)+1.5(W1)
206	0.9(DL)+1.5(W2)
207	0.9(DL)+1.5(W3)
208	1.2(DL)+1.2(LL)+1.2(W1)
209	1.2(DL)+1.2(LL)+1.2(W2)
210	1.2(DL)+1.2(LL)+1.2(W3)
211	1.2(DL)+1.2(LL)+0.6(W1)
212	1.2(DL)+1.2(LL)+0.6(W2)
213	1.2(DL)+1.2(LL)+0.6(W3)

3.2 Analysis Results of Truss

Span: 10m
Wind speed: 33 m/s
Pitch of truss: 1 in 6
Thickness of roof sheet: 1.0 mm
Truss Spacing: 4m

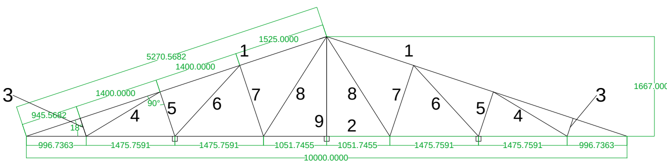

Fig -4: Truss Configuration No.1; span 10m, pitch 1 in 3

The analysis tables are shown in tabular form:

Table 2: Group 1 Axial loads

Group	Member No.	Maximum Compression (kN)	Load Case	Maximum Tension (kN)	Load Case
Rafter	1	58.05	201	28.81	202
		5.89	208	4.46	203
		26.16	209	24.75	204
		9.94	210	38.16	205
		26.16	211	12.82	206
		36.30	212	33.10	207
		28.19	213		

Table 3: Group 2 Axial loads

Group	Member No.	Maximum Compression (kN)	Load Case	Maximum Tension (kN)	Load Case
Bottom Chord	2	27.43	202	54.63	201
		5.22	203	5.75	208
		24.18	204	23.51	209
		35.43	205	8.34	210
		13.22	206	24.73	211
		32.19	207	33.61	212
				26.02	213

3.3 Design Results of Truss

Span: 10m
Wind speed: 33 m/s, 39 m/s, 44 m/s, 47 m/s, 50 m/s, 55 m/s
Pitch of truss: 1 in 3, 1 in 4, 1 in 6
Thickness of roof sheet: 1.0 mm
Truss Spacing: 4m, 5m, 6m

The design tables are shown in tabular form:

Table 4: Group 3 Axial loads

Group	Member No.	Maximum Compression (kN)	Load Case	Maximum Tension (kN)	Load Case
Member	3	4.31	201	2.97	205
	4	7.75	205	5.89	201
	5	6.68	201	5.10	205
	6	8.66	201	6.55	205
	7	9.38	201	7.20	205
	9	0.1	201	0.09	202
	3	4.31	201	2.97	205

Table 5: Summary of Truss weight for roofing sheet thickness of 1 mm (kg/m2)

Span (m)	Pitch	Truss spacing (m)	Wind speed 33 (kg/m²)	Wind speed 39 (kg/m²)	Wind speed 44 (kg/m²)
10	1in3	4	2.20	2.28	2.86
		5	1.84	2.01	2.78
		6	1.72	1.83	2.42
	1in4	4	2.64	3.67	5.90
		5	2.69	3.44	4.72
		6	2.41	3.34	5.39
	1in6	4	3.52	3.88	4.68
		5	3.10	3.16	4.41
		6	2.87	3.19	4.23

Table 6: Summary of Truss weight for roofing sheet thickness of 1 mm (kg/m2)

Span (m)	Pitch	Truss spacing (m)	Wind speed 47 (kg/m²)	Wind speed 50 (kg/m²)	Wind speed 55 (kg/m²)
10	1in3	4	2.51	3.54	3.06
		5	2.43	3.03	2.91
		6	2.35	2.88	2.62
	1in4	4	5.05	6.51	6.50
		5	4.04	5.21	5.20
		6	4.63	6.66	6.08
	1in6	4	4.26	5.80	5.11
		5	3.97	5.76	5.13
		6	3.69	5.45	5.27

3. CONCLUSIONS

It is observed that as the roof slope decreases, the weight of the truss increases.

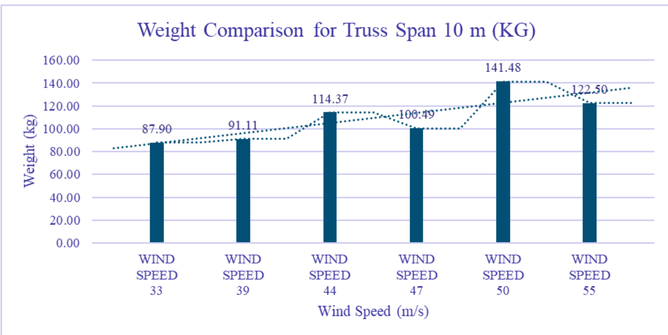

Chart -1: Total weight variation for Span 10 m, Slope 1 in 3 Bay 4m, R.S. thickness 0.5 mm

The trusses intended for wind zones 44 m/s and 55 m/s are heavier than the rest of the zones because these zones are influenced by cyclonic storms. According to IS 875-part 3 (2015), the importance factor for the cyclonic zone is 1.15 in the design wind pressure calculation for the location which is less than 60 km from the sea.

The proposed handbook will provide structural designers with ready-to-use designs of steel pitched roof trusses and mono slope roof trusses in accordance with the most recent Indian Standards, namely IS800 -2007 and IS875 Part 3, 2015, for various spans, pitches, truss spacings, and across the country, incorporating all wind zones.

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