International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 06 | June 2019 www.irjet.net p-ISSN: 2395-0072

OPTIMIZATION OF INDUSTRIAL TRUSS

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Abstract –*We know that India is the fastest growing country in the world. We can also see that industries are increasing day by day. These industries are built using steel truss. If proper design and analyses are not done there is a chance of increase in weight of truss which in turn increases the cost of construction. So to reduce and optimize the truss proper design and analyses is required. In the present work we have considered a truss of span 16m. We have analyzed this truss by varying its slope and taking different sections and shapes of trusses by using staad pro software. After analyses is completed results obtained are compared with each other to obtain the lesser and optimum weight truss. After the comparison of results we have found that for all six type of truss pipe section was more economical. We have found that truss with slope of 20.6 of pipe sections is lesser and optimum in weight and it is found to be more economical compared to all six types of trusses*

Key Words: **Lesser weight, Fink type truss, slopes, Auto caad and staad pro, sections.**

1. INTRODUCTION

The members which are joined at the joints is called as truss. The truss members are normally straight. It is formed by joining different members depending upon different span, slopes, type and sections. Steel trusses are increasing in construction of industrial buildings. Because of increase in construction of steel buildings all over India there is a need of lowering the overall weight of truss. The design should also satisfy all the various conditions.

Industrials buildings are of two types one is braced structures and other is unbraced structures. In braced structures, for stability of trusses in three mutually perpendicular directions bracings are provided and columns are provided to support the trusses. The unbraced trusses are most commonly used truss in industrial structures as these are economy, simple in design, easy and faster to construct. These are used for larger areas. As the cost of steel as well as other items is increasing day by day we need have a optimum design.

1.1 Literature review

Dr. Vivek Garg, et.al (2015) [1], In his work he have considered a truss of span 16m with different geometries and sections to get the optimum weight. He have performed the analyses using staad pro software. The analysis results are compared to obtain optimum truss design. The results indicate that A-type truss has lesser weight compared to other truss geometries. The truss consists of tube or square hollow section is having much lesser weight compared to angle section. The optimum truss slope is found nearly 24^0. The truss with rigid connection between members is found heavier than the truss with pin connection.

Er. Raj winder Singh Bansal, et.al. (Vol.5, June 2016) [2], The aim of this is to concentrate on the impacts of various truss shapes in the design of plane truss by utilizing angle section. In the present study different spans and depth of 20 shape trusses were selected and designed with the guide of STAADPro. The span of 8m, 9m, 10m, 12m, 14m and depth is $1/4^{th}$and 1/5th of span is selected. He has found out from his study that the best truss shape is really particular for each truss span and height.

A. Jayaraman, et.al, (Vol.3, Oct 2014)[3], This paper presents a study on behaviour and economical of roof trusses and purlins by comparison of limit state and working stress method. The studies reveal that the theoretical investigations limit state method design has high bending strength, high load caring capacity, minimum deflection and minimum local buckling & distortional buckling compare to the working stress method. But working stress method is most economical compare to the limit state method design. In working stress method, the total weight of steel is required 1502 kg and total rate of cost is RS 82,610. The limit state method the total weight of steel is required 2308 kg and total rate of cost is RS 126,940. In this paper it is found that for limit state method the total quantity of weight of steel and rate of cost is 34.78% higher than the working stress method.

1.2 Objectives

The main objective our studies are as follows;

a) Giving the most economical design.
b) Reducing the quantity of steel required.
c) Reducing the overall weight of the structure there by reducing the cost of columns.

1.3 Load consideration

1.3.1Dead load

Dead load on the roof trusses in single storey industrial buildings consists of dead load of claddings and dead load of purlins, self-weight of the trusses in addition to the weight of bracings etc.

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1.3.2 Live load

The live load on roof trusses consist of the gravitational load due to erection and servicing as well as dust load etc. and the intensity is taken as per IS:875-1987.

1.3.3 Wind load

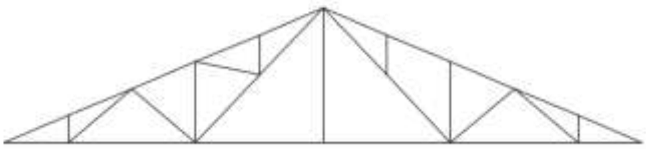
Wind load on the roof trusses, unless the roof slope is too high, would be usually uplift force perpendicular to the roof, due to suction effect of the wind blowing over the roof. Wind load is considered as per IS 875- part III.

1.4 Load combinations

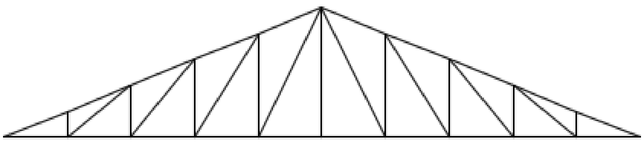
1. DL+ LL
2. 1.5DL+1.5LL
3. 1.5DL+1.5WL0
4. 1.5DL+1.5WL90
5. 0.9DL+1.5WL0
6. 0.9DL+1.5WL90
7. 1.2DL+1.2LL+1.2WL0
8. 1.2DL+1.2LL+1.2WL90

2. Modeling

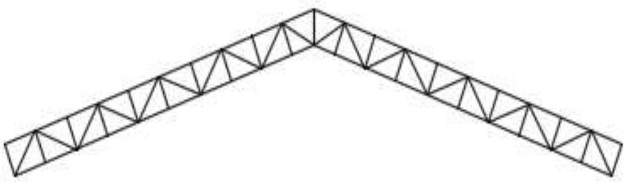
In the market different geometries and sections of trusses are available. In this work we have considered six different shapes of trusses with four different slopes and three different sections. The figures of different geometries and sections are shown in fig 1 and fig 2.



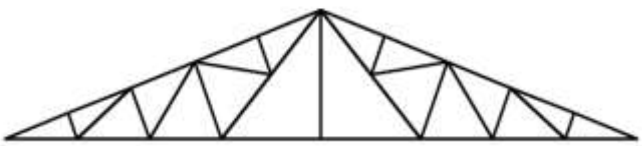
a) A-type truss



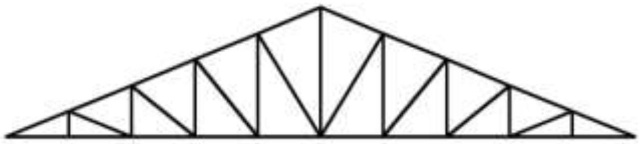
b) Howe truss



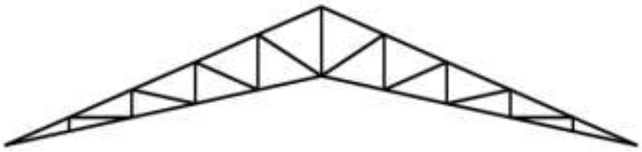
c) Lattice truss



d) Fink truss

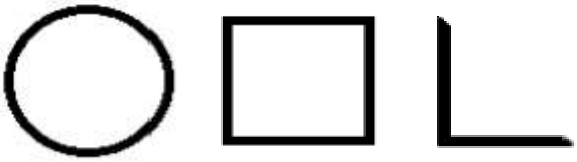


e) Pratt Truss



f) Cambered truss

Fig 1. Types of truss geometries used



a) Tube b) Pipe c) Angle

Fig 2. Types of sections

3. Analysis

The various types of trusses have been considered and they are analyzed using a computer software called staad pro. The trusses which are used are analyzed for various dead loads, live loads and wind loads. These are considered as per IS 875 part I, II and III.

Table 1. Parameters of truss design

Sl. No.	Particulars	Data
1.	Span of truss	16 m
2.	Spacing between trusses	4 m
3.	Location	Mangalore
4.	Roofing	Asbestos sheets (dead weight = 171 N/m^2)
5.	Self-weight of purlin	318 N/m^2
6.	Live load	750 N/m^2
7.	Wind zone	5
8.	Basic wind speed (V_b)	39 m/sec
9.	Probability factor or risk co-efficient (K_1)	1 (for 50 years)
10.	Terrain heights and structure size factor (K_2)	1.03 (for category 1, class B structure & building heights 6m)
11.	Topography factor (K_3)	1 (for plain land)

4. About the models

We have considered six different types of truss for analysis. We have considered A-type, Howe, Lattice, Fink, Pratt and Cambered type truss. For this truss different loads and sections are applied and analyzed using staad pro software. This consists of four different models with 14°, 17.4°, 20.6° and 23.6° slopes and three different sections i.e. angle, tube, pipe. In this we have considered category 1 and class B type of structures with asbestos sheeting's and results are compared with other models for optimum design.

Table 2. Details of models

Sl. no	Type	Slope (θ)	Section	Model name
1.	A-type truss	14.0°	Angle	Model 1
			Pipe	Model 2
			Tube	Model 3
		17.4°	Angle	Model 4
			Pipe	Model 5
			Tube	Model 6
		20.6°	Angle	Model 7
			Pipe	Model 8
			Tube	Model 9
		23.6°	Angle	Model 10
			Pipe	Model 11
			Tube	Model 12
2.	Howe type truss	14.0°	Angle	Model 13
			Pipe	Model 14
			Tube	Model 15
		17.4°	Angle	Model 16
			Pipe	Model 17
			Tube	Model 18
		20.6°	Angle	Model 19
			Pipe	Model 20
2.	N-type truss		Tube	Model 21
		23.6°	Angle	Model 22
			Pipe	Model 23
			Tube	Model 24
3.	Lattice type truss	14.0°	Angle	Model 25
			Pipe	Model 26
			Tube	Model 27
		17.4°	Angle	Model 28
			Pipe	Model 29
			Tube	Model 30
		20.6°	Angle	Model 31
			Pipe	Model 32
			Tube	Model 33
			Angle	Model 34
		23.6°	Pipe	Model 35
			Tube	Model 36
4.	Fink type truss	14.0°	Angle	Model 37
			Pipe	Model 38
			Tube	Model 39
		17.4°	Angle	Model 40
			Pipe	Model 41
			Tube	Model 42
		20.6°	Angle	Model 43
			Pipe	Model 44
			Tube	Model 45
		23.6°	Angle	Model 46
			Pipe	Model 47
			Tube	Model 48
5.	Pratt type truss	14.0°	Angle	Model 49
			Pipe	Model 50
			Tube	Model 51
		17.4°	Angle	Model 52
			Pipe	Model 53
			Tube	Model 54
		20.6°	Angle	Model 55
			Pipe	Model 56
			Tube	Model 57
		23.6°	Angle	Model 58
			Pipe	Model 59
			Tube	Model 60
6.	Cambered type truss	14.0°	Angle	Model 61
			Pipe	Model 62
			Tube	Model 63
		17.4°	Angle	Model 64
			Pipe	Model 65
			Tube	Model 66
		20.6°	Angle	Model 67
			Pipe	Model 68
			Tube	Model 69
		23.6°	Angle	Model 70
			Pipe	Model 71
			Tube	Model 72

5. Results and discussion

The results of various analyses for different geometries, sections and support conditions are compared for obtaining optimum and economical truss design. The below mentioned table gives the weight of different type of truss for different section and different slope conditions.

Table 3. Weight of different truss geometries

Truss Geometry	Slope (θ)	Type of Section	Members			Weight (KG)
			Top Chord	Bottom Chord	Other members	
A-type truss	14.0 °	Angle	ISA 55*55*6 LD	ISA 90*90*6 LD	ISA 55*55*6	591.02
		Pipe	PIP 1016 M	PIP 761 M	PIP 424 M	357.30
		Tube	TUB 70*70*4	TUB 89*89*3.6	TUB32*32*4	394.11
	17.4 °	Angle	ISA 50*50*6 LD	ISA 80*80*6 LD	ISA 55*55*6	556.45
		Pipe	PIP 603 M	PIP 889 M	PIP 424 M	318.96
		Tube	TUB63*63*3.6	TUB 72*72*4.8	TUB 35*35*2.6	371.27
	20.6 °	Angle	ISA 45*45*6 LD	ISA 70*70*6 LD	ISA 60*60*6	540.95
		Pipe	PIP 603 M	PIP 889 M	PIP 424 M	330.38
		Tube	TUB 48*48*3.7	TUB 75*75*3.2	TUB 32*32*3.2	299.89
	23.6 °	Angle	ISA 50*50*6 LD	ISA 65*65*6 LD	ISA 65*65*6	570.93
		Pipe	PIP 603 M	PIP 761 M	PIP 424 M	312.23
		Tube	TUB 48*48*3.7	TUB 63*63*4.5	TUB 35*35*2.6	322.02
Howe type truss	14.0 °	Angle	ISA 55*55*6 LD	ISA 65*65*6 LD	ISA 55*55*6 LD ISA 45*45*6	546.46
		Pipe	PIP 761 M	PIP 889 M	PIP 483 M	351.39
		Tube	TUB 63*63*4.5	TUB 63*63*4.5	TUB 45*45*3.2	363.12
	17.4 °	Angle	ISA 50*50*6 LD	ISA 55*55*6 LD	ISA 55*55*6 LD ISA 55*55*6	555.84
		Pipe	PIP 603 M	PIP 761 M	PIP 603 M PIP 424 M	319.78
Fink type truss	14.0 °	Angle	ISA 55*55*6 LD	ISA 65*65*6 LD	ISA 55*55*6 ISA 35*35*6	494.15
		Pipe	PIP 603 H	PIP 889 M	PIP 424 M PIP 337 M	330.08
		Tube	TUB 63*63*4.5	TUB 63*63*4.5	TUB 35*35*2.6 TUB 25*25*2.6	350.17
	17.4 °	Angle	ISA 50*50*6 LD	ISA 60*60*6 LD	ISA 55*55*6 ISA 45*45*6	482.42
		Pipe	PIP 603 M	PIP 761 M	PIP 424 M PIP 337 M	281.54
		Tube	TUB 49*49*4.5	TUB 63*63*3.6	TUB 38*38*2.6 TUB 30*30*2.6	297.24
	20.6 °	Angle	ISA 45*45*6 LD	ISA 50*50*6 LD	ISA 60*60*6 ISA 55*55*6	465.70
		Pipe	PIP 603 M	PIP 603 M	PIP 424 M PIP 337 M	270.22
		Tube	TUB 45*45*4.5	TUB 63*63*3.2	TUB 32*32*4 TUB 32*32*3.2	296.73
	23.6 °	Angle	ISA 45*45*6 LD	ISA 55*55*6 LD	ISA 65*65*6	522.80
		Pipe	PIP 603 M	PIP 603 M	PIP 483 M PIP 424 M	286.03
		Tube	TUB 45*45*3.6	TUB 63*63*3.2	TUB 35*35*4 TUB 35*35*3.2	297.75
Pratt type truss	14.0 °	Angle	ISA 55*55*6 LD	ISA 65*65*6 LD	ISA 65*65*6	496.80
		Pipe	PIP 761 M	PIP 889 M	PIP 483 M PIP 424 M	320.29
		Tube	TUB 63*63*4.5	TUB 63*63*4.5	TUB 45*45*3.2 TUB 35*35*3.2	340.38
	17.4 °	Angle	ISA 50*50*6 LD	ISA 55*55*6 LD	ISA 70*70*6 ISA 60*60*6	486.91
		Pipe	PIP 603 M	PIP 761 M	PIP 424 M	276.95
		Tube	TUB 49*49*4.5	TUB 63*63*3.6	TUB 40*40*4 TUB 32*32*3.2	312.54
	20.6 °	Angle	ISA 45*45*6 LD	ISA 50*50*6 LD	ISA 90*90*6 ISA 65*65*6	520.76
		Pipe	PIP 603 M	PIP 603 M	PIP 483 M PIP 424 M	280.01
		Tube	TUB 48*48*3.7	TUB 49*49*4.5	TUB 45*45*3.6	326.81

		Tube	TUB 63*63*3.6	TUB 63*63*3.6	TUB 48*48*3.7	337.83
	20.6 °	Angle	ISA 50*50*6 LD	ISA 50*50*6 LD	ISA 60*60*6 LD ISA 65*65*6	611.00
		Pipe	PIP 603 M	PIP 603 M	PIP 603 M PIP 424 M	317.13
		Tube	TUB 48*48*3.7	TUB 49*49*4.5	TUB 49*49*4.5 TUB 40*40*4	365.16
	23.6 °	Angle	ISA 50*50*6 LD	ISA 50*50*6 LD	ISA 70*70*6 LD ISA 80*80*6	724.09
		Pipe	PIP 603 M	PIP 603 M	PIP 761 M PIP 483 M	382.18
		Tube	TUB 45*45*3.6	TUB 45*45*4.5	TUB 45*45*4.5 TUB 63*63*3.2	388.61
Lattice type truss	14.0 °	Angle	ISA 80*80*6 LD	ISA 65*65*6 LD	ISA 80*80*6 ISA 25*25*5	686.16
		Pipe	PIP 889 M	PIP 1016 M	PIP 603 M PIP 213 M	465.90
		Tube	TUB 89*89*4.9	TUB 91*91*3.6	TUB 45*45*4.5 TUB 25*25*2.6	553.70
	17.4 °	Angle	ISA 75*75*6 LD	ISA 55*55*6 LD	ISA 75*75*6 ISA 25*25*5	626.71
		Pipe	PIP 889 M	PIP 889 M	PIP 603 M PIP 213 M	446.73
		Tube	TUB 75*75*4.9	TUB 70*70*4	TUB 45*45*4.5 TUB 25*25*2.6	486.50
	20.6 °	Angle	ISA 55*55*6 LD	ISA 65*65*6 LD	ISA 70*70*6 ISA 25*25*5	578.88
		Pipe	PIP 889 M	PIP 761 M	PIP 603 M PIP 213 M	414.30
		Tube	TUB 63*63*3.6	TUB 72*72*4	TUB 49*49*3.6 TUB 25*25*2.6	411.86
	23.6 °	Angle	ISA 55*55*6 LD	ISA 55*55*6 LD	ISA 60*60*6 LD ISA 75*75*6 ISA 25*25*5	561.14
		Pipe	PIP 889 M	PIP 761 M	PIP 603 M PIP 213 M	417.26
		Tube	TUB 70*70*4.9	TUB 75*75*3.2	TUB 63*63*3.2 TUB 25*25*2.6	476.59
Pratt type truss	23.6 °	Angle	ISA 45*45*6 LD	ISA 50*50*6 LD	ISA100*100*6 ISA 80*80*6	593.57
		Pipe	PIP 603 M	PIP 603 M	PIP 483 M PIP 761 M	337.93
		Tube	TUB 45*45*3.6	TUB 48*48*4.5	TUB 48*48*4.5 TUB 63*63*3.6	382.90
Cambered type truss	14.0 °	Angle	ISA 75*75*6 LD	ISA 90*90*6 LD	ISA 55*55*6 ISA 30*30*5	575.72
		Pipe	PIP 1016 M	PIP 1270 M	PIP 761 M PIP 269 M	488.33
		Tube	TUB 100*100*5	TUB 90*90*5.4	TUB 35*35*2.6 TUB 25*25*2.6	512.20
	17.4 °	Angle	ISA 65*65*6 LD	ISA 80*80*6 LD	ISA 55*55*6 ISA 35*35*6	526.06
		Pipe	PIP 889 M	PIP 1143 M	PIP 424 M PIP 269 M	394.11
		Tube	TUB 90*90*4.5	TUB 89*89*4.5	TUB 35*35*2.6	442.45
	20.6 °	Angle	ISA 60*60*6 LD	ISA 70*70*6 LD	ISA 55*55*6	500.57
		Pipe	PIP 761 M	PIP 889 M	PIP 424 M PIP 269 M	304.48
		Tube	TUB 89*89*3.6	TUB 89*89*3.6	TUB 32*32*4 TUB 25*25*2.6	381.06
	23.6 °	Angle	ISA 55*55*6 LD	ISA 65*65*6 LD	ISA 55*55*6 ISA 40*40*6	471.51
		Pipe	PIP 761 M	PIP 889 M	PIP 337 M	321.10
		Tube	TUB 63*63*4.5	TUB 72*72*4	TUB 30*30*2	336.91

6. CONCLUSIONS

In the present work on optimization of truss, we have analyzed for various slopes, sections, supports and type of truss and the we have obtained following conclusions;

i. From above observation and results we can conclude that for slope of 14° and 17.4° Pratt truss is more economical. For slope of 20.6° fink type truss is found to be economical and lastly for slope of 23.6° A-type truss is found to be economical with optimum weight.

ii. Different sections are also used to obtain optimum weight. For A-type truss with slopes 14°, 17.4° and 23.6° pipe section is economical and for 20.6° slope tube section is economical.
In Howe, lattice, fink, Pratt and cambered type of slopes we have found that for all slopes i.e. 14°, 17.4°, 20.6° and 23.6° pipe section is economical.

iii. In truss there will be deflection due to the application of various loads. The minimum deflection is found to be 15.533 mm for slope of 23.6° in Howe type truss and maximum deflection is 137.845 mm for slope of 14° in cambered type truss.

iv. From overall study, analysis and comparison of resultant weight obtained for different type of trusses with three different sections and four different slopes it is found that fink type truss with slope 20.6° of pipe section is lesser and optimum in weight and it is found to be economical for span of 16 m.

The present study shows that the analysis of truss for different slope and sections is very much essential for the optimization of truss and make it an economical truss.

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