ISSN 2056-5860

DEVELOPMENT OF WEIGHT BASED DECISION SUPPORT SYSTEM FOR OPTIMUM ECONOMIC ROOF TYPE FOR A GARBLE FRAME

Okonkwo, V. O.
Department of Civil Engineering
Nnamdi Azikiwe University
Awka, **NIGERIA**

Mbachu, V. M.
Department of Industrial & Production Engineering
Nnamdi Azikiwe University Awka, **NIGERIA**

ABSTRACT

The choice of roof truss type for use in buildings is arbitrary and often determined by a simple rule of thumb. It is usually difficult or time consuming in determining an economic roof truss type at the design period. In this work five commonly used roof truss types of the same span were chosen and analyzed for internal stresses (axial forces in the members). An expression for the weight of the truss element as a function of its axial force was developed. This was used to compute a weight coefficient for the truss. Values of this coefficient were compared for roof trusses of different types, and at different roof pitches. The results showed that the flat pitch truss and the warren truss generally gave an economic design for roof trusses. The pratt truss and fink truss gave a more expensive design for lower pitches and this increase comparatively for higher pitches. It was observed that at very high pitch heights (heights greater than 8m) the calculated weights of the roofs tend to converge. Hence the choice of roof truss type at such pitch height should be governed by other considerations other than weight.

Keywords: Economic design, roof truss types, roof cost.

INTRODUCTION

Truss was derived from the old French word 'trousse' which means "collection of things bound together" [1,2]. In engineering a truss is regarded as a single plane framework of individual structural members connected at their ends to form series of triangles that span large distances [3]. The triangular arrangement of elements in trusses typically offers structural stability [4]. The most common use of trusses in buildings is to provide support to roofs, floors and such internal loadings as services and suspended ceilings [5]. The type of truss selected for any role is determined by the expected load and span [6]. The pratt truss has diagonals in tension and vertical members in compression under normal loading and since the diagonals are longer this is an advantage. The compression members however are more heavily loaded than the tension members [7]. In the howe truss the tension cord is more heavily loaded than the compression cord under normal loading [8]. The fink truss because of its unique configuration is economical for high pitched long span roofs [9]. The warren truss has equal length of compression and tension members resulting in net savings in steel weight for short spans. It is cheaper to use trusses when the span of the roof is more than 40feet [10]. All these trusses can be used to achieve the same objective but with varying efficiency and cost. It is important to know the truss type to adopt when least weight is paramount.

METHODOLOGY

Five trusses of the same pitch and span were selected. They are the pratt truss, fink truss, howe truss, warren truss and flat pitch truss. The trusses were analysed under normal roof loading to determine the axial forces P in their members. The selected pitch heights were 2m, 4m, 6m and 8m while the span was kept constant at 20m. The weight of steel is directly proportional to its volume.

$steel\ weight\ \alpha\ L\ \times A$ . . . . (1)

Where L is the length of the member and A its cross sectional area. By introducing a constant of proportionality K and stress $\sigma = {}^{P}/_{A}$ we find out

$\frac{weight \times \sigma}{K} = L \times P$ . . . . (2)

Since K and σ are all constants for homogenous material we can state that

$weight\ coefficent(wc) = L \times P$ . . . . (3)

The weight coefficient (wc) was used as a expression of the weight of the truss.
The truss analysis parameter were
Spacing of truss =5m
Pitch height = 2m
Dead load (on plan) = 0.38kN/m2
Imposed load (on plan) = 0.75kN/m2
Distance between purlins = 1.08m.

RESULTS AND DISCUSSION

The results of the analysis of the Pratt truss (Figure 1) is presented in table 2. The computed length and axial force in truss elements were used to compute their element weight coefficients. These were summed together to get the total truss weight coefficient. The results from the analysis of the fink, Howe, warren and flat pitch trusses are presented in table 3, 4, 5 and 6 respectively. By extracting the total weight coefficient from these tables are summary of the results were presented in Table 1.

Table 1: Summary of the results arrange in order of increasing weight coefficient

Truss Type	**Weight coefficient**			
	2m pitch	**4m pitch**	**6m pitch**	**8m pitch**
Flat pitch	654.2	510.39	493.08	547.28
Warren	652.43	489.13	587.99	523.88
Howe	2236.08	1532.22	844.18	678.93
Fink	2670.4	1393.58	1023.18	914.2
Pratt	2888.43	1472.78	1131.32	999.95

The table above shows that the weight of these truss type even under the same external load varies and this variation is further reinforced when the roof pitch height is varied. To appreciate the results of the table it is necessary to put it in graphical form (see figure 1)

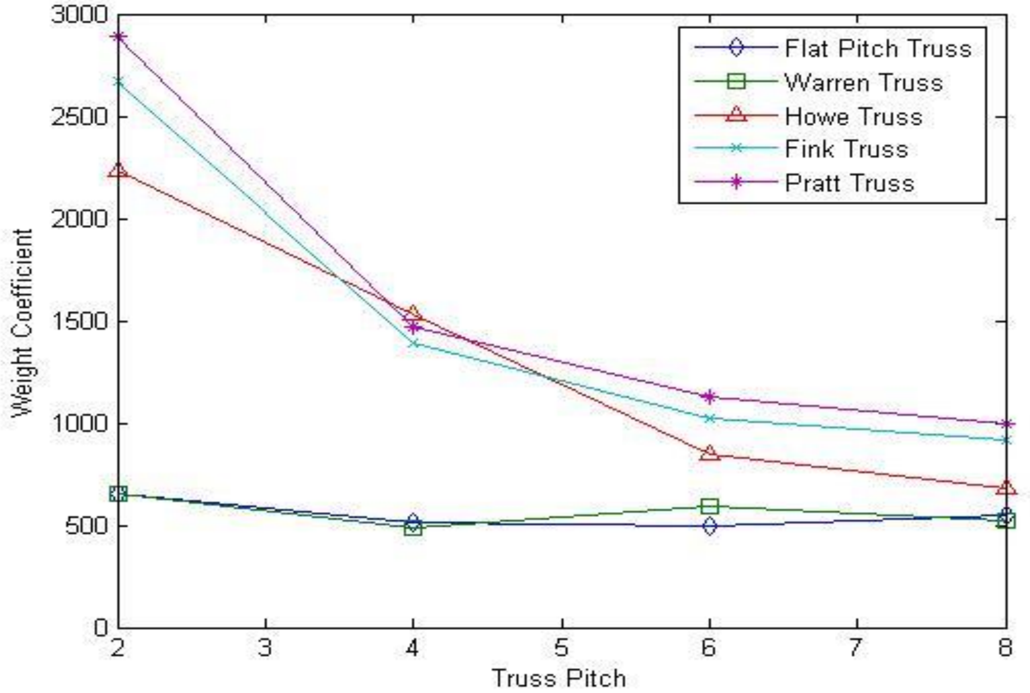

Figure 1: A graph of weight coefficient against truss pitch for different types of trusses

From figure 1 the following observations are made

i) The warren and the flat pitch truss are generally lighter, followed by the howe truss, then the fink and finally the pratt truss.

ii) The weight coefficient of each truss decreased at increasing pitches. This shows that trusses are more efficient at higher pitches.

iii) For trusses of pitch height 3.5m to 5m, the fink and pratt truss is more economical than the howe truss.

iv) As the pitch height increases the difference in the weight coefficient for the different truss types reduced drastically which shows that for high pitch roofs, the choice of truss types might not be very necessary.

CONCLUSION AND RECOMMENDATION

The weight of steel roof affect the cost of the building as this weight no doubt must be supported by other structural elements of the building. Hence a light roof will invariably lead to some savings in cost. The flat roofs, with low pitch heights offer least roof weight and for such a roof system the flat pitch and warren truss offer the considerably a sound structural system. The flat pitch truss was the lightest amongst the common types of roof trusses. It has the least values of axial forces in the members which makes it more efficient in load carrying.

It is important to note that this work did not factor in the cost implication of connections in the studied roof types. Numerous or complex connections attract high cost that can offset the benefits of lighter weight and this is the object of future research.

ISSN 2056-5860

REFERENCES

[1] Douglas H (2011), Online Etymology Dictionary, www.etymonline.com/index.php?term = truss

[2] Wehmeier S, Mcintosh C, Turnbull J. and Ashby M (2006), Oxford Advanced Learner's Dictionary, Seventh Edition, Oxford University Press, New York

[3] Shekhar R. K. C.(2005), Academic dictionary of Civil Engineering, Isha Books Delhi,

[4] Beer F and Johnston R (2013), Vector Mechanics for Engineers, Statics, Tenth Edition, New York, McGraw-Hill

[5] Megson T. H. G.,(2005). *Structural and Stress Analysis*, 2nd Edition, Elsevier Butterworth-Heinemann, Oxford

[6] Tasou P.,(2007). Trusses: *Steel Designer's Manual* Sixth Edition, Blackwell Science Ltd, United Kingdom

[7] Stalnaker J. J (2013), Structural Design in Wood, Springer Science and Business Media,U. S. A

[8] Schmits B (2008), Design Considerations for parallel chord one-way long span steel trusses, Unpublished M.Sc Thesis, Department of Architectural Engineering, Kansas State University, Kansas

[9] Ghogare K. K., Deshmukh S. K (2014), Stability Analysis of Industrial Shed subjected to wind load, International Journal for Engineering Application and Technology, pp 78 – 81

[10] Fisher J. (1993), Industrial Buildings-Roofs, AISC Steel Design Guide Series No. 7 U. S. A

Appendix

Table 2: Summary of the results of the Pratt truss analysis for the 2m pitch

Member	Length (m)	Axial force P (kN)	Weight coefficient L x P
AC	5	65.25	326.25
CE	5	65.25	326.25
EG	5	65.25	326.25
GH	5	65.25	326.25
HF	5.1	66.54	326.25
FD	5.1	44.39	226.39
DB	5.1	85.29	434.98
BA	5.1	66.54	339.35
BC	1	0	0
BE	5.1	22.155	112.99
DE	2	8.69	17.38
EF	5.1	22.155	112.99
FG	1	0	0
			2888.43

Vol. 3 No. 4, 2015
ISSN 2056-5860

Table 3: Summary of the results of the Fink truss analysis for the 2m pitch

Member	**Length (m)**	**Axial force P (kN)**	**Weight coefficient L x P**
AC	4	65.25	261
CE	4	89.05	356.2
EG	4	32.7	130.8
FH	4	89.05	356.2
HI	4	65.25	261
IG	5.10	66.54	339.35
GD	5.10	9.13	45.56
DB	5.10	9.13	45.56
BA	5.10	66.54	339.35
CB	4.123	8.69	35.83
BE	4.123	35.5	147.37
ED	3.2	26.09	83.49
DF	3.2	26.09	83.49
FG	4.123	35.5	147.37
GH	4.123	8.69	35.83
			2670.4

Table 4: Summary of the results of the Howe truss analysis for the 2m pitch

Member	**Length (m)**	**Axial force P (kN)**	**Weight coefficient L x P**
AB	5	67	335
BC	5	55.28	276.4
CD	5	55.28	276.4
DE	5	45.45	227.25
EF	1	4.35	4.35
FG	5.09	0	0
GH	5.09	3.75	19.08
HI	5.09	3.75	19.08
IJ	5.09	0	0
JA	1	4.35	4.35
AI	5.09	68.64	349.378
IB	1	58.62	58.62
BH	5.09	59.78	304.28
HC	1	0	0
HD	5.09	50.13	255.16
GD	1	49.16	49.16
GE	5.09	13.31	57.57
			2236.08

ISSN 2056-5860

Table 5: Summary of the results of the Warren truss analysis for the 2m pitch

Member	**Length (m)**	**Axial force P (kN)**	**Weight coefficient L x P**
AB	5	2.61	13.05
BC	5	4.34	21.7
CD	5	4.34	21.7
DE	5	34.78	173.9
EF	1	4.35	4.35
FG	5.02	0	0
GH	5.02	3.75	18.3
HI	5.02	3.75	18.3
IJ	5.02	0	0
JA	1	4.35	4.35
JB	5.02	13.31	67.75
IB	1	8.69	8.69
BH	5.02	8.86	45.1
HC	1	0	0
HD	5.02	35.47	180.54
GD	1	6.95	6.95
DF	5.02	13.31	67.75
			652.43

Table 6: Summary of the results of the Flat pitch truss analysis for the 2m pitch

Member	**Length (m)**	**Axial force P (kN)**	**Weight coefficient L x P**
AB	5	2.61	13.05
BC	5	1.73	8.65
CD	5	1.73	8.65
DE	5	40.82	204.1
EF	1	4.35	4.35
FG	5.02	0	0
GH	5.02	3.75	18.83
HI	5.02	3.75	18.83
IJ	5.02	0	0
JA	1	4.35	4.35
JB	5.09	13.31	67.75
IC	5.09	4.47	22.75
GC	5.09	39.86	202.89
GD	1	7.89	7.89
IB	1	4.36	4.36
FD	5.09	13.31	67.75
HC	1	0	0
			654.20