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Effect of Variation in Geometrical Parameters on the Roof Trusses

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ABSTRACT: The purpose of this project is to study the Effect of variation in geometrical parameters on the roof trusses in the design of plane truss by using angle section. The need of this study arises where sometimes it is difficult or taking much time to choose effective and economical truss geometry during the design period. In investigating the effectiveness of various truss geometry, a total of nine-truss geometry with simply pinned supports are chosen. The design loads are distributed to the joints so that there is no moment to be resisted by the members. A total of five span trusses with nine-truss geometry were analyzed and designed. Optimal trusses from each span of trusses are to be compared to determine whether the effective geometry is the same for different spans and heights. This study shows that there is no certainty in determining the most effective geometry neither with same span, height nor height over span ratio. The most effective truss geometry is actually specific for every truss span and height. For same span the among all the nine truss, Warren truss geometry seems to be the most optimum truss configuration with about 10% savings in weight when compared to its closest contenders Pratt truss or Howe truss. However, close results might be obtained where it does help to provide a good guideline in choosing a truss that does not waste much material. It has been observed from the results that warren truss is the most effective truss system in carrying the design loads. This feature has been attributed to the alignment of the compression chords and tension chords in a symmetric manner, which allows the truss to distribute the load in most effective way. Also it is noted that more the angle made by the compression and tension chords more effectively the load is distributed. Finally an optimality curve has been derived for understanding the relation between the span of the truss, optimum depth and least self-weight for the warren truss configuration. It is also observed that the optimum depth of any truss increases linearly with respect to its span.

KEYWORDS: *optimization, roof trusses, STAAD Pro, parameters, geometry, Steel take off.*

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1 INTRODUCTION

A truss is a system composed of members connected together at joints (or nodes). All the joints are considered to be pinned although some of the joints may be fixed rather than pinned. Generally, the design of truss system includes selecting member sizes, joint locations and the number of members. The truss structures are required to be designed in such a way that they have enough strength and rigidity to satisfy the strength and serviceability limitation. It is not difficult to conceive that there are quite a number of structures with different shapes, which meet the requirement. But among them it is the most economical one that interests the structural engineer the most. Until the advent of structural optimization, the usual path to follow in the solution of this problem was to make use of the experience and intuition of the designer.

Andrew B. Templeman (1983)[1] presented a paper stating major reason why only some research output in structural optimization has been applied to design practice is that very little of it satisfies the specific needs of its potential users. Randolph Thomas and Daniel Brown (1977)[2] presented a paper for design of roof truss system using optimization, with mentioning cost function as a parameter and mentioned an algorithm encompassing the application of 8 optimization methods. M. P. Saka (1991)[3] presented a paper on optimization of structures and has carried out a lot of studies on structures where optimality criteria method has been employed. The design algorithm, which was from the optimality criteria approach, is then extended to take the slope as design variables to determine the optimum slope according to his study. S. Rajasekaran (1983)[4] presented a paper on Computer Aided Optimal Design of industrial roof, and the design procedure on the optimal design of industrial roof was carried out. M.Ohsaki (1995)[5] presented a paper on optimal topologies and carried out a study keeping stress and displacement constraints under multiple static using genetic algorithms. It is shown that the use of the topology bit leads to rapid convergence to optimal topology with a small number of members. The efficiency of the approach is shown in the examples of plane trusses and the effect of the nodal cost on optimal topology is discussed.

In this study, STAAD Pro has been used for fully stressed design of various 9 trusses. For this fully stressed design of all trusses, dead load, wind load and live load cases have been considered. 9 types of trusses were used with varying span and parameters. Each distinct load case optimized truss is found and its Steel Take-Off is evaluated.

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2 LOAD CACULATIONS

A single standard loading calculation has been carried out and applied accordingly for all the truss types based upon truss span as per the IS 875 Part 1, 2 and 3. The following sections explain the calculations for roof truss loading.

2.1 CALCULATION DEAD LOAD, LIVE LOAD AND WIND LOAD

Dead load is calculated from contributory width of truss, unit weight of sheeting material, unit weight of purlin and service load. Live load has been considered as per IS 875 (Part-2). These loads are applied to top chord member as point load as per purlin spacing. Wind load is calculated in accordance with IS 875 (Part-3) in separate worksheet. This procedure creates primary load case for Staad file. Three primary load cases that has been considered here are, 1.Dead Load (Self weight, Point Load) 2.Live Load 3.Wind Load. Load combination are generates according to IS 800:2007 for steel design.

Table 2.1: Roof truss loading for different nodes on truss

Span, m	Total load with Factor, KN	4 Node, KN	5 Node, KN	6 Node, KN	7 Node, KN
6	96.73	24.18	19.34	16.12	13.8
7	112.99	28.25	22.6	18.83	16.14
8	129.29	32.32	25.85	21.54	18.47
9	145.63	36.4	29.12	24.27	20.8
10	162	40.5	32.4	27	23.14

Table 2.2: Roof truss loading for different nodes on truss

Span m	Total load with Factor KN	8 Node KN	9 Node KN	10 Node KN
6	96.73	12	10.74	9.67
7	112.99	14.12	12.55	11.29
8	129.29	16.16	14.36	12.92
9	145.63	18.2	16.18	14.56
10	162	20.25	18	16.2

3 STRUCTURALMODELLING AND ANALYSIS

Here a total of nine different truss structure analyzed and designed for 6m to 10 m span. Each truss designed for this span and the height of truss is varying with difference of 0.2 m for each fix span up to where gets the least weight of truss. In designing, each type of truss getting a minimum self-weight at different height due to different geometry of truss for a given span has been analyzed.

3.1 SELF WEIGHT (STEEL TAKE-OFF) V/S DEPTH FOR SPANS 6M TO 10M FOR DIFFERENT ROOF TRUSSES

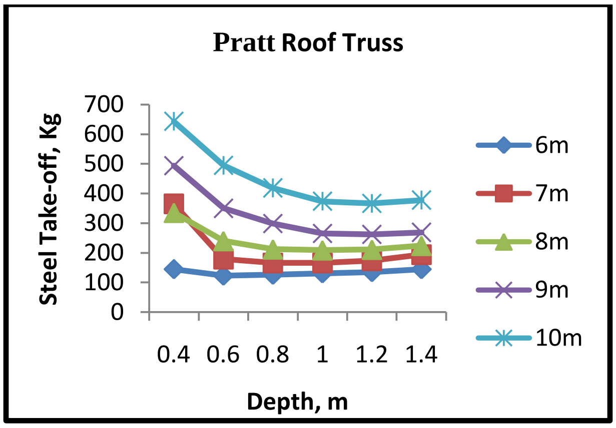

Fig 3.1 Self Weight V/s Depth for spans 6m to 10m for Pratt Roof Truss

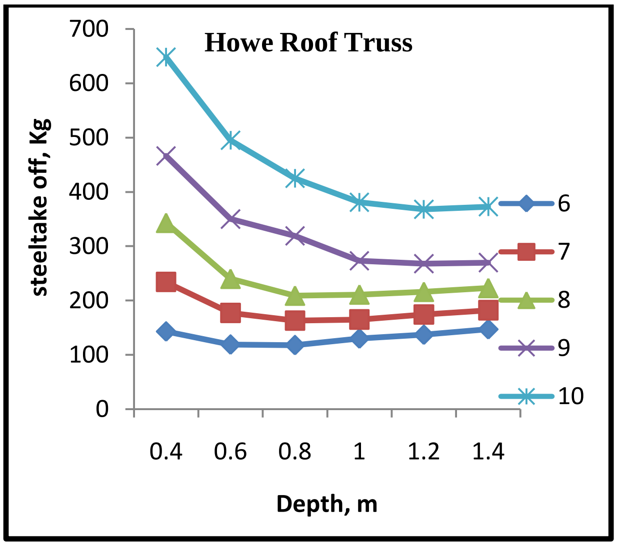

Fig 3.2 Self Weight V/s Depth for spans 6m to 10m for Howe Roof Truss

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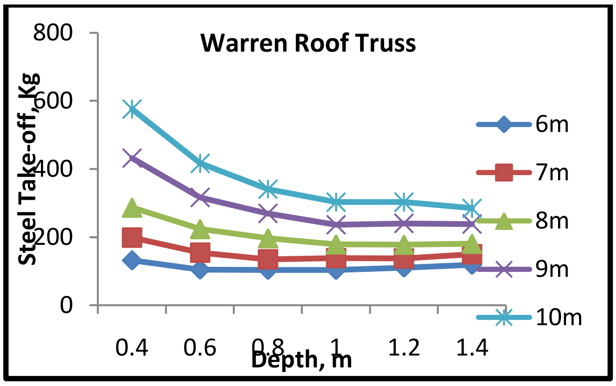

Fig 3.3 Self Weight V/s Depth for spans 6m to 10m for Warren Roof Truss

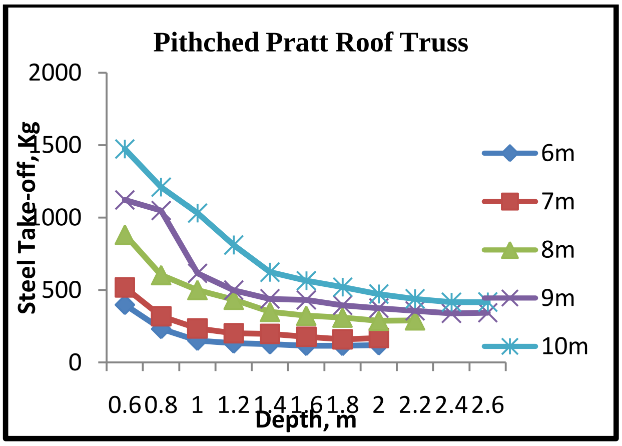

Fig 3.4 Self Weight V/s Depth for spans 6m to 10m for Pitched Pratt Roof Truss

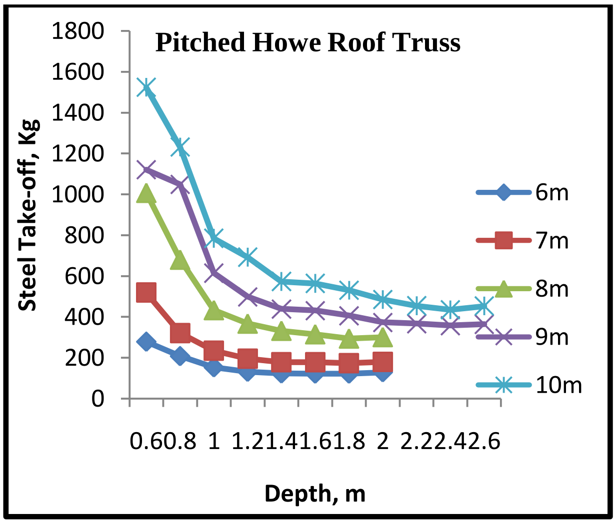

Fig 3.5 Self Weight V/s Depth for spans 6m to 10m for Pitched Howe Roof Truss

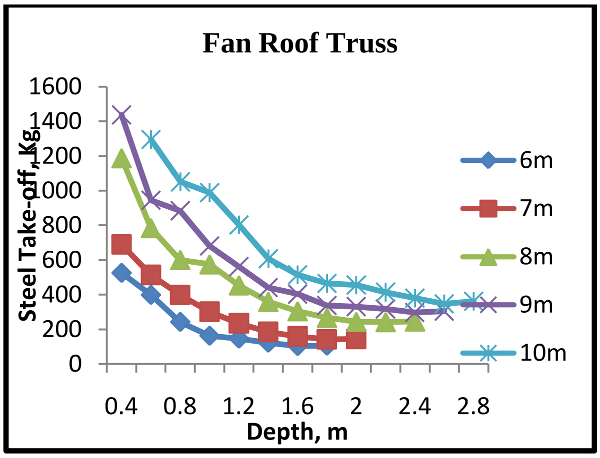

Fig 3.6 Self Weight V/s Depth for spans 6m to 10m for Fan Roof Truss

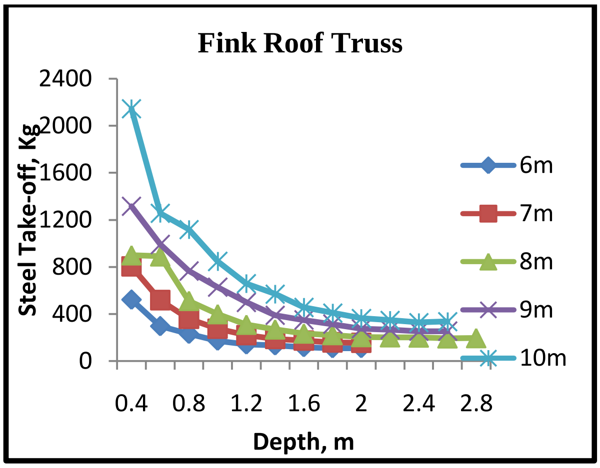

Fig 3.7 Self Weight V/s Depth for spans 6m to 10m for Fink Roof Truss

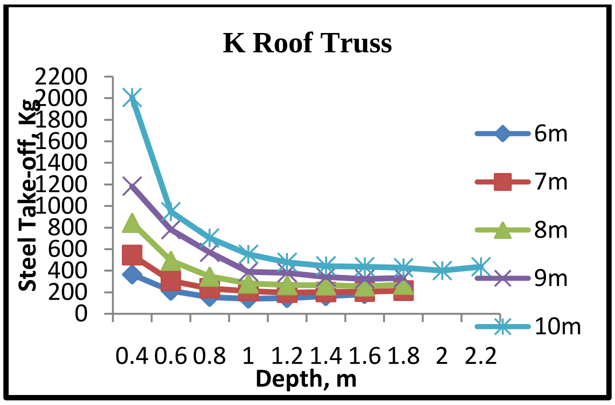

Fig 3.8 Self Weight V/s Depth for spans 6m to 10m for K Roof Truss

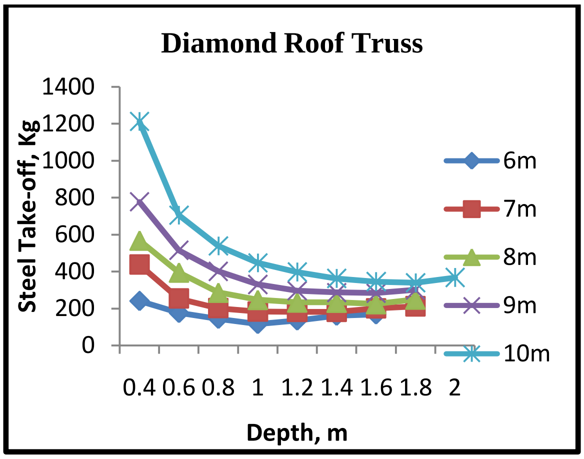

Fig 3.9 Self Weight V/s Depth for spans 6m to 10m for Diamond Roof Truss

4. SUMMARY OF LIGHTEST TRUSS FOR EACH SPAN

From the analysis results, the summary in which the trusses with the lightest weight in each span can be obtained. It is shown in Fig. 4.1 to Fig. 4.3 for different spans and depths of trusses including the optimal weight.

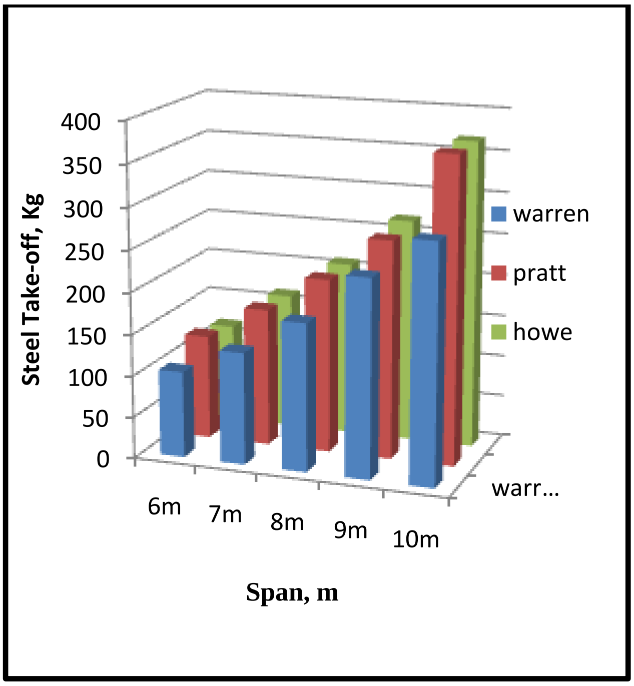

Fig. 4.1 Span V/s Self-Weight for Pratt, Howe and Warren Truss

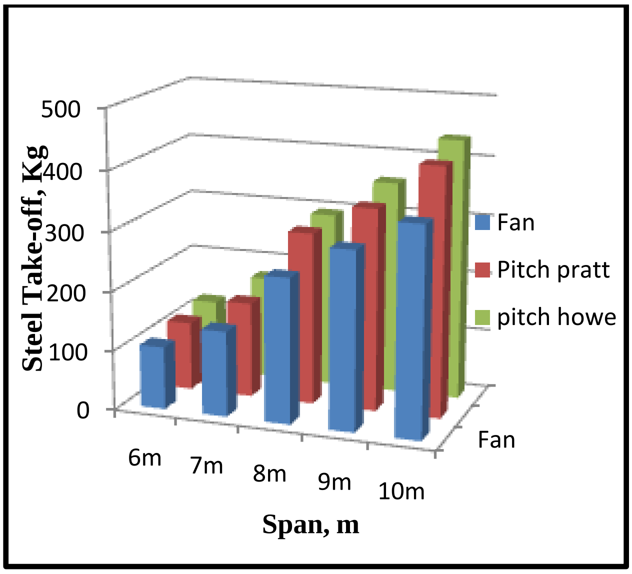

Fig. 4.2 Span V/s Self-Weight for Fan, Pitch Howe and Pitch Pratt Truss

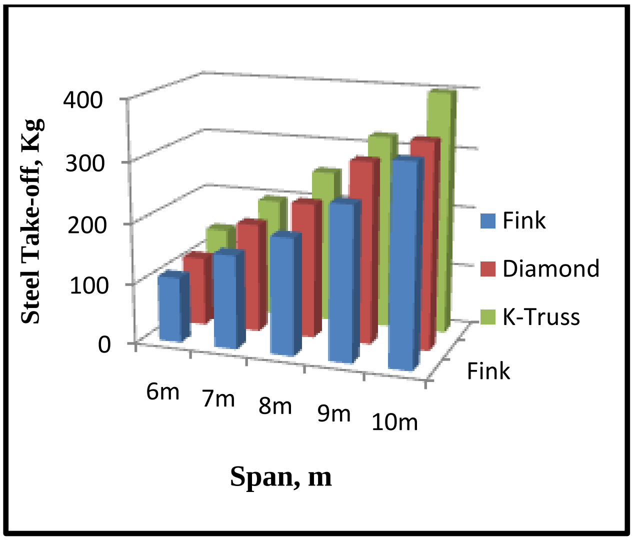

Fig. 4.3 Span V/s Self-Weight for Fink, K and Diamond Truss

5. CONCLUSIONS

Based on the study carried out, a few outcomes are,

- For the calculations of self weight of different members for a roof truss its geometry is very important factor. The Compression and Tension forces in the same members will also vary in the truss according to the geometry of the roof trusses.
- Warren truss geometry is lightest one for the same span as compare to other all trusses used in study. So warren truss is most optimum truss which saves about 10% to 12% material by its weight.

- From the optimality curve the depth of truss linearly increases with increase in span of the truss.
- It can be concluded that the optimum structure can be selected by an engineering based on his/her experience only. Because the different properties of structure varies in a linear manners. This is not properly definable.
- It may not possible to implement the same theory for smooth distribution of loads in the real situation of truss at site.

5.1 SCOPE OF THE FUTURE WORK

The scope of future work besides considering weight of material, this study can also be furthered by determining the other factors that affect the overall practical cost such as erection and fabrication costs, costs for detailed connections etc. in order to determine the truss types that are most economical in practical usage. For example the optimal truss with least member self-weight might not be the most effective if the joints are too many.

REFERENCES

[1] Andrew B. Templeman. Optimization Methods in Structural Design Practice. ASCE *Journal of Structural Engineering*. 1983. Volume 109: 2420-2433.

[2] H. Randolph Thomas, JR. and Daniel Brown. Optimum Least-Cost Design of a Truss Roof System. 1977. *Computers and Structures*. Volume 7: 13-22.

[3] M. P. Saka. Optimum Geometry Design of Roof Trusses by Optimality Criteria Method. 1991. *Computers and Structures*. Volume 38, No.1: 83-92.

[4] S. Rajasekaran. Computer Aided Optimal Design of Industrial Roof. ASCE *Journal of Structural Engineering*. 1983. Volume 10, No 2, July 1983: 41-50.

[5] M. Ohsaki. Genetic Algorithm for Topology Optimization of Trusses. 1995.

[6] *Computers and Structures*. Volume 57, No. 2: 219-225

[7] Lluis Gil and Antoni Andreu. Shape and Cross-Section Optimization of a Truss Structure. 2001. *Computers and Structures*. Volume 79: 681-689.

[8] Weniyarti Bt. Yunus. *To Investigate the Effects of Different Truss Shapes on Design*. B.Sc Thesis. Universiti Teknologi Malaysia; 2005

[9] U. Kirsch and B. H. V. Topping. “Minimum Weight Design of Structural Topologies.” Vol. 118, No. 7, July, 1992.

[10] S. Rajeev and C.S. Krishnamoorthy. “Genetic Algorithms-Based

[11] Methodologies for Design Optimization of Trusses.” *Computers and Structures* Vol. 123, No. 3, July, 1997.

[12] Kalyanmoy Deb and Surendra Gulati. “Design of Truss-Structures for Minimum Weight using Genetic Algorithms”. *Computers and Structures*, 2004.

[13] N. Subramanian, Design of Steel Structures, Oxford Higher Education 2008.

[14] Danial L. Schodek & Martin Bechthold, Structures, PHI (Sixth Edition).

[15] Singiresu S. Rao. Engineering Optimization Theory and Practice-fourth edition, New Age Publisher, pages 314-315.

[16] IS 800: 2007, General Construction In Steel – Code Of Practice (Third Revision), Bureau

[17] IS 875 (Part-3): 1987, Code Of Practice For Design Loads (Other Than Earthquake) For Buildings And Structures (Second Revision).

[18] Hajela, P., Lee, E., and Lin, C. Y. (1993) "Genetic algorithms in structural topology optimization" , *Topology Optimization of Structures*, pp. 117–133

[19] Kang Seok Lee, S. W. (2011) "Discrete size and discrete-continuous configuration optimization methods for truss structures using the harmony search algorithm", *International Journal of Optimization in Civil Engineering*, 107-126.

[20] Karim Hamza, H. M. (2003), "Design optimization of N-shaped roof trusses using", *Applied Soft Computing* 3, 221–235.

[21] Krish, U. (1989), "Optimal topologies of truss structures", *Computer Methods in Applied Mechanics and Engineering*, 72, 15–28

[22] Rajeev S, Krishnamoorthy CS "Discrete optimization of structures using genetic algorithms" ASCE *Journal of Structural Engineering* 1992; 118(5): 1233-50.

[23] Rajan, S. D. (1995). "Sizing, Shape, and Topology Design Optimization of Trusses Using Genetic Algorithm", ASCE *Journal Of Structural Engineering*, 1480-1487.

[24] Ringertz, U. T. (1985) "On topology optimization of trusses", engineering optimization, 9, 209–218