

Parametric Studies of Standard 2-D Roof Truss Configuration

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Abstract— Now a day, our observation about the steel structures, Industrial trusses form one of the major structural systems, which require accurate and economic design. Their span and corresponding weight plays an important role in planning the industrial area. The shape and configuration is decided upon the span, pitch, spacing of truss, various loads and naturally the weight. In this paper a humble attempt is made to compare various truss configurations with same span, pitch, spacing of truss regarding the weight aspects. All the trusses have been analysed and designed by Staad Pro, software for the span 20 m which are the most common spans used in practices. From the parametric study, the most appropriate span will be formulated considering geometric shape, weight, economy and other criteria.

Keywords— Shape and Configuration, Parametric study, Geometric Shape,

I. INTRODUCTION

Structural optimization has become a valuable tool for engineers and designers in last two decades Lee al et. (2011); Rajan, (1995). Although it has been applied for over forty years, optimization in engineering has not been a commonly used design tool until high performance computing systems were made widely available. Structures are becoming lighter, stronger, and cheaper as industry adopts higher forms of optimization. This type of problem solving and product improvement is now a crucial part of the design process in today's engineering industry.

The basic principle of optimization is to find the best possible solution under given circumstances. The term optimal structure is very uncertain. This is because a structure can be optimal in different aspects. These different aspects are called objectives, and may for instance be the weight, cost or stiffness of the structure. The solution of problem depends on various factors like objective function formulation, constraint formulation, method adopted, starting point, step size etc.

Truss optimization is not a new idea; a large body of previous research attempts to provide solutions to the questions of optimal member sizing, geometry, or topology. Optimal design of truss-structures has always been an active area of research in the field of research and optimization. Various techniques based on classical optimization methods have been developed to find optimal truss-structures Krish (1989), Ringertz (1985), and Topping (1983).

Objective function for truss optimization is weight minimization or Cost minimization. Design criteria like allowable stress in tension, slenderness ratio of compression member, stability of structure (permissible deflection) etc. are constraints Lee al et. (2011)

In most attempts, multi-level optimization methods have been used Ringertz, (1985). It is obvious that such a multi-level optimization technique may not always provide the globally best design, since both these problems are not linearly separable. Truss optimization is nonlinear optimization problem. There are numerous techniques to solve nonlinear constrained problem like Exhaustive search, Dichotomous search, Interval Halving method etc. and for nonlinear unconstrained problem like Random search method, Grid search method, Univariate method, steepest descent (Cauchy) method. Different method give different solution, one can't say this solution is optimal solution. Method adoption is depends on nature of objective function like linear, nonlinear, continuous, discrete.

II. TYPES OF OPTIMIZATION

Basically there are three different ways of truss optimization.

- (A) Sizing optimization
- (B) Configuration Optimization
- (C) Topology optimization

(A) Sizing optimization

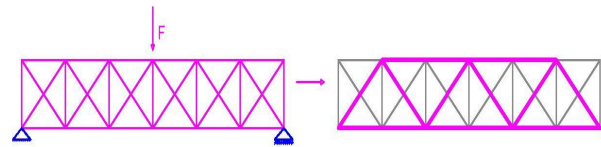


Figure 1 Sizing Optimization

Sizing optimization is the simplest form of structural optimization. The shape of the structure is known and the objective is to optimize the structure by adjusting sizes of the components. In the sizing optimization of trusses, cross-sectional areas of members are considered as design variables and the coordinates of the nodes and connectivity among various members are considered to be fixed Goldberg and Samtani, (1986) as shown in [Figure 1]. The sizing optimization problem is extended and made practically useful by restricting the member cross-sectional areas to take only certain pre-specified discrete values Rajeev and Krishnamoorthy, (1992).

(B) Configuration Optimization

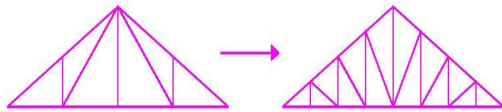


Figure 1 Configuration or Shape Optimization

As with sizing optimization the topology (number of holes, beams, etc.) of the structure is already known when using shape optimization, the shape optimization will not result in different shape. In the configuration or shape optimization of trusses, the change in nodal coordinates is kept as design variables. In most studies, simultaneous optimization of sizing and configuration has been used Deb and Gulati. A fundamental difference between shape vs. topology and size optimization is that instead of having one or more design variable for each element, the design varies in shape optimization each affect many elements.

(C) Topology optimization

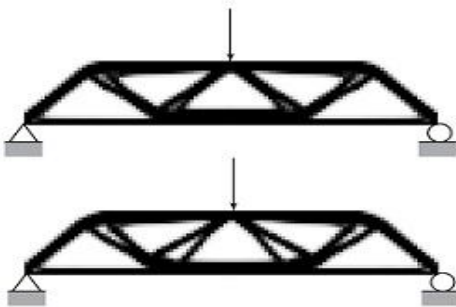


Figure Error! No text of specified style in document. Topology Optimization

The most general form of structural optimization is topology optimization. In the topology optimization, the connectivity of members in a truss is to be determined Krish, (1989); Ringertz, (1985). Classical optimization methods have not been used adequately in topology optimization, simply because they lack efficient ways to represent connectivity of members. In such a method, when topology optimization is performed, member areas and the truss configuration are assumed to be fixed. Once an optimized topology is found, the member areas and/or configuration of the obtained topology are optimized Deb and Gulati.

Goldberg and Samtani, (1986) and Rajeev and Krishnamurthy, (1992) have used only size optimization, whereas Hejela al et., (1993) have used a two-level optimization scheme of first finding multiple optimal topologies and then finding the optimal member areas for each of the truss topologies. Rajan, (1995) and Hamza, (2003) has used all three optimization methods to only two 2-D truss

design problems. Deb and Gulati has used all three optimization methods to 2-D and 3-D truss problems.

III. STEPS IN PARAMETRIC STUDY OF 2D- ROOF TRUSS

Step by step procedure for the parametric study is as under.

- 1) Generate geometry of standard truss configuration,
- 2) Calculate Dead load, Live load and Wind load,
- 3) Create STAAD file from basic input and perform analysis,
- 4) Create steel design command to perform steel design,
- 5) Call STAAD result and result interpretation

IV. MINIMUM TRUSS CONFIGURATION

Objective of this exercise is to find out minimum weight truss configuration among two truss types pratt roof truss and Howe roof truss. First individual truss configuration is compare and then it compare with other configuration. For comparison purpose parameters like loading condition, member specification, and member profile are constant for all truss types. All major parameters are tabulated in Table 1

Table 1 Common Geometry & Design Input

Span (m)	20
Min. Truss Height (m)	2 m
Max. Truss Height(m)	6 m
Height Variation	1 m
Step size in Height (m)	1 m
Min. no. of Bays (nos.)	6
Max. no. of Bays (nos.)	14
Total Geometry Generated	30 for each type of truss
Total Dead Load (Sheeting + Purlin + Fixing + Service)	This is varies with geometry
Live Load	This is varies with geometry
Truss Spacing (m)	4 m
Basic Wind Speed	44 m/sec (SURAT)
Life of structure	50 years
Wall opening	0.1
Length of shed	50 m
Slenderness Ratio for Compression Member	180
Net Area for Tension Member	0.85
Allowable Deflection	span/240

V. SUMMARY OF PRATT TRUSS EXERCISE

Table 2 shows that truss weight is minimum at **4 m** height and **6** number of bays for the Pratt truss of span 20 m and it is **909 kg**.

Table Error! No text of specified style in document.-2 Pratt Truss Steel Take off (Kg) of Span 20 m

HEIGHT (m)	2	3	4	5	6
NOS OF BAY					
6	1575	1166	909	1354	1585
8	1378	1062	958	1467	1634
10	1424	1073	1000	1473	1874
12	1397	1019	1052	1573	2098
14	1364	1051	1090	1708	2319

Figure 4 is truss weight surface plot against truss height and number of bays, minimum weight region is indicated by arrow.

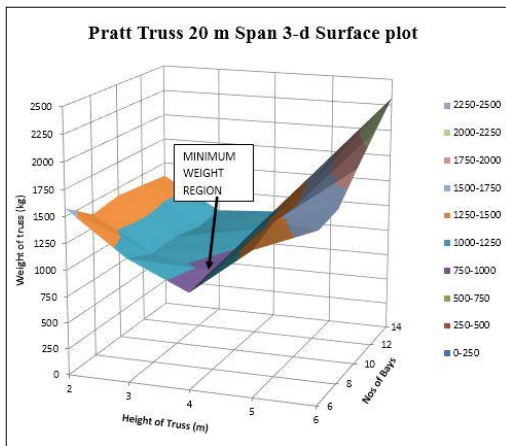


Figure 4 Pratt Truss 3-D Surface Plot of Span 20m

Figure shows Pratt truss weight contour with respect to truss height and number of bays. Contour shows a region (Pink Colour) where minimum solution is lie

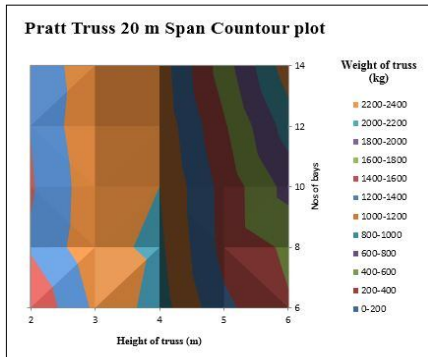


Figure 5 Pratt Truss Contour Plot of Span 20 m

Figure shows truss weight variation V/s number of bays with constant height range and Error! Reference source not found.7 Shows truss weight variation V/s truss height with constant number of bays range.

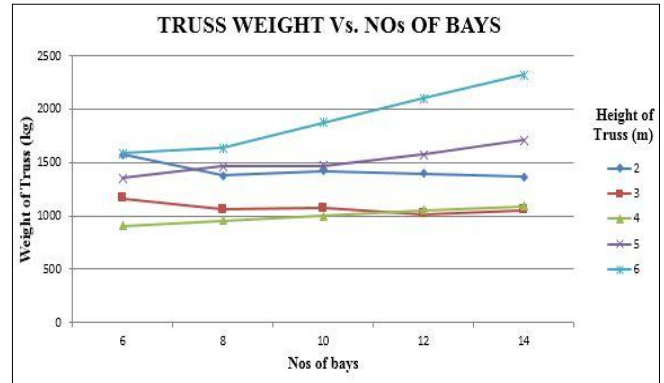


Figure 6 Truss Weight V/s Number of Bays of Span 20 m

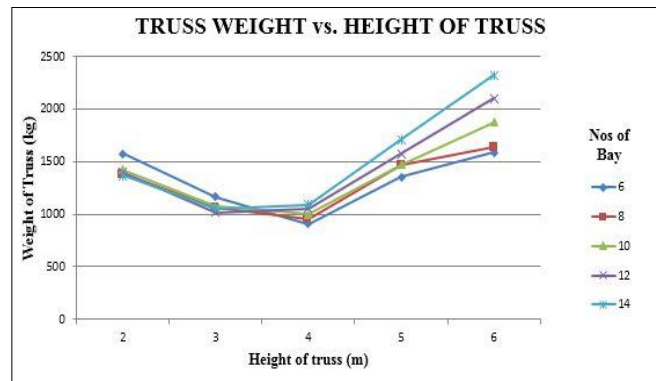


Figure 8 Truss Weight v/s Height of truss of Span 20 m

VI. SUMMARY OF HOWE TRUSS EXERCISE

Table 3 shows that truss weight is minimum at **4 m** height and **6** number of bays for Howe type truss of span 20 and it is **910 kg**.

Table 9 Howe Truss Steel Take off (Kg) of Span 20 m

HEIGHT (m)	2	3	4	5	6
NOS OF BAY					
6	1432	1132	910	1332	1462
8	1388	1001	950	1430	1718
10	1430	1003	999	1511	1966
12	1337	988	1086	1633	2235
14	1371	1054	1193	1790	2538

Figure 8 is truss weight surface plot against truss height and number of bays, minimum weight region is indicated by arrow.

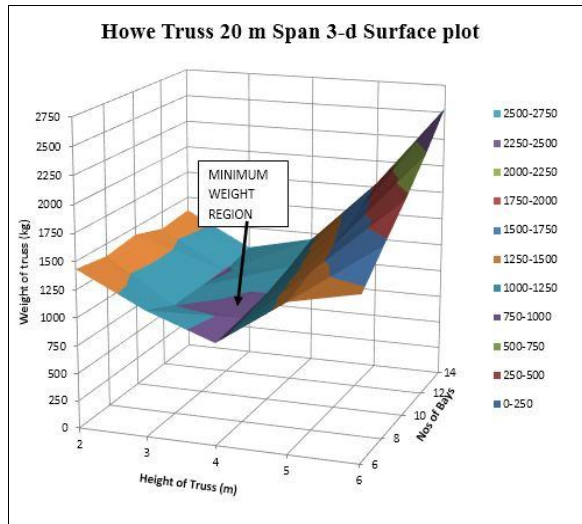


Figure 8 Howe Truss 3-D Surface Plot of Span 20 m

Figure 9 shows Howe truss weight contour with respect to truss height and number of bays. Contour shows a region (Blue Colour) where minimum solution is lie

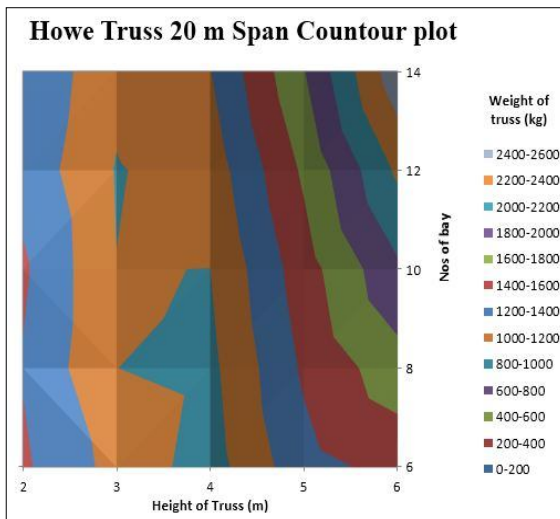


Figure 9 Howe Truss Contour Plot of Span 20 m

Figure 10 shows truss weight variation V/s number of bays with constant height range and Figure 11 shows truss weight variation V/s truss height with constant number of bays range.

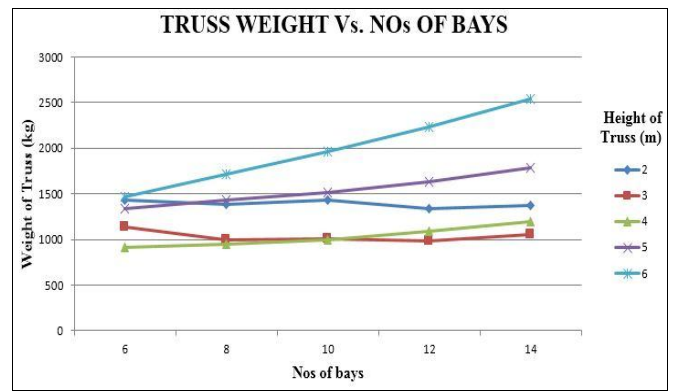


Figure 10 Truss Weight V/s Number of Bays of Span 20 m

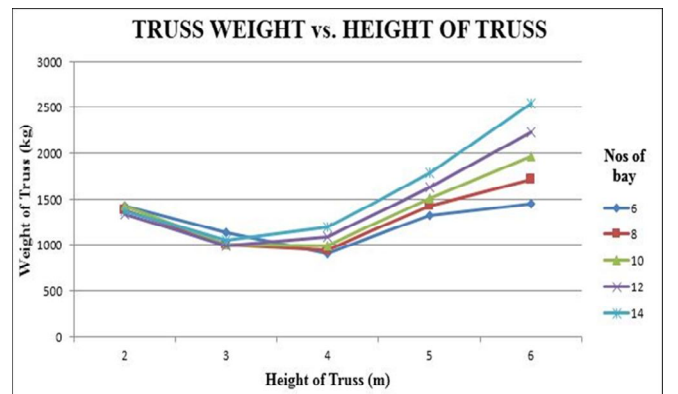


Figure 11 Truss Weight V/s Height of truss of Span 20 m

VII. CONCUSSION

Influence of Span to Height of truss keeping all other parameters as constant the least weight is obtain at certain height beyond which either increase or decrease in height of truss leads to loss of economy. Most economical height of truss varies according to the other parameter that is number of bays. It can be generalized from the parametric study of pratt and howe truss spam ranging from 12 m to 20 m that most economical configuration for pratt type truss is when span to height of truss ratio is nearly 5 and for howe type truss it is 5.

Influence of Span to Number of bay keeping all other parameters as constant the least weight is obtain at certain number of bays beyond which either increase or decrease in number of bays of truss leads to loss of economy. Most economical number of bays of structure varies according to the parameter that is height of truss. It can be generalized from the parametric study of pratt and howe truss spam ranging from 12 m to 20 m that most economical configuration for pratt type truss is when span to number of bays ratio is nearly 3.0 and for Howe type truss it is 3.0

VIII. REFERENCE

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