

Topology Optimization on Nine Different truss geometry as plane truss by only Using Anngle Section

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ABSTRACT

The main purpose of this project was to study and apply the topology optimization on nine different truss geometry as plane truss by only using angle section. The need of this study arises when time is a constraint in the project and it is difficult or taking much time to choose effective and economical truss geometry during the design period. Its main purpose is to determine the minimum angle section which can be used to design a truss geometry which should be safe and should be able to take loads which are common in Hamirpur region. Design loads were distributed to the joints so that no moment is generated over the members. Total five span were analyzed in various geometries mentioned till the minimum steel take off was achieved. Optimal geometries from each span of each 9 trusses were compared to determine whether it is the same effective geometry for different combinations of spans and heights. This work and analysis shows that no fixed most effective geometry can be determined for different as well as same span, height nor height over span ratio. For each case different geometry was obtained. However, close results were obtained where it does help to provide a good guideline in choosing a truss that does not waste much material.

INTRODUCTION

GENERAL

Trusses are most common type of structure used in constructing building roofs, bridges and towers etc. [1]. The truss is types of structural frames formed from structural members. A truss consists of a group of ties and struts designed and connected to form a structure that acts as a large span beam. A truss can be constructed by straight slender members joined together at their end by bolting, riveting or welding (Fig. 1). Generally a designer needs to decide member sizes, joint locations and the number of members for a truss design. Trusses are subjected to nodal loads only, which only generate tension or compression forces therefore trusses are lighter than their load capacities.

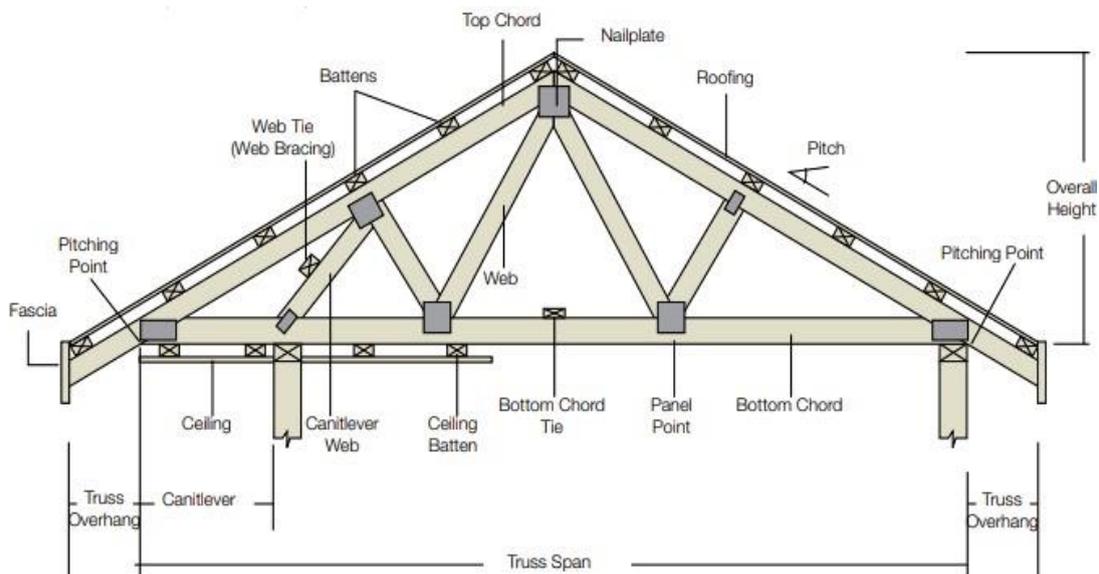


Fig.1 Terms of Truss

OPTIMIZATION OF STRUCTURES

As we all know that resources in the world are limited, so it becomes indispensable that the material is put to its utmost service. This can be achieved by applying the concept of mathematical optimization to any relevant field. The main purpose is to minimize the overall cost of structure and not affecting its structural integrity and safety. The parameters involved in the process of optimization are mostly contradictory in nature for instance, if one want to make the structure as light as possible i.e., to minimize weight or as stiff as possible one could make it more vulnerable to buckling or instability. Such maximizations or minimization needs some constraints. For instance, if there is no limitation on the amount of material that can be used, the structure can be made stiff without limit and we have an optimization problem without a well-defined solution.

OBJECTIVE OF RESEARCH

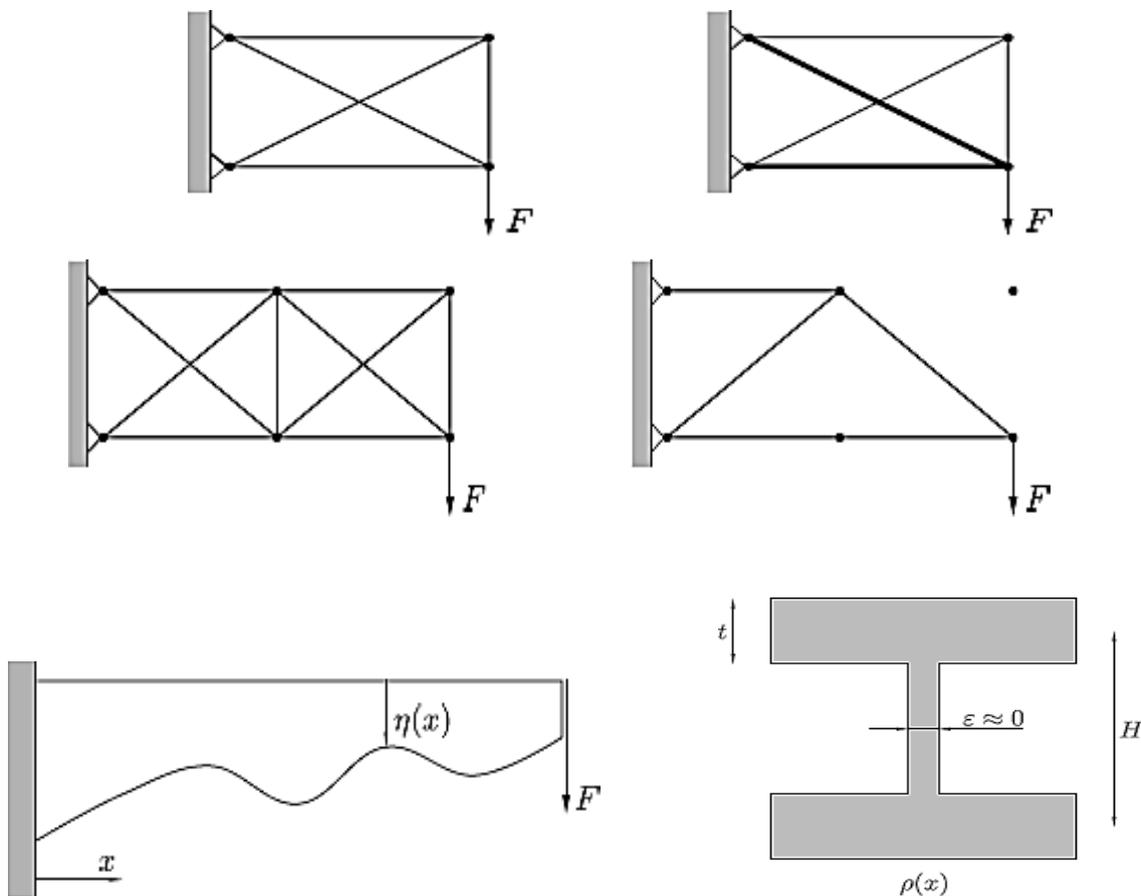
As mentioned above about the practical usage of optimization techniques in field work is limited and very less. It is a mere effort of this research work to provide the threshold limit for a designer for erecting a truss over a particular span to depth ratio. This research will provide the value for a designer that in a loading condition similar to the research work he/she can opt for which section which will be economic as well as safe. The main objective of this research work is to understand the behavior of the truss structure with varied topology or exactly by varying the geometric parameters such as depth of the truss and span of the truss and finding the relation between such parameters and weight of the structure required to carry the design load.

LITERATURE REVIEW

TYPES OF STRUCTURAL OPTIMIZATION

Essentially there are three types of structural optimization Size, Shape and Topology Optimization.

- **Sizing optimization:** In Sizing optimization a structural dimension is considered as a parameter as variable x .
- **Shape optimization:** In case of shape optimization contour or the boundary of the geometry domain is considered as variable x .
- **Topology optimization:** The most general or common type of optimization is topology optimization in structure.



Literature Review of Truss Optimization

According to Andrew B. Temple man [9] explained why the research output of structural optimization given by various research scholars is not being used in the field work by designers. Foremost reason is that it doesn't satisfy the specific

needs of its potential users. Several specific requirements that should be met are:

- (a) The designer should be assisted in performing his overall task.
- (b) Computer programs should be easy to use.
- (c) They should speed up the design process.
- (d) They should address practical design problems.
- (e) They should produce useful, practical design results.
- (f) They should be checkable.

METHODOLOGY

Types of Roof Trusses Shapes

Basically the nine types of roof trusses have been analyzed, towards finding out minimum self-weight of truss for single span to variable depth of trusses.

Loading Calculation

Loading calculation has been done accordingly and has been applied to each truss span considering IS 875 Part 1, 2 and 3. All the load parameters are considered and applied by following the rules mentioned in the IS code given above and mentioned in the below section.

Calculate Dead load, Live load and wind load

Dead load is calculated considering width of truss, unit weight of sheeting material, service loads and unit weight of purlin. 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 have been considered here are, 1. Dead Load (Self weight, Point Load) 2. Live Load 3. Wind Load. Load combination are generated according to IS 800:2007 for steel design.

RESULT AND DISCUSSIONS

Self-weights of Trusses Obtained from Analysis

The self-weight (Steel Take-off) of trusses given by the results of analysis using STAAD.pro. In Table 4.1 to Table 4.45, the truss with lightest weight in each span is highlighted. In these tables there are 5 columns having Depth in meter, Top chord, Middle chord, Bottom chord in minimum ISA and Steel Take-off in KN.

Design Result and interferences

The design details after the iterative optimization procedure has been explained and discussed in the following sections. It has to be noted that for every truss type for a given span the optimal depth varies considerably depending upon the geometry of the truss structure.

Pratt Roof Truss

Pratt Roof Truss with their model Figure, Tables showing design sections for optimum weight and respective Graph showing the relation between the depths and self-weight of the truss is shown below in Fig. 4.1 and Fig. 4.2 and Tables 4.1 to Tables 4.5 for changed span.

Howe Roof Truss

Howe Roof Truss with their model Figure, Tables showing design sections for optimum weight and respective Graph showing the relation between the depths and self-weight of the truss is shown below in Fig. 4.3 and Fig. 4.4 and Tables 4.6 to Tables 4.10 for changed span.

CONCLUSIONS

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

- It was observed that among all nine trusses, the geometry of warren truss was the most optimum configuration. It almost saved 10% in weight when compared to its closest contenders Pratt truss or Howe truss.
- From the optimality curve it was concluded that optimum depth of any truss increases linearly with respect to its span.
- No defined pattern or no clear relation can be developed between the geometrical parameters such as depth of truss configuration, span and the topology of the structure. It was observed that it was varying in a piecewise linear function. Therefore only a trial and error method coupled with structural engineer's experience can accomplish the difficult task of choosing an optimum truss system.
- The optimized truss geometry that is effective in distributing load to their members might not be practical to use

in the construction of real structures.

- The optimized minimum weight section obtained through analysis was of different cross sections so to make it look more practical a uniform section was chosen to make it ready for use in field.

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