Plane Truss Optimization using Genetic Algorithm

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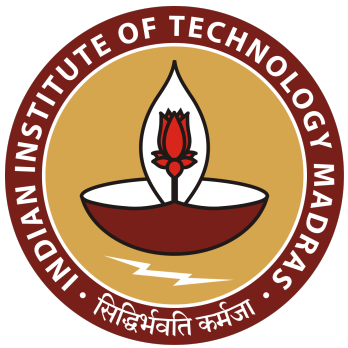

Overview

Introduction to Truss Optimization

Truss Structures

What is a Truss Structure?

Truss is a two or three dimensional structure composed of linear elements connected at nodes to sustain load subjected to tension and compression

How is a Truss analyzed?

- Common approach is to implement Finite element method by modelling the truss as a simpler set of elements interconnected at nodes.
- The global stiffness matrix is computed and the displacements and forces are determined.

Figure: Bridge - A real life example of Truss

What is Truss Optimization?

Optimization in Truss Structures

- Every structure should have to fulfil the structural and economic requirement
- The optimum design of the structure should satisfy various constraints such as displacement, allowable stresses in members and local stability constraints
- In order to incorporate the constraints and make the system economic, we need optimization

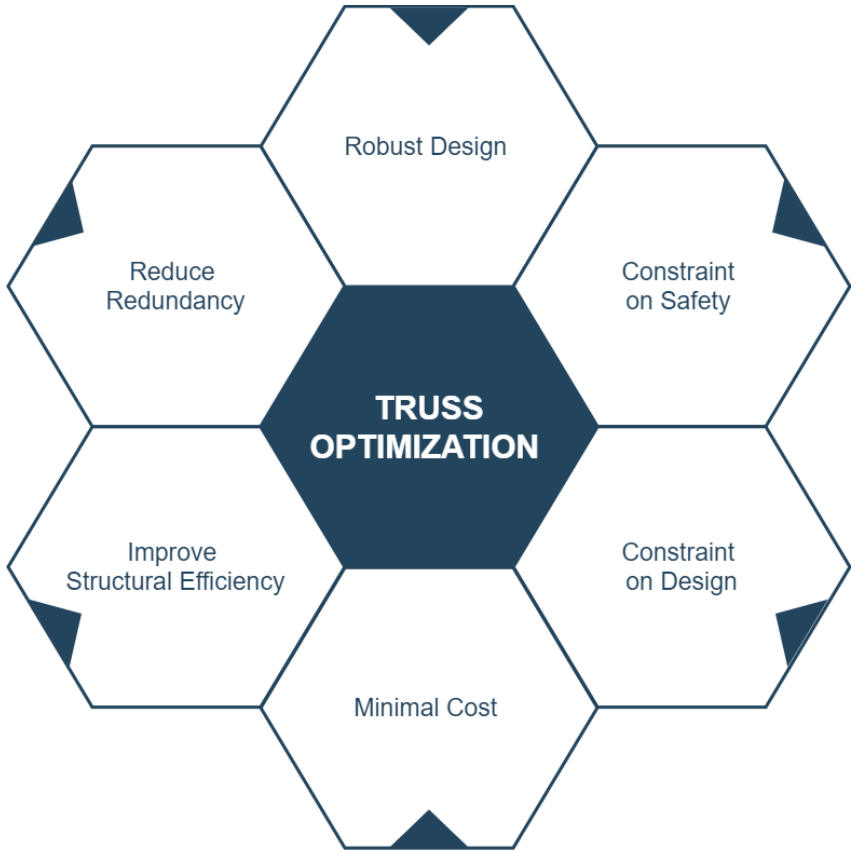

Figure: Need for Truss Optimization

Classification of Truss Optimization Techniques

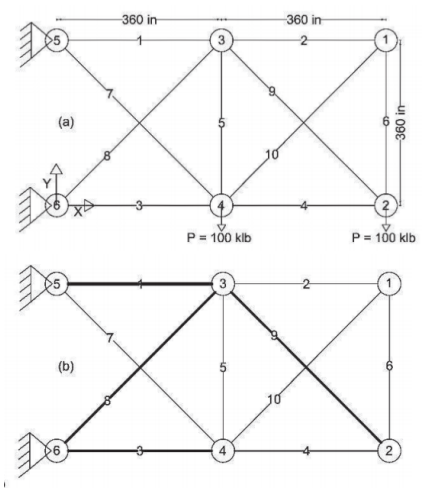

Figure: Size Optimization

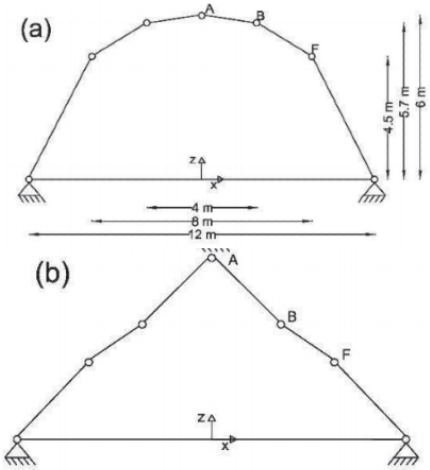

Figure: Shape Optimization

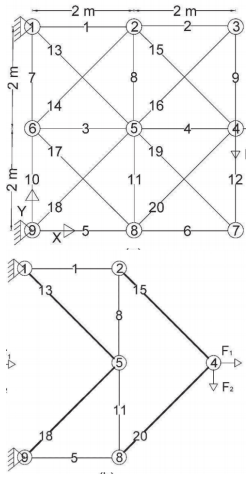

Figure: Topology Optimization

Size Optimization

Changing cross-sectional areas of elements

Shape Optimization

Shifting Coordinates of elements

Topology Optimization

Addition or removal of elements

Methodology

Problem Definition

Problem Definition

The adjacent truss is considered for optimization, the objective is to minimize weight based on constraints on maximum stress and displacements

Objective

Minimize the weight by optimizing the cross-sectional area of elements using genetic algorithm

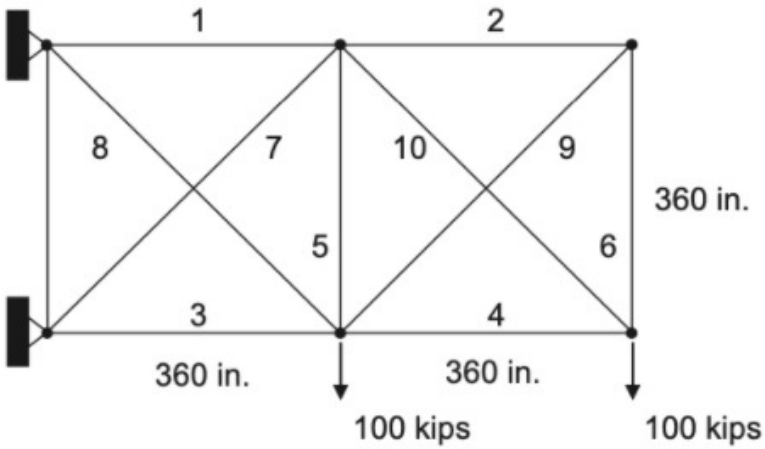

Figure: 6 Node, 10 Element Truss

Objective and Constraint Formulation

Formulation of Optimization

Minimize F(A) where

$$F(A) = \sum_{i=1}^{n} A_i \rho_i L_i$$

Subjected to constraints,

$$\text{Stress Constraint } |\sigma_i| - \sigma_i^{max} \leq 0$$

$$\text{Displacement Constraint } |\delta_i| - \delta_i^{max} \leq 0$$

Flowchart of Genetic Algorithm approach

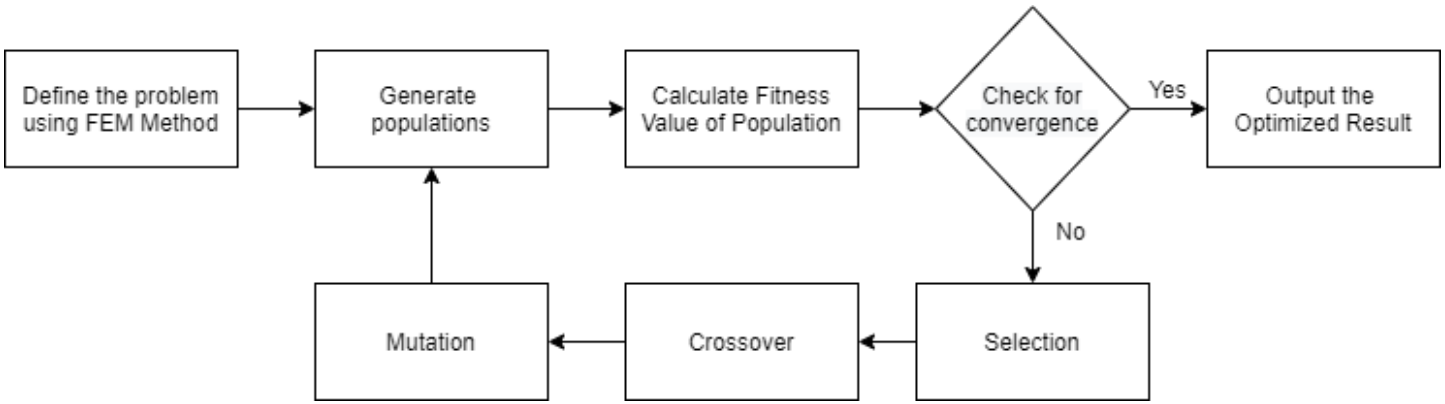

Figure: Flowchart of Genetic Algorithm approach

Outcomes

Results

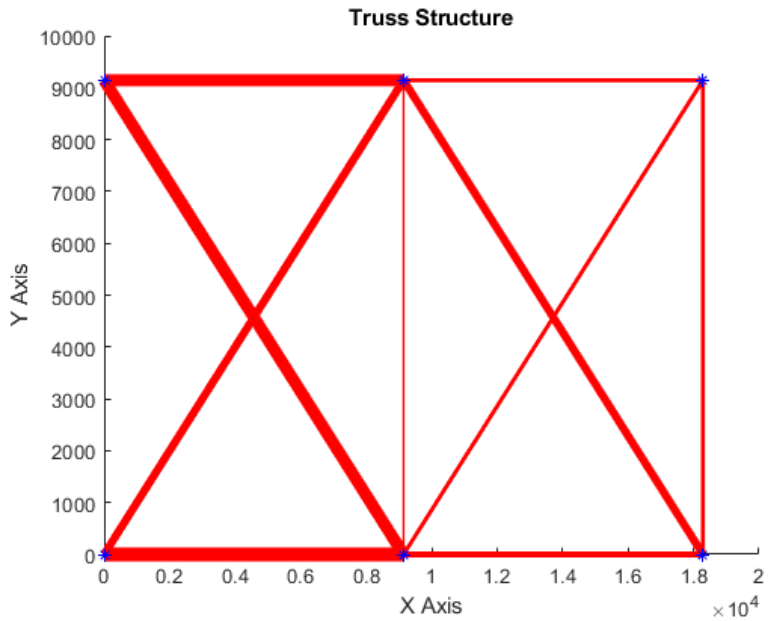

Figure: Truss with Area as linewidth

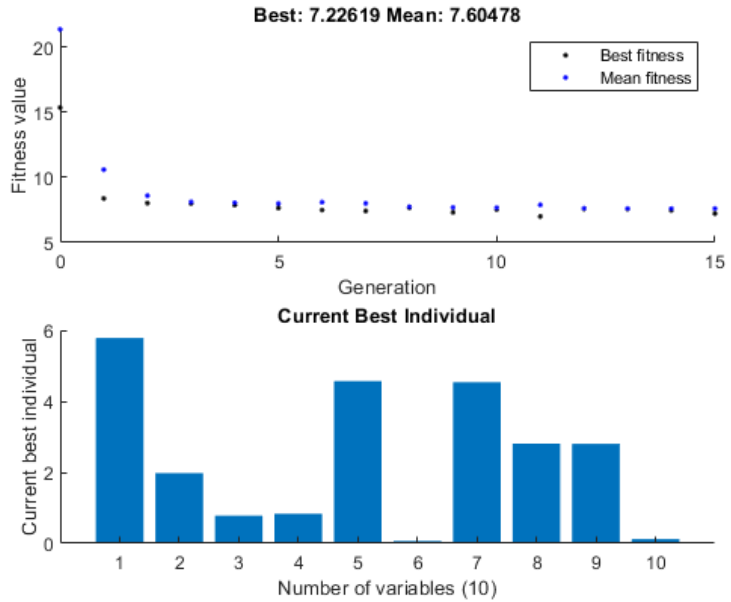

Figure: Best and mean fitness vs. Generations

Conclusion and Summary

Conclusion

- Four of the elements have minimal area compared to the other elements
- The area of elements have been optimized and the total weight of the truss has been reduced to 7.226 Kgs.

Summary

The benchmark truss problem of 6 node, 10 element problem can be optimized using genetic algorithm. Moreover the area leading to a very small value can imply that the element maybe removed without causing any effects on the truss.

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Thank You