10-bar Truss Optimization

DingChun Hsieh

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1 Problem

Figure 1 shows the structure of the ten bar truss. Node numbers and element numbers also present in figure 1.

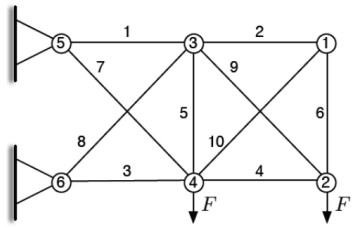

Figure 1: Ten bar truss nodes and elements

Figure 2 is the optimum formula and constraint for the optimization.

$$\begin{aligned} \min_{r_1,\, r_2} \quad & f(r_1, r_2) = \sum_{i=1}^{6} m_i(r_1) + \sum_{i=7}^{10} m_i(r_2) \\ \text{subject to} \quad & |\boldsymbol{\sigma}_i| \le \sigma_y \\ & \Delta s_2 \le 0.02 \\ \text{where} \quad & f : \text{所有桿件的質量} \\ & \Delta s_2 : \text{node 2 的位移} \\ & \sigma_y : \text{降伏應力} \\ & \boldsymbol{\sigma}_i : \text{所有桿件的應力} \end{aligned}$$

Figure 2: Optimum formula and constraint

Problem definition

- All the structure under static equilibrium condition.
- All the cross-section is circle.
- $E = 200GPa$, $\rho = 7860kg/m^3$, $\sigma_y = 250MPa$.
- Length of element 1-6 is 9.14 m.
- Radius of element 1-6 is r_1, radius of element 7-10 is r_2.
- 0.001 m $\leq$ r $\leq$ 0.5 m
- Forces apply on node 2, 4 is $1.0 \cdot 10^7 N$ downward.

2 Calculation

Calculation based on Finite Element Truss, using stiffness matrix and input force to calculate element displacement and stress.
The calculation is been done with Matlab and posted on Git Hub.

3 Result

The result radius of $r_1 = 0.3000mm, r_2 = 0.2663mm$.
$fval = 2.1241e + 05$.