HOMEWORK 3 DUE 2018.11.06

ME7129 Optimization in Engineering,
National Taiwan University.

Ten Bar Truss Problem 100%

A ten-bar truss as shown in Fig.1 is considered. An external force is applied to node 2 with $F(kN)$. All members have circular cross sections. Members $\{1, 2, 3, 4, 5, 6\}$ are identical with length l(cm) and members $\{7, 8, 9, 10\}$ are also identical. Please download the Ten-bar analysis Matlab files (*.m) and make sure it runs well in your computer.

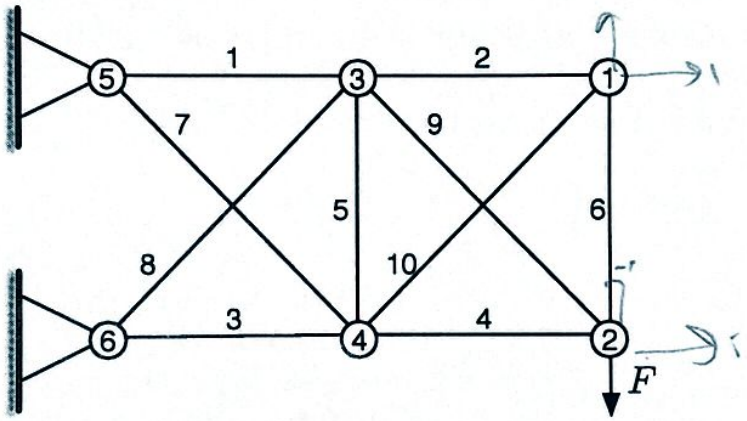

Figure 1: Ten-bar Truss

The design problem is to find the optimal radii of all bar members to minimize the overall weight of the truss system without any yielding and buckling occurring.

The problem also constrains node 2 displacement to be no bigger than 2 cm. The problem is summarized in Eq.(1), where r_1 and r_2 are the radii of the cross-section areas for bars $1 \sim 6$ and $7 \sim 10$, respectively. Yield strength E, moment of inertia I, resulting force F, and tensile stress σ all have subscript i indicating the number of the bar element. δ_2 is the node 2 displacement. Structural steel (ASTM-A36) with density $\rho = 7860\text{kg/m}^3$, modulus of elasticity $E = 200\text{GPa}$, and yield strength $Y = 250$ MPa is used

for this truss system. Finite element analysis is used to calculate the resulting forces and displacements on each member.

$$\min_{r_1, r_2} 6 \cdot \pi r_1^2 l + 4 \cdot \pi r_2^2 \sqrt{2} l$$

s. t.

$$F_i \leq P^c = \frac{\pi^2 E_i I}{l^2}$$

$$\sigma_i \leq Y_i$$

$$\delta_2 \leq 2$$

Please use 'fmincon' in Matlab to obtain the deterministic optimal design.

1. Try at least three different starting points. Are the results the same?
2. What are the optimal values of all cross sections?
3. What is the minimal weight of the truss obtained?
4. How was your design problem terminated?
5. Which constraint(s) is(are) active?
6. Please provide a rationale that you have found the correct result.

HOMEWORK 3 DUE 2018.11.09

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Additional Information

1. In the `TenBarAnalysis.zip` provided on Ceiba, you should note that the following will cause error because of the order of E and length is different.
   In `main.m` :
   ```
   [ stress ] = TenBarAnalysis( r, E, length, F )
   ```
   In `TenBarAnalysis.m` :
   ```
   function [ stress, Q ] = TenBarAnalysis( r, length, E, F )
   ```

2. The displacement Q in `TenBarAnalysis.m` :
   ```
   %% Displacement Calculatuin
   Q_re=K_re^-1*F_re;
   Q=[Q_re ;zeros(4,1)];
   ```

   Note that Q is an 12×1 matrix.
   `Q(1)` is the displacement of node 1 in x direction.
   `Q(2)` is the displacement of node 1 in y direction.
   `Q(3)` is the displacement of node 2 in x direction.
   `Q(4)` is the displacement of node 2 in y direction…

   Please refer to *Finite Element Truss* for detailed information.