Simple stress problem
(Strength of Materials - I, Mid-term Exam-44-1)

Problem:
Each of the two vertical links CF connecting the two horizontal members AD and EG has a $10 \times 40$-mm uniform rectangular cross section and is made of a steel with an ultimate strength in tension of 400 MPa, while each of the pins at C and F has a 20-mm diameter and is made of a steel with an ultimate strength in shear of 150 MPa. Determine the overall factor of safety for the links CF and the pins connecting them to the horizontal members.

Solution:

The equilibrium equation

$$\sum M_E = 0, \quad 0.4F_{CF} - 0.65 \times 24 = 0$$

$$F_{CF} = 39 \text{ kN}$$

$$F_{BE} = F_{CF} - 24 = 39 - 24$$

$$F_{BE} = 15 \text{ kN}$$

The links CF are in tension (critical)

$$A = (b - d) \times t = (40 - 20) \times 10$$

$$A = 200 \text{ mm}^2$$

$$\sigma_u = \frac{F_u}{2A}$$

$$F_u = 2A \times \sigma_u$$

$$F_u = 2 \times 200 \times 400$$

$$F_u = 160 \times 10^3 \text{ N}$$
The pins at F are in double shear

\[ A = \frac{\pi}{4} (20^2) = 314.16 \text{ mm}^2 \]

\[ \tau_u = \frac{F_u}{2A}, \quad F_u = 2A \times \tau_u \]

\[ F_u = 2 \times 314.16 \times 150 \]

\[ F_u = 94248 \text{ N} \]

The critical force in link CF

\[ F_{cr} = 94248 \text{ N} \]

Factor of safety

\[ F.S = \frac{F_{cr}}{F_{CF}} = \frac{94248}{39 \times 10^3} \]

\[ F.S = 2.4166 \]