“More hardness& more profit!”

목발의 경량화

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Introduction

- **Why crutches have to be lightened?**
  - Often, it is not the efficient tool because of its heavy weight.
  - It is essential that crutches be lightened.

Problem Formulation & Process

- Step1: Problem/Project Statement
  - Design for minimum cross section to support a vertical force W(150Kgf) without failure.
  - When 70Kgf is applied to crutches lied on, sho uldn’t occur the failure.
  - The shape of Cross-sectional area is fixed to t he tube.
  - Minimize the weight of the crutches.

Problem Formulation & Process

- Step2: Data & Information Collection

$l = 1.2595m$

$l_h = 0.8242m$

$l_{total} = 2.3159m$

$\sigma_{allow} = 240MPa$

$\tau_{allow} = 140MPa$

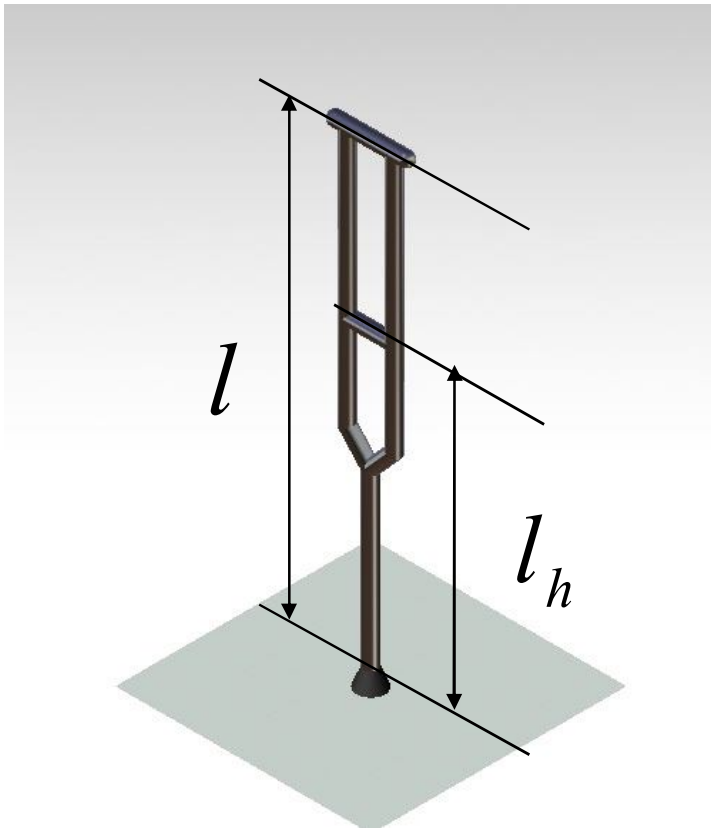
$$\sigma_{allow,\text{at the column}} = \frac{351\times10^3\,MPa}{(L/r)^2}$$

$\rho = 2710Kg/m^3$

$E = 70GPa$

$W_1 = 1569N$

$W_2 = 686N$



Problem Formulation & Process

- Step3: Design Variables

  r_o, r_i

  r_o :outter radius of cross section

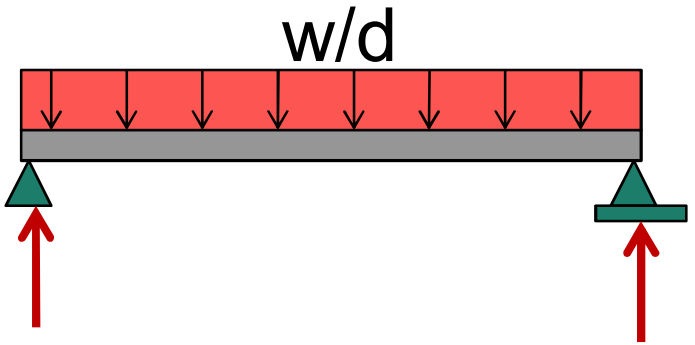
  r_i :inner radius of cross section

- Step4: Objective Function

$$\underset{r_o, r_i}{\text{minimize}} \; f = l_{total}\pi\rho(r_o^2 - r_i^2)$$

Problem Formulation & Process

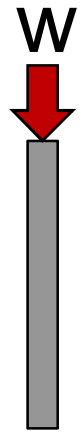
- Step5: Constraints



$$g_1 = \frac{My}{I} - \sigma_a = \frac{wdr_d}{2\pi\left(r_o^4 - r_i^4\right)} - \sigma_a \le 0$$

$$g_2 = \frac{2w}{\pi(r_o^2 - r_i^2)} - \tau_a \le 0$$

$$g_3 = \frac{w(r_o^2 + r_i^2) + 2wdr_o}{2\pi\left(r_o^4 - r_i^4\right)\cos\theta} - \frac{351\times10^9(r_o^2 + r_i^2)}{4l^2} \le 0$$



$$g_4 = w - P_{cr} = w - \frac{\pi^3 E\left(r_o^4 - r_i^4\right)}{4l^2} \le 0$$

Problem Formulation & Process

- Step5: Constraints

$$g_5 = \frac{2(l-l_h)l_h w r_d}{\pi(r_o^4 - r_i^4)l} - \sigma_a \le 0$$

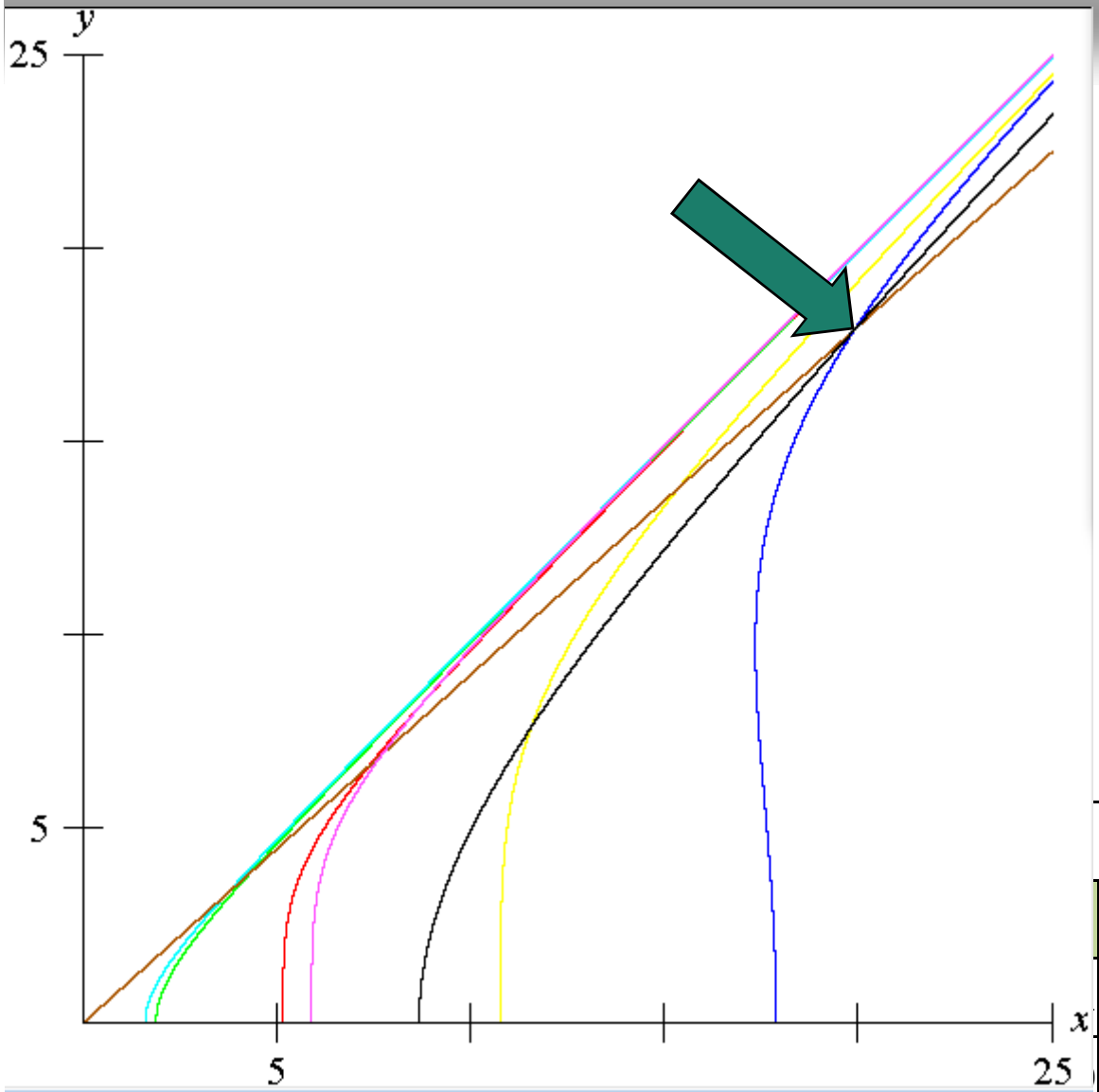
$$g_6 = \frac{2(l-l_h)w}{\pi\left(r_o^2 - r_i^2\right)l} - \tau_a \le 0$$

$$g_7 = 0.1r_o - (r_o - r_i) \le 0$$

$$g_8 = -r_o \le 0$$

$$g_9 = -r_i \le 0$$

Graphical Solution & Solver



g4	g5	g6	g7	f
-97351	-205.76	-138.57	-429.19	2.189
-67932	-191.56	-137.89	-412.71	1.481

Conclusion & Comment

- Conclusion

$$r_0 = 19.882mm$$

$$r_i = 17.894mm$$

$$f_{r_0, r_i} = 1.481Kg$$

- Comment
  - The mass of crutch decreases about , comparing the present design of crutch.
  - There are some assumptions to make the problem simple, thus, it is possible for assumptions to make lower mass.

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Thank You !

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