Truss Weight Optimization

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October 3, 2024

1 PROBLEM STATEMENT

(A problem taken from Mechanics of Materials, 4th edition, Craig, Taleff, John Wiley Sons, 2020.)

The pin-jointed planar truss shown in the figure below is to be made of two steel two-force members and support a single vertical load P = 15kN at joint B. For the steel truss members, the allowable stress in tension is $(\sigma_{\mathrm{T}})_{\mathrm{allow}} = 150\mathrm{MPa}$, the allowable stress in compression is $(\sigma_{\mathrm{C}})_{\mathrm{allow}} = -80\mathrm{MPa}$, and the weight density is $77.2\frac{\mathrm{kN}}{\mathrm{m}^3}$. You are to consider truss designs for which joint B can be located at any point along the vertical line that is 1m to the right of AC, with a y_B varying from $y_B = 0$ to $y_B = 2m$

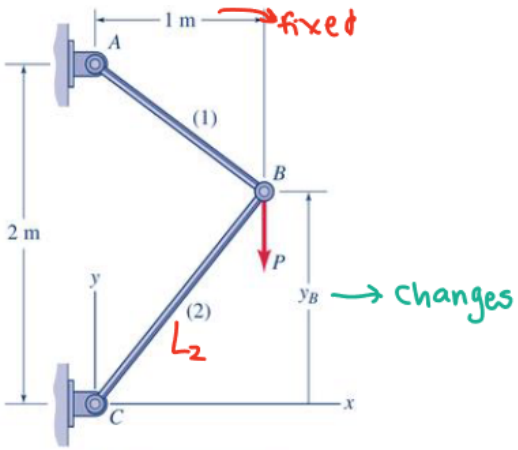

Figure 1: Two-Bar Planar Truss System, Labeled

2 EQUATIONS

Equations and explanations to be added.

3 RESULTS AND CALCULATIONS

The following code was used to create this simulation:

```
import matplotlib.pyplot as plt
import numpy as np

g = 77.2 * 10**3
P = 15 * 10**3
s_tallow = 150
s_callow = -80
x = P/2

a = np.linspace(0, 2, 20)
l_one = np.sqrt(1**2 + (2-a)**2)
l_two = np.sqrt(1 + a**2)

W = g * (x * ((l_one**2 / s_tallow) - (l_two**2 / s_callow)))

# Index of the minimum value of W
min_index = np.argmin(W)

# Minimum W value and corresponding "a" value
min_a = a[min_index]
min_W = W[min_index]
print(f"Minimum W: {min_W} at $y_B$ = {min_a}")

# Index where a = 0
a_0_index = np.where(a == 0)[0][0]
W_0 = W[a_0_index]
print(f"At a = 0, W = {W_0}")
plt.scatter(0, W_0, color='blue', zorder=5, label=f'({0}, {W_0})')

# graph of W vs "a" or (y_B)
plt.plot(a, W, 'r', label="W vs $y_B$")

# Minimum W on graph
plt.scatter(min_a, min_W, color='blue', zorder=5, label=f'Min W
    ({min_a:.2f}, {min_W:.2f})')
plt.text((min_a*0.60), (min_W+0.125*10**7), f'({min_a:.2f}, {min_W:.2f})')

# Title and Labels
plt.xlabel('Position of Joint B ($y_B$)')
plt.ylabel('Weight of Truss (W)')
plt.title('Weight of Truss vs. Position of Joint B')

plt.legend() # Legend
```

```
plt.show()
```

From this code, the following graph was produced:

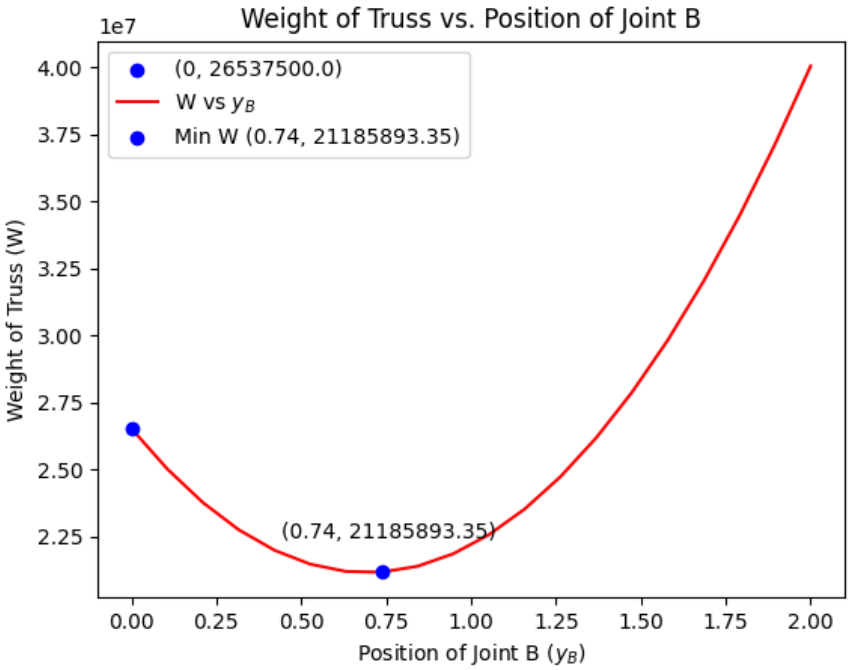

Figure 2: Weight of Truss vs. Position of Joint B y_B

Thus, the optimal weight of the truss is 21185893 N, or 21186 kN.