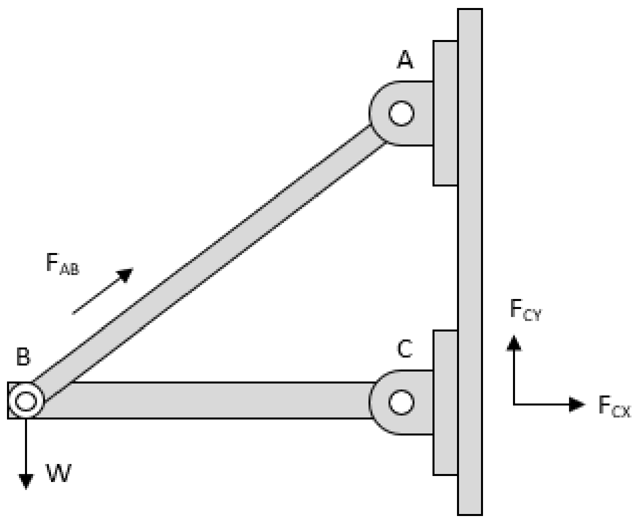
Design of a Strut

Consider the mechanism below. BC is a square tube strut and AB is a solid steel rod eyebar - both are manufactured from ASTM A36 Steel. What is the weight W that BC can support without buckling, and the diameter of AB to support AB?



Dimensions $L_{AC} := 20\ \text{ft}$ $L_{BC} := 11\ \text{ft}$

Width of square tube $Width_{BC} := 2.5\ \text{inch}$

Wall thickness $t_{BC} := 0.25\ \text{inch}$

Yield stresses $\sigma_{Y\_BC} := 36\ \text{ksi}$ $\sigma_{Y\_AB} := 36\ \text{ksi}$

Modulus of elasticity $E := 29000\ \text{ksi}$

Length of AB $L_{AB} := \sqrt{{L_{AC}}^2 + {L_{BC}}^2} = 22.825\ \text{ft}$

Moment of inertia for square rod $I_{BC} := \dfrac{{Width_{BC}}^4}{12} - \dfrac{\left(Width_{BC} - 2 \cdot t_{BC}\right)^4}{12} = 1.922\ \text{in}^4$

Constraint data constraintTypeData :=

"Constraints"	"K"
"Fixed-Fixed"	0.5
"Pinned-Pinned"	1
"Fixed-Pinned"	0.7
"Fixed-Translation Free"	1
"Fixed-Free"	2
"Pinned-Translation Free"	2

Constraint type $conType := "Pinned\text{-}Pinned"$

$K_{BC} := ArrayTools:\text{-}Lookup(conType, constraintTypeData, 1, 2) = 1$

Critical buckling load for member BC $Pcr_{buckling} := \frac{\pi^2 \cdot E \cdot I_{BC}}{K_{BC} \cdot L_{BC}^2} = 31.570\ kip$

The column will buckle when F_{CX} is the same as the critical buckling load $F_{Cx} := Pcr_{buckling}$

Solve for Load and Forces

Now find the values of W, F_{AB} and F_{Cy}

Sum of forces in X $eq1 := \frac{L_{BC}}{L_{AB}} \cdot F_{AB} - F_{Cx} = 0$

Sum of forces in Y $eq2 := \frac{L_{AC}}{L_{AB}} \cdot F_{AB} + F_{Cy} - W = 0$

Sum of moments about C $eq3 := \frac{L_{AC}}{L_{AB}} \cdot F_{AB} \cdot L_{BC} - W \cdot L_{BC} = 0$

Solve for unknowns $sol := fsolve(\{eq1, eq2, eq3\})$

$sol = \{F_{AB} = 2.914 \times 10^5\ N, F_{Cy} = -0., W = 2.553 \times 10^5\ N\}$

$W := eval(W, sol) = 57.400\ kip$

$F_{AB} := eval(F_{AB}, sol) = 65.509\ kip$

$F_{Cy} := eval(F_{Cy}, sol) = -0.$

Sizing Member AB

Member AB is a solid steel road

Cross sectional area $Area_{AB\_min} := \frac{F_{AB}}{\sigma_{Y\_AB}} = 1.820\ in^2$

Diameter $Diam_{AB\_min} := \sqrt{Area_{AB\_min} \cdot \frac{4}{\pi}} = 1.522\ in$

Standard rod sizes $std\_rod\_sizes := [20\ mm, 25\ mm, 30\ mm, 40\ mm, 50 mm, 60\ mm, 75\ mm]$

Smallest rod diameter that satisfies requirements $\min\left(select\left(i \to i - Diam_{AB\_min} > 0\ mm, std\_rod\_sizes\right)\right) = 40\ mm$