Application Sheet
Crane tension cable

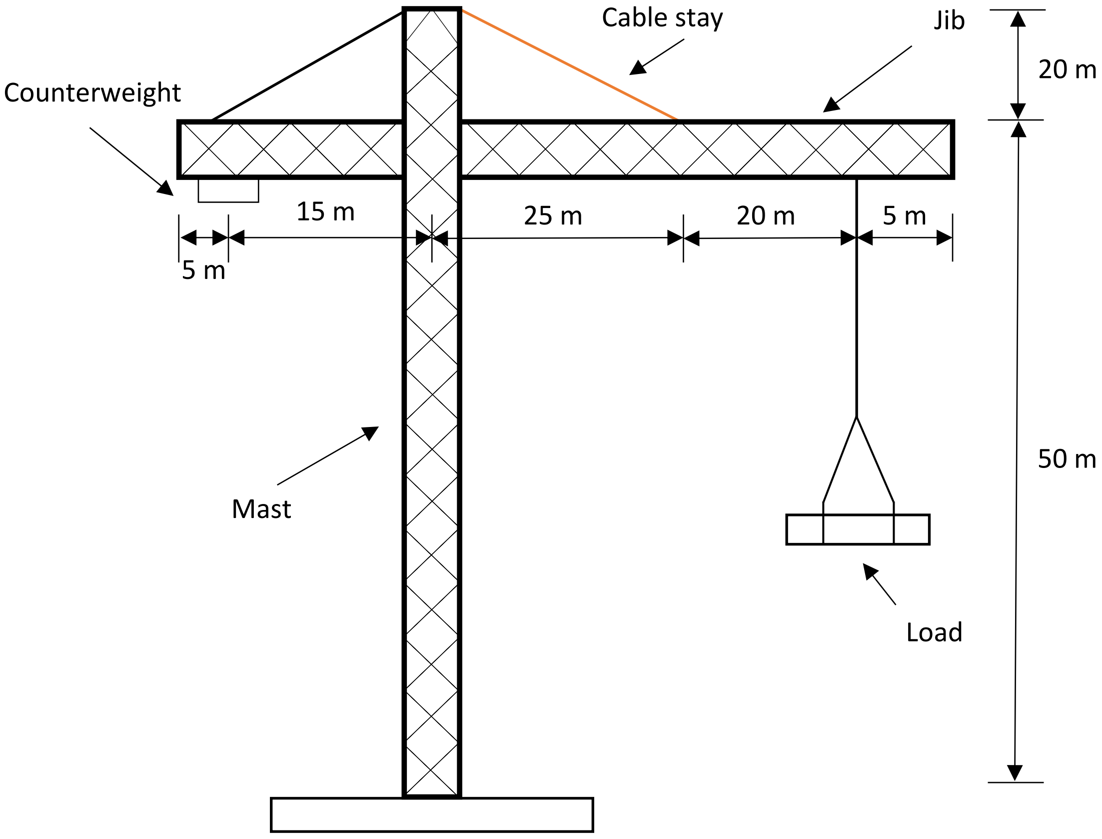
Figure 1 "Crane"

Context: Design of a tower crane
Objective: To assess the adequacy of the cable stay for the jib.

Concepts used in this application sheet

- Force: applied load, moments, force resolution

Engineering model

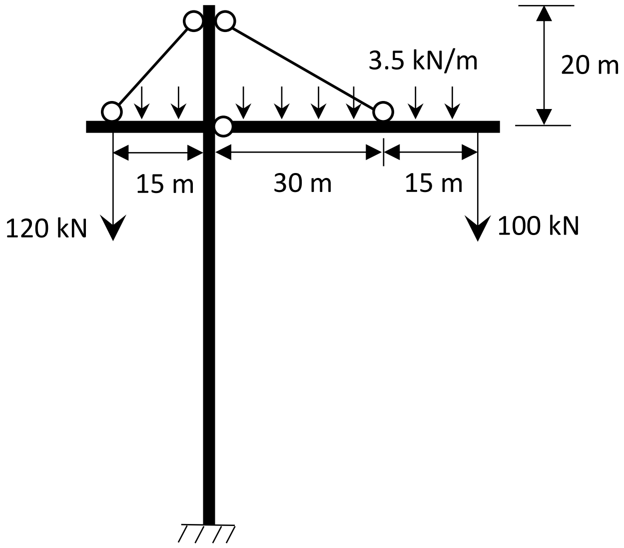


Structural analysis

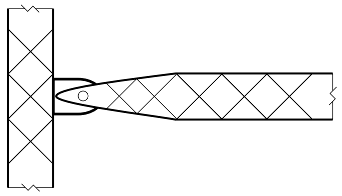
Analysis model

The self-weight of the jib is modelled as a uniformly distributed load along the length of the jib.

As a simplifying assumption for this calculation, it is assumed that there is no moment continuity in the jib at the mast i.e. the end of the jib is pinned to the mast.



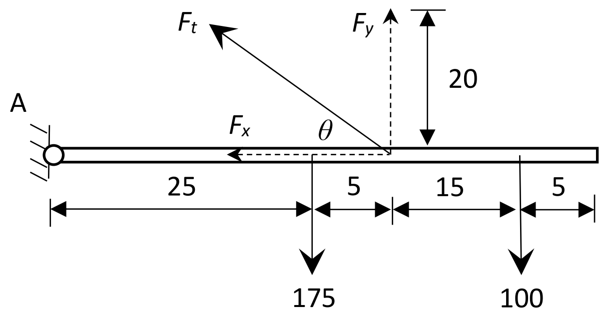
Pin connection:



All forces and dimensions are given in kN and m respectively, unless otherwise stated.

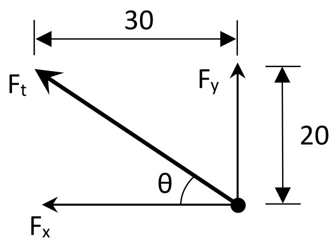
Calculate tension force in the stay

Free body diagram of the jib:



Calculate the resultant load due to the self-weight of the jib:
3.5*50 = 175 kN at 25 m

Take moments about A:
$\Sigma M = (100*45) + (175*25) – (F_y*30) = 0$
$F_y = 296$ kN



Resolve forces to find the total cable force:
Using basic trigonometry:
$\theta = \tan^{-1}(20/30) = 34^o$
$F_t = F_y/\sin(\theta) = 296/\sin(34) = 529$ kN

Apply partial factor for load
Partial safety factor for load $\gamma_f = 1.5$ (for preliminary checking)
Design load $N_{Ed} = F_t \times \gamma_f = 529*1.5 = 794$ kN

Assessment

Strength criterion for axial force
Use the partial factor method
$N_{Ed} / N_{Rd} \leq 1.0$

- N_{Ed} is the design axial force in the stay due to the applied loading
- N_{Rd} is the design axial resistance

$N_{Rd} = (A f_y) / \gamma_m$
where A is the cross-sectional area of the section
γ_m is the partial safety factor for resistance

Data input
Design force N_{Ed} = 794 kN = 794*10^3 N
Diameter of the stay D = 25 mm
Yield stress of the stay f_y =355 N/mm^2 (for Grade S355 steel from EN 1993-1-1 - Table 3.1)
Partial safety factor for material resistance γ_m = 1.0 (from Eurocode)

Calculations
Area of stay A = $\pi D^2/4$ = π*25^2/4 = 491 mm^2
Design axial resistance $N_{Rd} = (A f_y)/\gamma_m$ = (491*355)/1.0 = 174 kN

Apply the criterion
N_{Ed} / N_{Rd} = 794/174 = 4.6 > 1.0 ∴ not acceptable
Decision: cable size must be increased

Validation
The force in the cable may be significantly less than the estimated value because of the assumption of the pin connection for the jib. Overestimating the force is a safe assumption.

Crane collapses are relatively common and can result in deaths. Therefore, a higher than normal factor of safety is used to ensure the crane will not be overloaded.

Note: A version of this example using the factor of safety method is available here.

Metadata
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