Online information resource for structural mechanics

Application Sheet
Crane tension cable

Figure 1 "Crane"
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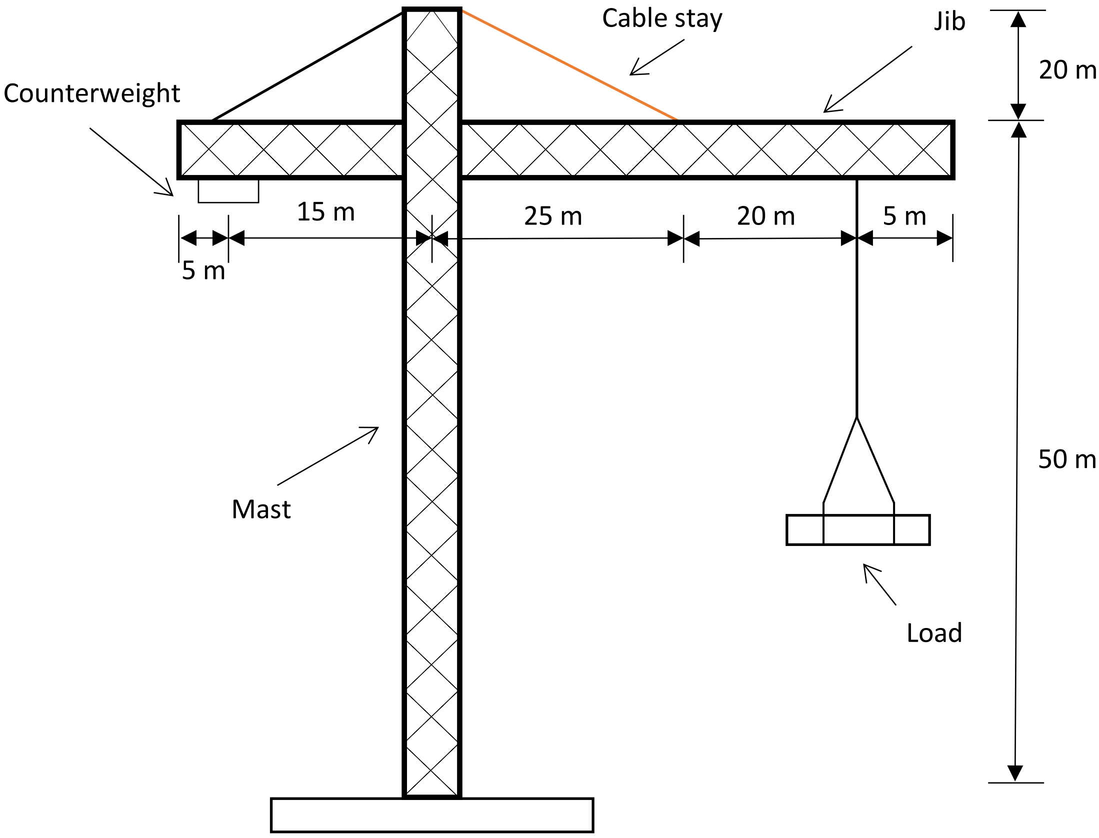
Context: Design of a tower crane
Objective: To assess the adequacy of the cable stay for the jib.

Concepts used in this application sheet

- Force: applied load, moments, force resolution

Engineering model

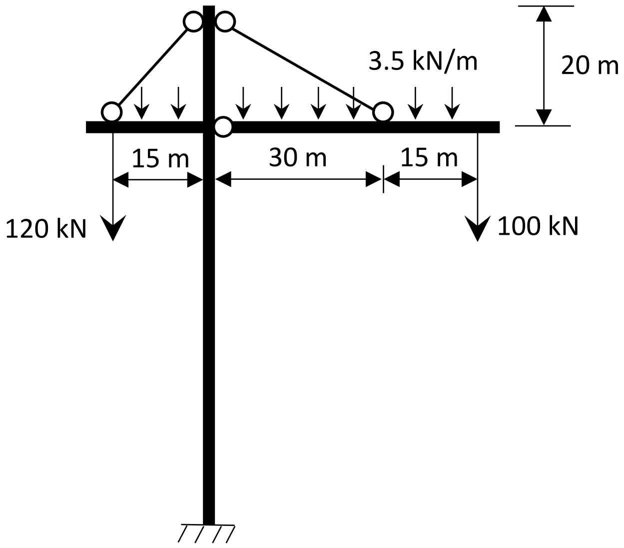


Structural analysis

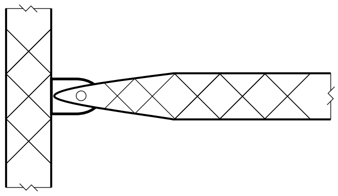
Analysis model

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.



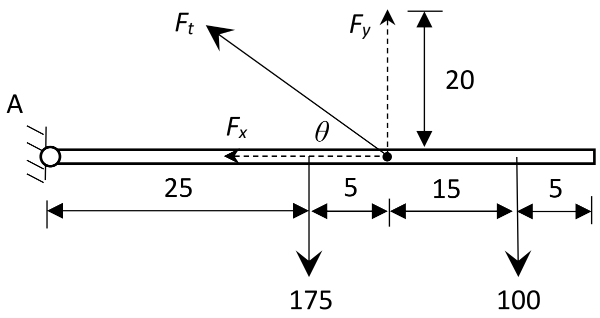
Pin connection:



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

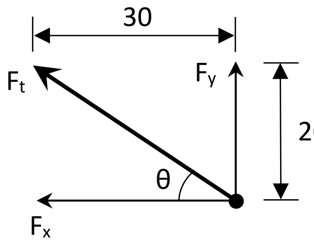
Calculate tension force in the stay

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:
$\theta = \tan^{-1}(20/30) = 34^o$
$F_t = F_y/\sin(\theta) = 296/\sin(34) = 529$ kN

Assessment

Criterion
Factor of Safety = σ_u/σ_w

- σ_u is the ultimate tensile stress
- σ_w is the working stress

Data input
Force in stay F_t = 529 kN = 529*10^3
Diameter of the stay D = 25 mm
Cabe stay ultimate tensile stress σ_u = 345 N/mm^2
Minimum required FoS = 3.0

Calculations
Area of stay A = $\pi D^2/4$ = π*25^2/4 = 491 mm^2
Stress in stay $\sigma_w = F_t/A$ = 529*10^3/491 = 1077 N/mm^2

Apply the criterion
FoS = σ_u/σ_w = 345/1077 = 0.32 ∴ this is much less than the required FoS of 3.0 so the design is 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.

Metadata:
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