Lab 2: Session 2 - Factor of Safety

ASEN 2001

Fall 2016

Announcements

- By next lab:
  - complete 3D conversion of truss code
  - modify code to account of truss' self-weight
  - (for head start on following weeks tasks: detailed designs and Monte Carlo simulation)
- 2D MATLAB Monte Carlo simulation code truss2dmcs.m posted on D2L
- Guidelines on computing Factor of Safety posted on D2L

Why is factor of safety important?

$$FOS = \frac{F_{\max}}{F_{design}}$$

Photo courtesy: Department of Mines of Western Australia

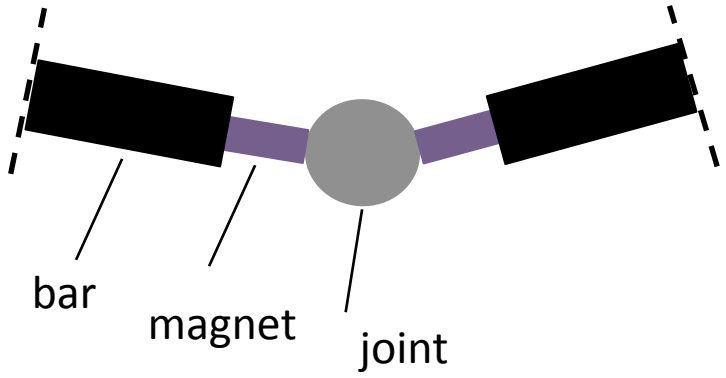
Selecting factor of safety

Some considerations:

- accuracy of predicted loads
- variation in strength of material
- environmental effects
- cost of over-engineering components
- consequences of failure
- …

Aloha Airlines Flight 243 Fuselage blew open in flight due to material fatigue effect as a result of corrosion (1988). [the.honoluluadvertiser.com]

Steps involved



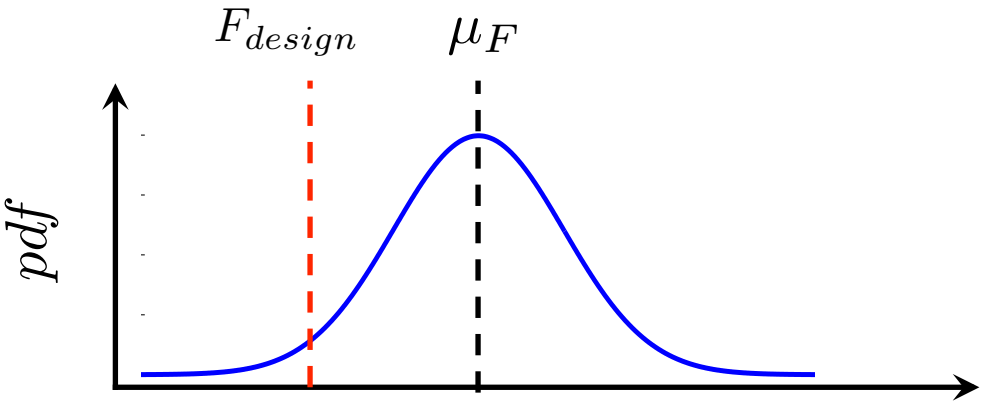
Failure: $|F_{bar}| > F_{\max}$

geometry, loading, …

"material"

- Step 1: Assuming a failure probability, identify *FOS* and F_{design} for a bar
- Step 2: Design the truss so that the bar forces do not exceed F_{design}
- Step 3: Perform Monte Carlo simulation to estimate failure probability of truss under as-built deviations from design; refine failure probability of bars if needed

Step 1 – From failure probability to FOS

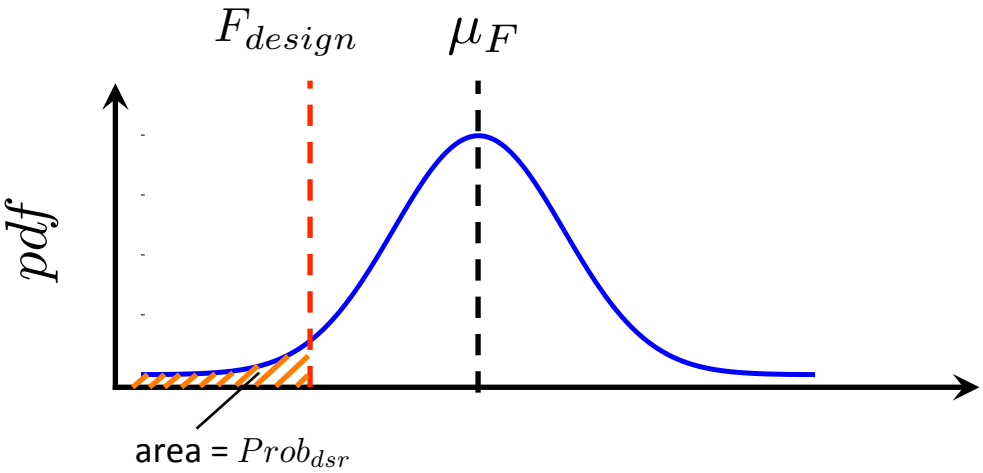


$$FOS = \frac{F_{\max}}{F_{design}} = \frac{\mu_F}{F_{design}}$$

$$F_{design} = \mu_F - 1 \cdot \sigma_F \longrightarrow Prob(F_{max} < F_{design}) = 0.32$$

$$F_{design} = \mu_F - 3 \cdot \sigma_F \longrightarrow Prob(F_{max} < F_{design}) = 0.0027$$

Step 1 – From failure probability to FOS



$$FOS = \frac{F_{\max}}{F_{design}} = \frac{\mu_F}{F_{design}}$$

$$F_{\max} \sim N(\mu_F, \sigma_F)$$

$$F_{design} = \mu_F - 1 \cdot \sigma_F \longrightarrow Prob(F_{max} < F_{design}) = 0.32$$

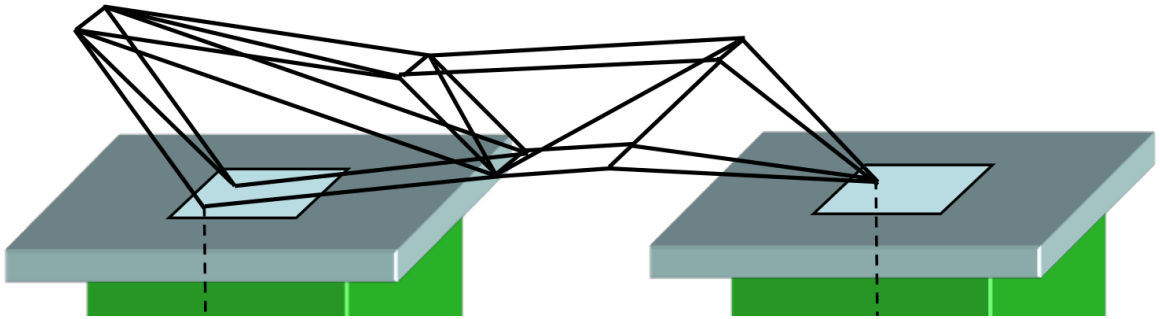
$$F_{design} = \mu_F - 3 \cdot \sigma_F \longrightarrow Prob(F_{max} < F_{design}) = 0.0027$$

- Pick a failure probability and find F_{design} :

MATLAB: $F_{design} = icdf('normal', Prob_{dsr}, \mu_F, \sigma_F)$

Step 2 – Truss design

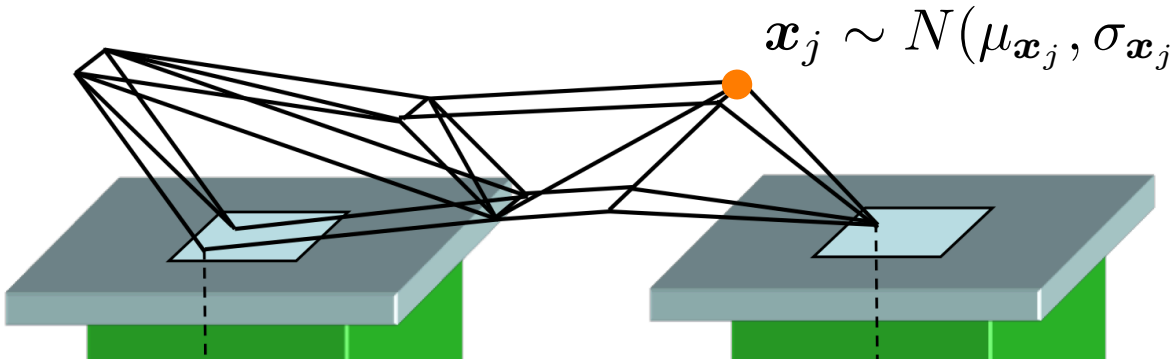
Design your truss such that: $\max(|F_{bar}|) \leq F_{design}$



$\max(|F_{bar}|)$: maximum bar force magnitude

Step 3 – Monte Carlo simulation

Assume random perturbations over nominal joint locations:



Estimate failure probability:

$$Prob(\max(|F_{bar}|) > F_{design}) \approx \frac{\#\{\max(|F_{bar}|) > F_{design}\}}{N}$$

N: # of Monte Carlo trials