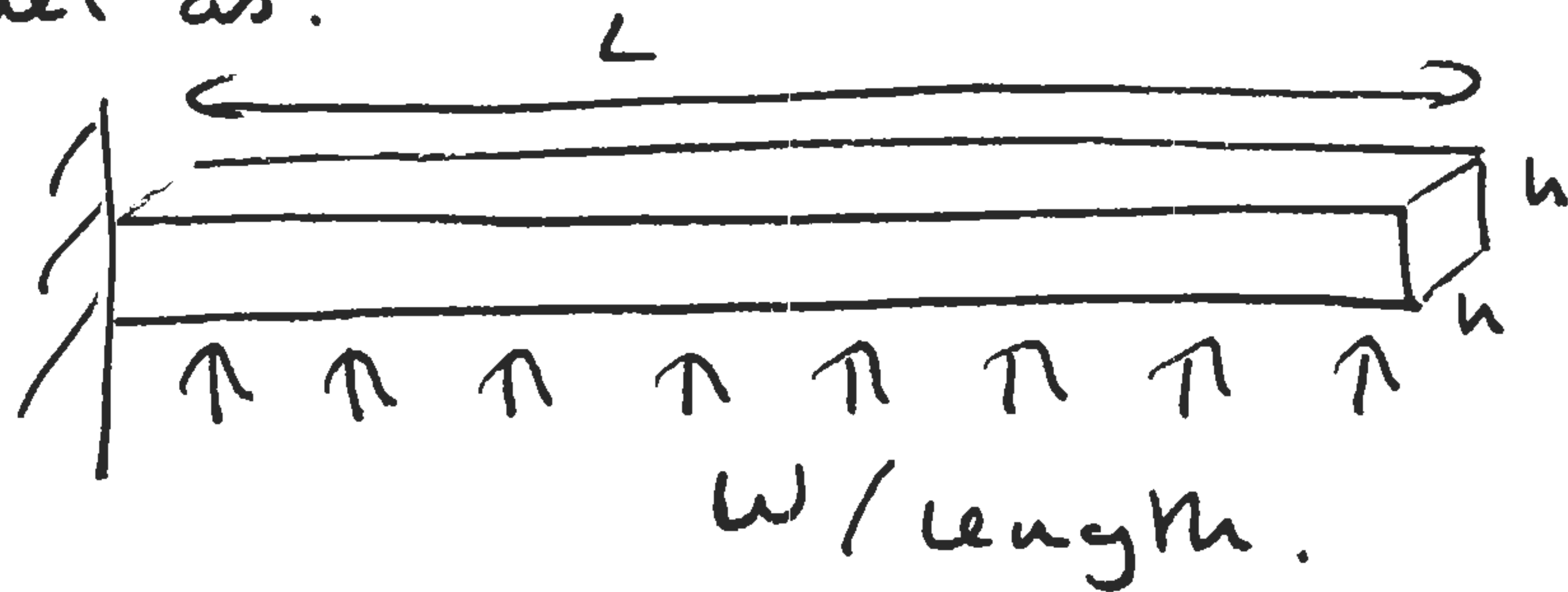


M19

Wing, designed for bending loads
Model as:



$$I = \frac{1}{12} h^4$$

$$\text{Max moment at root} = \frac{wL^2}{2}$$

$$\begin{aligned} \text{Max stress} &= \frac{Mz}{I} = \sigma_{\text{max}} = \frac{wL^2}{2} \cdot \frac{h}{2} \cdot \frac{12}{h^4} \\ &= \frac{3wL^2}{h^3} \quad \text{cannot exceed } \sigma_y \end{aligned}$$

$$\text{mass} = \rho AL = \rho h^2 L$$

$$h = \sqrt{\frac{m}{\rho L}}$$

substitute for h

$$\sigma_y = 3wL^2 \left(\frac{\rho L}{m} \right)^{3/2}$$

$$\therefore \text{minimum mass } m = (3wL^2)^{2/3} \frac{\rho L}{\sigma_y^{2/3}}$$

\therefore choose material with min

$$\text{or max } \sigma_y^{2/3} / \rho \quad \Leftarrow$$

$$\rho / \sigma_y^{2/3}$$

For turbine disk $\sigma_{max} < \sigma_y$

$$\therefore \frac{3}{8} \rho v^2 = \sigma_y$$

choose material with max σ_y/ρ

	ρ	σ_y	σ_y/ρ	$\sigma_y^{2/3}/\rho$
6) Al 2024	2800	345	0.12	0.018
Al 7075	2800	495	0.18	0.022
Ti 6-4	4510	910	0.20	0.021
Ph 17-7 Ph.	8000	1435	0.18	0.016
Steel	7800	260	0.03	0.005
			↓	↓
			<u>Ti</u>	<u>Al 7075</u>

Critical crack size for

$$\text{Al 7075} \quad a_c = \frac{1}{\pi} \left(\frac{K_{Ic}}{0.4 \sigma_y} \right)^2 = \frac{1}{\pi} \left(\frac{24 \times 10^6}{0.4 \times 495 \times 10^6} \right)^2$$

$$a_c = 4.7 \text{ mm.} \quad \text{- detectable}$$

$$\text{Ti 6-4} \quad a_c = \frac{1}{\pi} \left(\frac{50 \times 10^6}{0.9 \times 910 \times 10^6} \right)^2 = 1.2 \text{ mm}$$

|
Small

d) Critical crack size for Ti 6-4 is small, harder to detect, more difficult to implement a damage tolerant design approach.