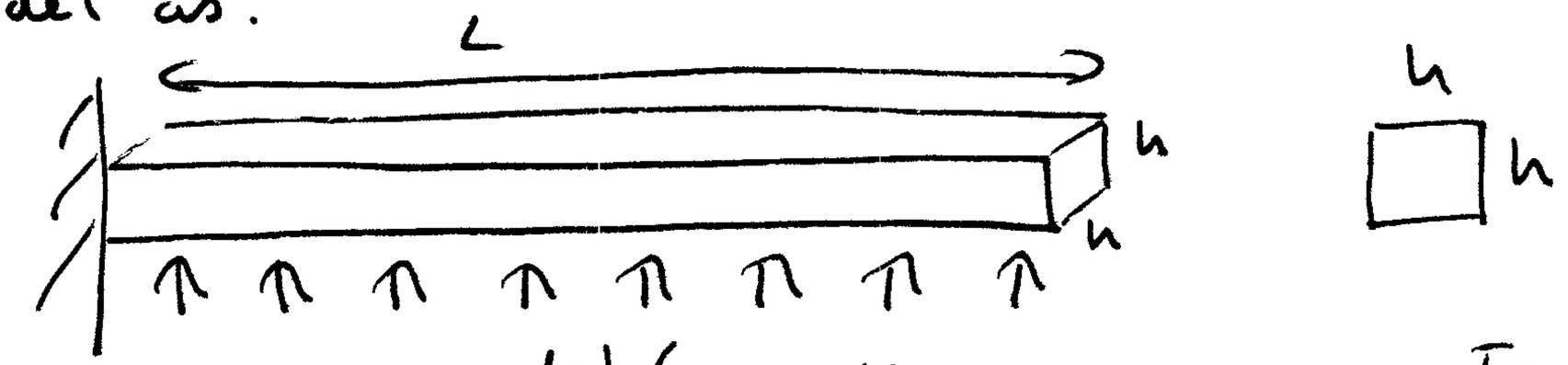
M19 Wing, designed for bending loads

Model as:



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

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

Max stress = $\frac{Mz}{I} = \sigma_{max} = \frac{WL^2}{2} \cdot \frac{h}{2} \cdot \frac{12}{h^3}$

$= \frac{3WL^2}{h^3}$ cannot exceed σ_y

Mass = $\rho A L = \rho h^2 L$ $\qquad h = \sqrt{\frac{m}{\rho L}}$

substitute for h

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

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

$\therefore$ choose material with min $\rho / \sigma_y^{2/3}$

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

For hoop mode dock $\sigma_{max} < \sigma_y$

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

choose material with max σ_y/ρ $\sigma_y^{2/3}/\rho$

	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
			↓	↓
			Ti	Al 7075

Critical crack size for

Al 7075 $\quad a_c = \frac{1}{\pi}\left(\frac{K_c}{0.4\sigma_y}\right)^2 = \frac{1}{\pi}\left(\frac{24\times10^6}{0.4\times495\times10^6}\right)^2$

$a_c = 4.7$ mm. - detectable

Ti 6-4 $\quad a_c = \frac{1}{\pi}\left(\frac{50\times10^6}{0.9\times910\times10^6}\right)^2 = 1.2$ mm

small

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