3.14) $\max F = 2000\ N$

$V_f = 0.65 \quad V_n = 0.35$

$\rho_n = 1.3 \quad \sigma_{uf} = 6200\ MPa \quad E_f = 5956\ MPa \quad \rho_f = 1.96 \frac{g}{cm^3} \quad \varepsilon_{uf} = 1.2\%$

$\sigma_{uc} = 0.65 \cdot 6200\ MPa = 4030\ MPa$

$$A = \frac{F}{\sigma_{uc}} = \frac{2000\ N \quad m^2}{4030 \times 10^6\ N} = 4.96 \times 10^{-7}\ m^2$$

$$\rho_c = V_f \rho_f + V_m \rho_m = 0.65 \cdot 1.96 + 0.35\ 1.3 = 1.729 \frac{g}{cm^3}$$

$$m = A \cdot L \cdot \rho = \frac{4.96 \times 10^{-7}\ m^2 \cdot L \cdot 1.729\ g}{cm^3} \quad \frac{100^3\ cm^3}{1\ m^3}$$

$m_c = L \cdot 0.858 \frac{g}{m}$

$$A_s = \frac{2000\ N \quad m^2}{150 \times 10^6\ N} = 4.\bar{4} \times 10^{-6}\ m^2$$

$$m_s = A_s \cdot L \cdot \rho_s = 4.\bar{4} \times 10^{-6}\ m^2 \cdot L \cdot 7.8 \frac{g}{cm^3} \frac{100^3\ cm^3}{1\ m^3}$$

$m_s = 1.34.7 \frac{g}{m}$

a) Steel rod would weigh aproximately 40x more than composite is better

3.14 (cont) b) it costs less to use the composite by approx 8x so it is better.

3.15 $\frac{V_m}{V_f} = 1.5$

$V_m = 1.5 V_f \qquad V_c = V_f + V_m$

$V_c = 2.5 V_f$

$V_f = \frac{1}{2.5} = 0.4 \qquad V_m = 0.6$

$\sigma_{c,0} = 0.4 \cdot 700 + 0.6 \cdot 52.5 = 312 \text{ MPa}$

$V_{epoxy} = 1.5 V_{gf} \qquad 1 = V_{cf} + 2.5 V_{gf}$

$\frac{1 - V_{cf}}{2.5} = V_{gf} \qquad V_{ep} = 1.5 V_{gf} \qquad \frac{1}{1.5} V_{ep} = V_{gf}$

$\sigma_{c,n} = V_{cf} \cdot 700 + \frac{1 - V_{cf}}{2.5} \cdot 700 + 1.5\left(\frac{1 - V_{cf}}{2.5}\right) \cdot 52.5$

$= 700 V_{cf} + 280(1 - V_{cf}) + 31.5(1 - V_{cf})$

$= 700 V_{cf} + 312 - 312 V_{cf}$

$= 388 V_{cf} + 312 \geq 312 \quad (\sigma_{c,0})$

$-312 \qquad -312$

$\boxed{V_{cf} > 0}$

3.16)

$V_m = 0.3 \qquad V_{gf} = 0.7 - V_{cf} \qquad V_{cf} = V_{cn}$

$E_{c,o} = 0.3 \cdot 3.5 + 0.7 \cdot 70 = 50.05 \text{ GPa}$

$E_{cn} = 50.05 \cdot 2 = 0.3 \cdot 3.5 + (0.7 - V_{cf}) \cdot 70 + V_{cf} \cdot 350$

$99.05 = 49 - 70 V_{cf} + 350 V_{cf}$

$\boxed{V_{cf} = 0.178}$

$\rho_{c,o} = 0.3 \cdot 1.2 + 0.7 \cdot 2.5 = 2.11 \frac{g}{cm^3}$

$\rho_{c,n} = 0.3 \cdot 1.2 + 0.522 \cdot 2.5 + 0.178 \cdot 1.8 = 1.99$

$\% = \frac{2.11 - 1.99}{2.11} \cdot 100 = \boxed{5.94\%}$

$\sigma_{u,o} = 0.3 \cdot 52.5 + 0.7 \cdot 700 = \boxed{506 \text{ MPa}}$

$\sigma_{un} = 0.3 \cdot 52.5 + 0.522 \cdot 700 + 0.188 \cdot 700 = \boxed{506 \text{ MPa}}$

Strength decreases because more voids and weaker bonds are formed in the new composite with more ingredients

3.17) $\sigma_u = E \cdot \varepsilon_u$

$\sigma_{Lu} = E_L \cdot \varepsilon_{Lu}$

$\sigma_{Lu} = 40 \cdot 10^9 \cdot 27.6 \cdot 10^{-3}$

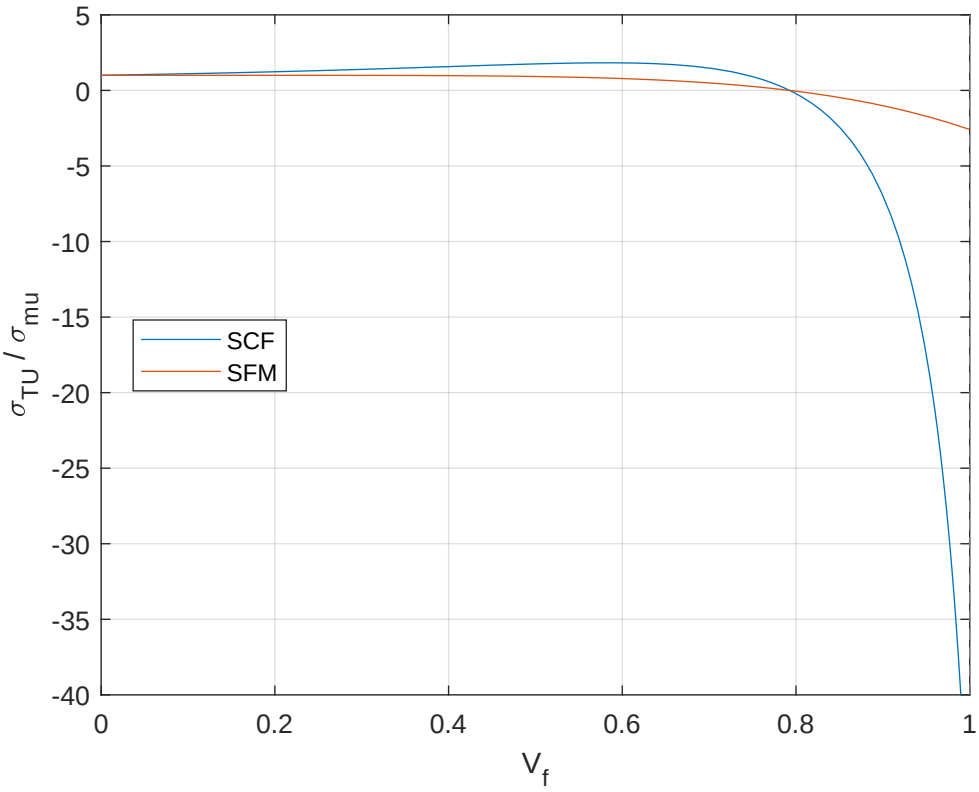
$\boxed{\sigma_{Lu} = 1104 \text{ MPa}}$

3.18) $\sigma_{Tu} = \frac{\sigma_{mu}}{S}$ $\qquad \frac{E_m}{E_f} = 0.05$

$\frac{\sigma_{Tu}}{\sigma_{mu}} = \frac{1}{S}$

$SCF = \frac{1 - V_f\left[1 - (E_m/E_f)\right]}{1 - (4V_f/\pi)^{1/2}\left[1 - (E_m/E_f)\right]}$

$SMF = \frac{1}{1 - (4V_f/\pi)^{1/2}\left[1 - (E_m/E_f)\right]}$


5
0
-5
-10
-15
-20
-25
-30
-35
-40
0
0.2
0.4
0.6
0.8
1
V_f
$\sigma_{TU} / \sigma_{mu}$
SCF
SFM