Solutions

2.1

- $S_e' = 0.5 S_{ut} = 315$ MPa.
- $k_a = 4.51 S_{ut}^{-0.265} = 4.51 \times 630^{-0.265} = \mathbf{0.817}$; $k_b = 1.24 d^{-0.107} = 1.24 \times 40^{-0.107} = \mathbf{0.836}$.
- $S_e = k_a k_b S_e' = 0.817 \times 0.836 \times 315 = \mathbf{215}$ MPa.

2.2

- The line is straight on log axes: each decade from 10^3 multiplies S by $(S_e / 0.9 S_{ut})^{1/3} = (215/567)^{1/3} = 0.724$.
- At 10^4: $S = 567 \times 0.724 = \mathbf{410}$ MPa.

3.1

- Goodman: $1/n = \sigma_a / S_e + \sigma_m / S_{ut} = 60/215 + 120/630 = 0.469$, so $n = \mathbf{2.13}$.
- Yield: $n_y = S_y / \sqrt{\sigma_a^2 + \sigma_m^2} = 530 / \sqrt{60^2 + 120^2} = \mathbf{3.95}$.
- Fatigue governs. Lower K_f first, with a larger shoulder fillet radius, before resorting to a bigger shaft or a stronger steel.

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