1. Design a cotter joint to transmit a load of 30kN in tension (or) compression. Allowable tensile stress is 55 MPas. Crushing stress is 70 MPa and shear stress is 40 MPas.

$\sigma_t = 55$ MPas

$\sigma_c = 70$ MPas

$\tau = 40$ MPas

1. Diameter of rod

$$\sigma_t = \frac{P}{(\pi d^2/4)}$$

$$55 = \frac{30 \times 10^3 \times 4}{\pi d^2}$$

$$d^2 = \frac{30 \times 10^3 \times 4}{\pi \times 55}$$

$$d = 26 \text{ mm}$$

2. Thickness of cotter.

$$t = 0.3d.$$

$$= 0.3 \times 26$$

$$t = 8 \text{ mm}$$

3. Diameter of spigot.

$$55 = \frac{30 \times 10^3}{\left[\left(\frac{\pi d_1^2}{4} - d_1 \times 8\right)\right]}$$

$$\frac{\pi d_1^2}{4} - 8d_1 = \frac{30 \times 10^3}{55}$$

$$= 545.45$$

$$\pi d_1^2 - 32 d_1 = 2181.818$$

$$\pi d_1^2 - 32.4 d_1 =$$

$$d_1 = 32 \text{ mm}$$

$$70 = \frac{30 \times 10^3}{d_1 \times 8.}$$

$$d_1 = \frac{30 \times 10^3}{70 \times 8.}$$

4. Outside diameter of socket (D_1).

$$\sigma_t = \frac{P}{\left[\frac{\pi(D_1^2 - d_1^2)}{4} - (D_1 - d_1)t\right]}$$

$$55 = \frac{30 \times 10^3}{\left[\frac{\pi(D_1^2 - 54^2)}{4} - (D_1 - 54)t\right]}$$

$$\frac{30 \times 10^3}{55} = 0.78(D_1^2 - 54^2) - (D_1 - 54)8$$

$$545.45 = 0.78D_1^2 - 2274.48 - 8D_1 + 432$$

$$0.78D_1^2 - 2274.48 - 8D_1 + 432 - 545.45 = 0.$$

$$0.78D_1^2 - 8D_1 - 2387.93 = 0.$$

$$D_1 = 60.6$$

$$D_1 = 61 \text{ mm}.$$

5. Distance from end of slot to end of spigot.

$$40 = \frac{30 \times 10^3}{2d_1 a}$$

$$a = \frac{30 \times 10^3}{40 \times 2 \times 54}$$

$$a = 7 \text{mm}.$$

6. Diameter of socket collar (D_2)

$$\sigma_c = \frac{P}{(D_2 - d_1)t}$$

$$70 = \frac{30 \times 10^3}{8(D_2 - 54)}$$

$$D_2 - 54 = \frac{30 \times 10^3}{70 \times 8}$$

$$D_2 = 107.57 \text{ mm}$$

$$D_2 = 108 \text{ mm}$$

7. Thickness of socket collar.

$$\tau = \frac{P}{2(D_2 - d_1)c}$$

$$c = \frac{30 \times 10^3}{2(108 - 54)40}$$

$$c = 7 \text{ mm}$$

8. Diameter of spigot socket.

$$\sigma_c = \frac{P}{\left[\frac{\pi (d_2^2 - d_1^2)}{4}\right]}$$

$$\frac{\pi}{4}(d_2^2 - d_1^2) = \frac{30 \times 10^3 \times 4}{70 \times \pi}$$

$$d_2^2 - 54^2 = 545.67$$

$$d_2 = 59 \text{ mm}$$

9. Thickness of spigot collar (t_1)

$$40 = \frac{30 \times 10^3}{\pi \times t_1 \times d_1}$$

$$t_1 = \frac{30 \times 10^3}{\pi \times 40 \times 54}$$

$$t_1 = 5 \text{ mm}.$$

10. Width of cotter (b)

$$\tau = \frac{P}{2bt}$$

$$b = \frac{30 \times 10^3}{40 \times 2 \times 8}$$

$$b = 47 \text{ mm}$$

$$\sigma_t = \frac{P(2D_2 - d_1)}{4b^2 t}$$

$$b^2 = \frac{30 \times 10^3 (2 \times 108 - 54)}{4 \times 55 \times 8}$$

$$b = 53 \text{ mm}.$$

Width of cotter = 53 mm.