Answer Key: Civil Engineering Licensure Exam – Mock Exam (Day 39: Combined Stresses and Mohr's Circle)

February 24, 2025

Answer Key

Section A: Multiple Choice Solutions

1. Normal stress formula: **(a)** $\sigma = \frac{F}{A}$
2. Principal stresses are: **(a) The maximum and minimum normal stresses**
3. The center of Mohr's Circle represents: **(a) The average normal stress**
4. The radius of Mohr's Circle represents: **(a) The maximum shear stress**
5. Mohr's Circle for pure shear stress: **(c) A vertical line on the shear stress axis**

Section B: Problem-Solving Solutions

1. Normal stress in a steel rod:

$$\sigma = \frac{F}{A} = \frac{50,000}{200 \times 10^{-6}} = 250 \text{ MPa}$$

2. Maximum bending stress:

$$\sigma = \frac{My}{I} = \frac{(10 \times 10^6)(100)}{5 \times 10^6} = 200 \text{ MPa}$$

3. Principal stresses using Mohr's Circle:

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \frac{80 + 40}{2} \pm \sqrt{\left(\frac{80 - 40}{2}\right)^2 + 30^2}$$

$$= 60 \pm \sqrt{400 + 900}$$

$$= 60 \pm \sqrt{1300}$$

$$= 60 \pm 36.06$$

$$\sigma_1 = 96.06 \text{ MPa}, \quad \sigma_2 = 23.94 \text{ MPa}$$

4. Maximum shear stress:

$$\tau_{\max} = \frac{\sigma_x - \sigma_y}{2}$$

$$= \frac{100 - 60}{2} = 20 \text{ MPa}$$

5. Principal stresses with combined shear and axial stress:

$$\sigma_{1,2} = \frac{\sigma_x}{2} \pm \sqrt{\left(\frac{\sigma_x}{2}\right)^2 + \tau^2}$$

$$= \frac{80}{2} \pm \sqrt{\left(\frac{80}{2}\right)^2 + 50^2}$$

$$= 40 \pm \sqrt{1600 + 2500}$$

$$= 40 \pm \sqrt{4100}$$

$$= 40 \pm 64.03$$

$$\sigma_1 = 104.03 \text{ MPa}, \quad \sigma_2 = -24.03 \text{ MPa}$$