6.5 Combined stress and Mohr's circle

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS Mohr's circle • principal stress

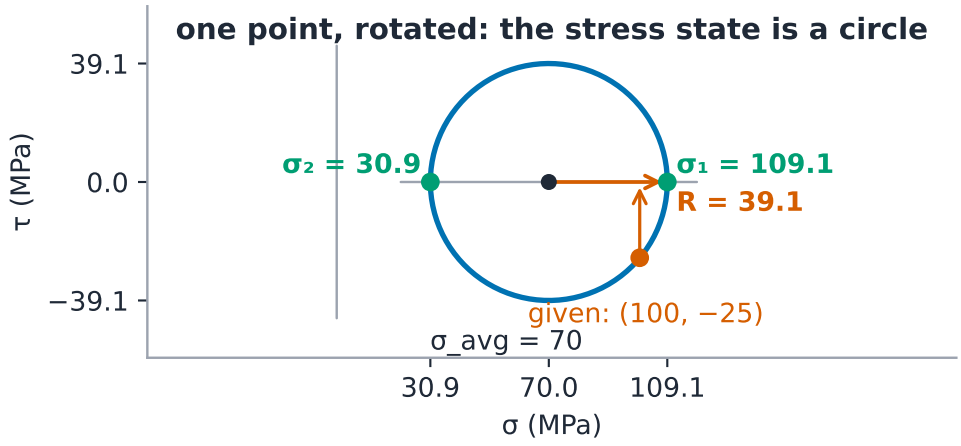
Objective

Transform a plane stress state with Mohr's circle: centre, radius, principal stresses, angles and the absolute-maximum shear.

1 Key knowledge and worked examples

■ The circle

Centre $\sigma_{avg} = (\sigma_x + \sigma_y)/2$, radius $R = \sqrt{((\sigma_x - \sigma_y)/2)^2 + \tau_{xy}^2}$; the circle turns 2θ as the element turns θ.



*Intercepts are the principal stresses

■ Worked example. One point, rotated

(100, 40, 25) MPa: centre 70, $R = 39.1$, $\sigma_1 = 109.1$ and $\sigma_2 = 30.9$ MPa at 19.9°; absolute-maximum shear 54.5 MPa (both positive).

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2 Practice

2.1 A point carries $\sigma_x = 80$, $\sigma_y = 20$ and $\tau_{xy} = 30$ MPa: the circle centre (MPa) and the radius (one decimal, MPa). [4]

2.2 The two principal stresses (one decimal each, MPa) and the principal angle from the x-face (one decimal, degrees). [4]

2.3 The absolute-maximum shear stress at the point (one decimal, MPa), with the reason. [3]

2.4 If the second normal stress were -20 MPa instead (all else equal): what changes about the maximum shear, and what is its new value (one decimal, MPa)? [3]

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Solutions

2.1

- $\sigma_{avg} = (80 + 20)/2 = \mathbf{50.0}$ MPa.
- $R = \sqrt{30^2 + 30^2} = \sqrt{1800} = \mathbf{42.4}$ MPa.

2.2

- $\sigma_1 = 50 + 42.4 = \mathbf{92.4}$ MPa.
- $\sigma_2 = 50 - 42.4 = \mathbf{7.6}$ MPa.
- $\theta_p = \tan^{-1}(2 \times 30/60)/2 = 45/2 = \mathbf{22.5}^\circ$.

2.3

- Both principals positive, so the absolute-maximum shear is $\sigma_1/2 = \mathbf{46.2}$ MPa.

2.4

- The principals would straddle zero, so the absolute-maximum shear becomes the in-plane radius itself.
- $R' = \sqrt{50^2 + 30^2} = \sqrt{3400} = \mathbf{58.3}$ MPa.

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