How to Draw Mohr's Circle with Previous Year Questions & Study Notes for GATE & SSC JE

Mohr's circle was named after a German Civil Engineer, Christian Otto Mohr, is a two-dimensional graphical representation of the transformation law for the Cauchy stress tensor. If you are preparing for Engineering exams like GATE or SSC JE, you might find questions from Mohr's Circle frequently. In this article, you will learn about the Mohr's Circle, how to draw it along with Previous Year Questions & quick quiz to test your knowledge. Aspirants of GATE ME & GATE CE, as well as SSC JE ME & SSC JE CE, will benefit from this article.

Mohr's Circle - An Introduction

Mohr circle is a graphical representation of plane stress which helps in determining the relationships between normal and shear stresses acting on any inclined plane at a point in a stressed body.

A member subjected to direct stress in one direction only -

Stress on X-face, A(σ, 0)

Stress on Y-face, B(0,0)

Mohr Circle -

x-coordinate on Mohr' circle - Normal stress

y-coordinate on Mohr' circle - Shear stress

σ: tensile(positive)
τ: clockwise(positive)

- Every plane is represented in Mohr's circle by doubles it actual angle
- Every plane is represented by a radial line in Mohr's cirle:
- Centre of the Mohr circle always lie on X axis:

Coordinates are $O'\left(\frac{\sigma}{2}, 0\right)$

Stress on an inclined plane AM, inclined at an angle θ with normal face:

Normal Stress (σ_n) and Shear Stress (τ_s) on an oblique plane:

σ_n = O'M' = O'O + OM cos 2θ = R + R cos 2θ = R (1 + cos 2θ)

$$\sigma_n = \frac{\sigma}{2}(1 + \cos 2\theta) = \frac{\sigma}{2}(2 \cos 2\theta)$$

$$\sigma_n = \sigma \cos 2\theta$$

τ_s = OM sin 2θ = R sin 2θ

Normal Stress will be maximum when:

$2\theta = 0°, 180° \Rightarrow \theta = 0°$ or $90°$

Shear stress will be maximum when:

$2\theta = 90°, 270° \Rightarrow \theta = 45°, 135°$

First maximum shear plane

Second maximum shear plane

Second maximum shear plane $(2\theta_4 = 270°)$ $(\tau_{max} = R = \sigma/2)$

B (0,0)

O

A $(\sigma,0)$

Minimum Principal plane $(2\theta_2 = 180°)(\sigma_2 = 0)$

Maximum Principal plane $(2\theta_1 = 0°)(\sigma_1 = \sigma)$

First maximum shear plane $(2\theta_3 = 90°)$ $(\tau_{max} = R = \sigma/2)$

$\sigma_2 = \sigma_{min}$

τ_{max}

τ_{min}

45°

$\sigma_1 = \sigma_{max}$

- Plane on which normal stress attains its maximum and minimum values are called principal planes.
- The shear stress on principal plane is zero.
- The planes of maximum and minimum normal stresses are at angle of 90° to each other.

- Planes of maximum shear stress occur at 45° to the principal planes.
- Plane normal to the axis of loading will carry the maximum normal stress.
- Shear stress will be max on two planes inclined at 45° & 135°.

1. Principal planes are the planes on which the shear components are zero.

i.e. it is represented on the Mohr's circle by the radial lines lying on x-axis.

Its magnitude is equal to the x-coordinate of the point of intersection where circle intersect x-axis.

The sum of the complementary normal and shear stress at a point is always remains constant and their sum is equal to $(\sigma_x + \sigma_y)$

$\sigma_n + \sigma'_n = \sigma_{max} + \sigma_{min} = const.$

2. Maximum shear planes are planes on which normal stress may or may not be zero.

τ_{max} planes are represented on the Mohr's circle by the radial lines parallel to y axis.

Normal stress on τ_{max} plane (σ_n^*) is equal to x-coordinate of centre of Mohr's circle.

$$\sigma_n^* = \frac{\sigma_x + \sigma_y}{2} = \frac{\sigma_1 + \sigma_2}{2} = \frac{\sigma}{2}$$

$$\pm R = \frac{\sigma_1 - \sigma_2}{2}$$

Previous Year Questions on Mohr's Law for GATE

Q1. At the principal planes _____.

1. The normal stress is maximum or minimum and the shear stress is zero.
2. The tensile and compressive stresses are zero.
3. The tensile stress is zero and the shear stress is maximum.
4. No stress acts.

Ans: 1

Solution:

Principal planes are the planes on which the shear components are zero. Plane on which normal stress attains its maximum and minimum values are called principal planes.

Q2. Principal plane is one which carries _____.

1. No shear stress
2. Maximum shear stress
3. No normal stress
4. Maximum resultant of stresses

Ans: 1

Solution:

Principal planes are the planes on which the shear components are zero. Plane on which normal stress attains its maximum and minimum values are called principal planes.

Q3. The shear stress along the principal plane subjected to maximum principal stress is _____.

1. Minimum
2. Maximum
3. Zero
4. Any value depending on loading conditions

Ans: 3

Solution:

Principal planes are the planes on which the shear components are zero. Plane on which normal stress attains its maximum and minimum values are called principal planes.

Q4. Mohr's circle can be used to determine the following stress on an inclined surface:

A. Principal stress
B. Normal stress
C. Tangential stress
D. Maximum shear stress

1. Only A
2. Only B
3. Only C
4. A, B, C and D

Ans: 4

Solution:

Mohr circle is a graphical representation of plane stress which helps in determining the relationships between normal and shear stresses acting on any inclined plane at a point in a stressed body.

Mohr's circle of stresses is a graphical method of finding normal, tangential and resultant stresses on an oblique plane.

As we all know, practice is the key to success. Therefore, boost your preparation by starting your practice now.

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