M T W T F S Date: 26 / 9 / 20

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Subject	Mechanic of Solid II
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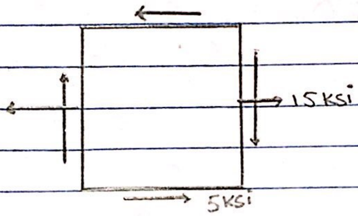
Q No 1



Given Data

$\sigma_x = 15\,ksi$

$\sigma_y = 0$

$\tau_{xy} = -5\,ksi$

Required Data

a) principle Stress

b) Max-plan Shear Stress

c) averge Normal Stress

Solution:-

a) principle Stresses

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

$$\sigma_{1,2} = \frac{15+0}{2} \pm \sqrt{\frac{(15-0)}{2} + (-5)^2}$$

$$\sigma_{1,2} = 7.5 \pm 9.01$$

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$\sigma_1 = 16.51 \text{ ksi}$

$\sigma_2 = 7.5 - 9.01$

$\sigma_2 = -1.51 \text{ ksi}$

Now we find orientation we know that

$$2\theta_2 = \frac{\tau_{xy}}{\sigma_x - \sigma_y / 2}$$

$$2\theta_2 = \frac{-5}{(15-0)/2}$$

$$\boxed{\theta_2 = 0.33}$$

Now we check which angle goes with which principle stress

We know that

$$\sigma_{x_1} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2} \cos 2\theta + \tau_{xy} \sin\theta$$

$$= \frac{15+0}{2} + \frac{15+0}{2} \cos 2(0.33) + (-5) \sin 2(0.33)$$

$$= \frac{15}{2} + \frac{15}{2}(0.99) + (-5)(-0.12)$$

$$= 14.925 + 0.6$$

$$\sigma_{x_1} = 15.525$$

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(b) Max - plan Shear stress :.

$$\tau_{max} = \sqrt{\left(\frac{\sigma x - \sigma y}{2}\right) + \tau xy^2}$$

$$\tau_{max} = \sqrt{\left(\frac{15 - 0}{2}\right)^2 + (-5)^2}$$

$$\tau_{max} = 9.01 \text{ Ksi}$$

Now we find orientation we know that

$$\tan 2\theta - \frac{(\frac{\sigma x - \sigma y}{2})/2}{2}$$

$$\tan 2\theta = +1.5$$

$$\theta = \tan^{-1}(+1.5)$$

$$2\theta = 56$$

$$\theta = 56/2$$

$$\boxed{\theta = 28}$$

We know that

$$\tau x'y' = \frac{-\sigma x - \sigma y}{2} \sin 2\theta + \tau xy \cos 2\theta$$

$$\frac{15 - 0}{2} \sin 2(28) + (-5) \cos 2(28)$$

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$= -7.5\ (0.82) - 28$

$= -8.95$

Q=1 Part (b)

$\sigma x = 15\ Ksi$

$\tau xy = -5\ Ksi$

$\sigma y = 0$

$h = \dfrac{\sigma x + \sigma y}{2} = \dfrac{15 + 0}{2}$

$h = 7.5\ Ksi$

Radius:-

$$R = \sqrt{\left(\frac{\sigma x - \sigma y}{2}\right)^2 + \tau xy^2}$$

$$R = \sqrt{\left(\frac{15 - 0}{2}\right) + (-5)^2}$$

$R = 9.01$

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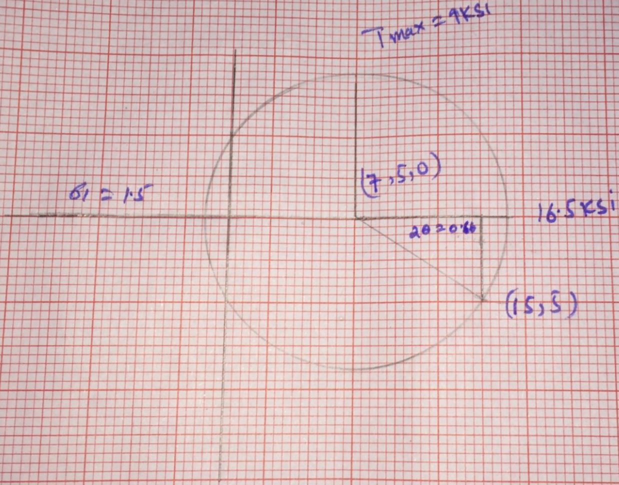
Scale

1 small box = 0.5 Ksi

3 Ksi = 1 cm

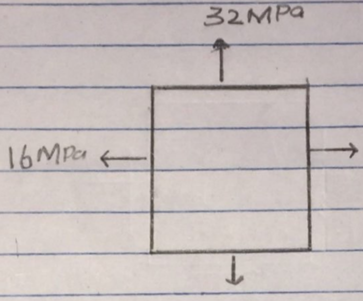
h = 7.5 Ksi = 2.5 cm

6x = 15 Ksi = 5 cm



Scale = 1 small box = 0.5 ksi

Q No 2



Given Data

$\sigma_1 = 32$ MPa

$\sigma_2 = 16$ MPa

Maximum Shear stress at point using Mohr's circle = ?

An orientation of an element 45° within this plane yields the state of absolute maximum shear stresses and the associated averge normal stress namly These stresses are ploted along the axis three Mohr's circle

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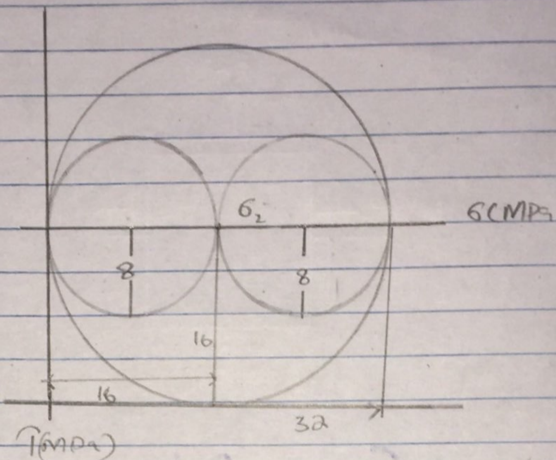
are constructed, Stresses are shown.



The largest circle has a radius of 16 Mpa and describes the state of stress in the plane only containing $\sigma_1 = 32$ Mpa

absolute Max. Shear stress and associated avg normal stress are

$$\tau_{abs\,max} = 16 \text{ Mpa}$$

$$\sigma_{avg} = 16 \text{ mpa}$$

τ_{abs} can be obtained from equation

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$$\tau_{\substack{abs \\ max}} = \frac{\sigma_1}{2} = \frac{32}{2} = 16 \text{ Mpa}$$

$$\sigma_{avg} = \frac{32+0}{2} = 16 \text{ Mpa}$$

By comparison the maximum in-plane shear stress can be determined from the Mohr's circle draw b/w

$\sigma_1 = 32$ Mpa and

$\sigma_2 = 16$ Mpa

This gives a value of

$$\tau_{\substack{max \\ inplane}} = \frac{32-16}{2} = 8 \text{ MPa}$$

$$\sigma_{avg} = \frac{32+16}{2} = 24 \text{ Mpa}$$

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QNO # 3

Main Stresses Responsible for failure of ductile and brittle materials:-

Stresses resposible for failure of dutile and brittle materials are following.

Ductile materials are limited by their shear strength. Ductile material usally fails because the shear stresses exceed the strength of ductile material.
Brittle material are limited by their tensile strengths. Brittle materials fails when the tensile stresses exceeds the strength of materials.

Two failure theories For Ductile Materials:-

1) Maximum Shear Stress theory
According to this theory "Failure in ductile materials occurs when the maximum shear stress in the part exceed the shear stress in a tensile test specimen (of same material of yeild) The slipping that occure is

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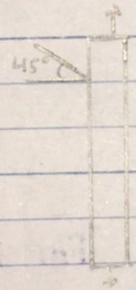
caused by shear stress.
The edge of planes slipping as they appear on the surface of the strip are referred as Luder's line These lines are clearly indicate the slip plane in the strip which occure at aproximetly 45° with axis of the strip.
The max shear stresses can be determined by drawing Mohr's circle for the element the result indicate that

$$\tau_{max} = \frac{\sigma_{u}}{2}$$



Luder's lines on mild steel strip.

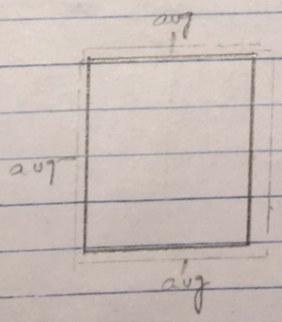
This theory can be used to predict the failure stress of ductile material subjected to any type of loading.

Maximom Distoration Energy Theory:-

According to this theory "failure accurs When an external loading Will deform a material causing it to store energy internally througout its volume. The energy per unit volume of material is called strain density energy.

$$u = \frac{1}{2}\sigma\epsilon$$

The strain energy density can be consided as the sum of two parts, one part represinting the energy needed to cause a volume energy of the element with no change in shape and other part representing the energy needed to distort the element.



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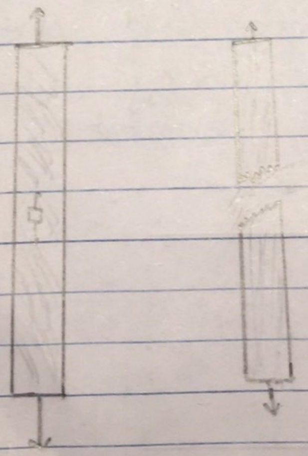
Theories OF Faliure for Brittle Material

1) Maximum - Normal Stress theory:-

According to this theory
" A brittle material will fail when the maximum tensile stress σ_1 in the material reaches a value that is equal to ultimate normal stress the material can sustain when it is subject to sample tension.

$$|\sigma_1| = \sigma_{ut}$$
$$|\sigma_2| = \sigma_{ult}$$



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Mohr's failure Criterion

In some brittle material tension and compression property are different when this occure Criterion based on use of Mohr's circle may be used to predict failure. This method was develop by otto Mohr and is some time reffered to as Mohr's failure Criterion. A unaxial tensile test and unaxial compresive test are used to determine the ultimate tensile and compresive stress (σ_{ult}), and material ultimate shear stress τ_{ult}. Mohr's circle for each of these stress condition is then plotted in diagram.

Which failure is more applicable on following materials why?

A) Steel

B) Concrete

B) Concrete

Maximum normal stress theory is applicable on concrete because tensile stresses are considered and as concrete is strong

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In compression and weak in tension. also Concrete is brittle material.

→ Mohr's failure Criteria theory is applicable to predict

The failure of brittle material as Concrete is brittle material.

Steel

Steel is a ductile material and due to maximum Shear Stress Steel bends which may cause the breaking of Steel therefor maximum Shear stress theory and max distortion theory are applicable to ductile material such as Steel.