Structural Mechanics I

KEY OF HOME WORK : 2

by

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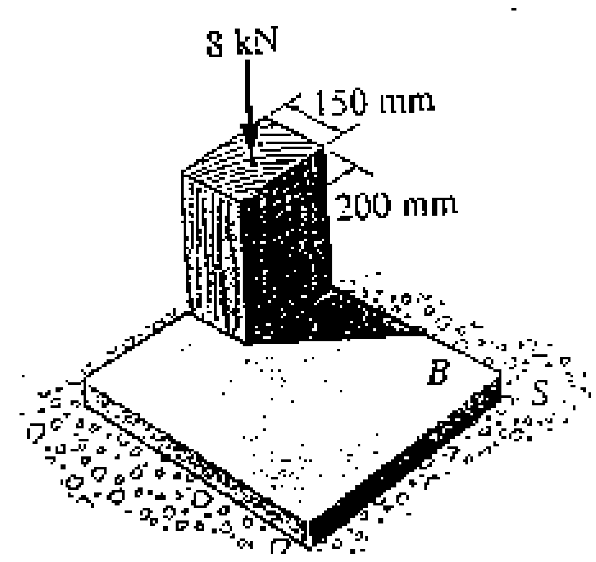
KEY OF HOMEWORK·2.

INSTRUCTOR :- . . ..

PROBLEM #① (1-107) :-

1–107. A force of 8 kN is applied at the *center* of the wooden post. If the post is placed at the corner of its base plate B, can the bearing stress that the base plate exerts on the slab S be assumed uniformly distributed? Why or why not? What is the average compressive stress in the wooden post?



Prob. 1–107

Solution:-

No, the bearing stress that the base plate exerts on the slab S cannot be assumed uniformly distributed as the applied force on the post is at the corner.

$$\sigma_{avg} = \frac{P}{A} = \frac{8\times10^3}{150\times200} = 0.267\ \text{MPa} = 267\ \text{KPa}$$

$$\therefore \sigma_{avg} = 267\ \text{KPa}.$$

PROBLEM #② (1-111) :-

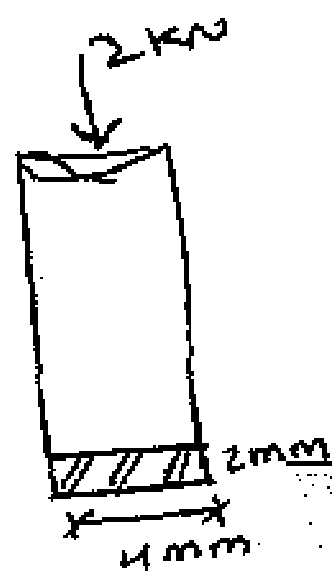
1–111. The circular punch B exerts a force of 2 kN on the top of the plate A. Determine the average shear stress in the plate due to this loading.

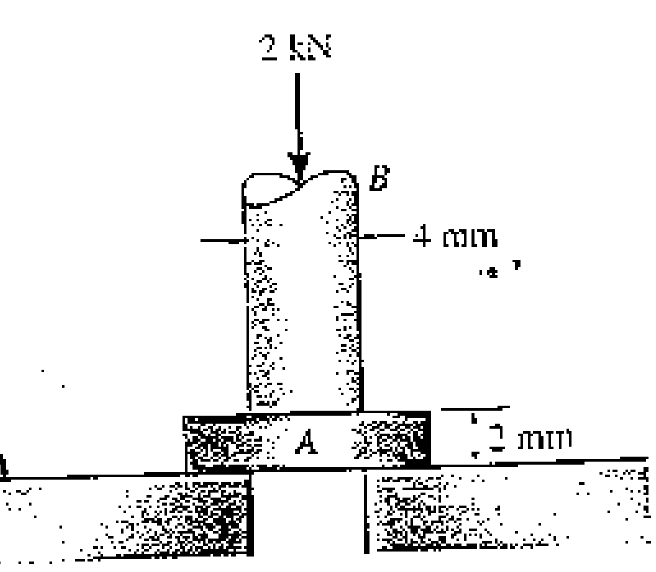
Solution:-

Given:- $F = 2\,kN$; $r = 2\,mm$; $t = 2\,mm$.

Shear force at each section to hold the segment in equilibrium $V = F = 2\,kN$.

Surface area of column = $A = 2\pi r t$.





Prob. 1–111

$$\therefore \tau_{avg} = \frac{V}{A}$$

$$= \frac{2\times10^3}{2\times\pi\times2\times2} = 79.57\,\text{MPa}$$

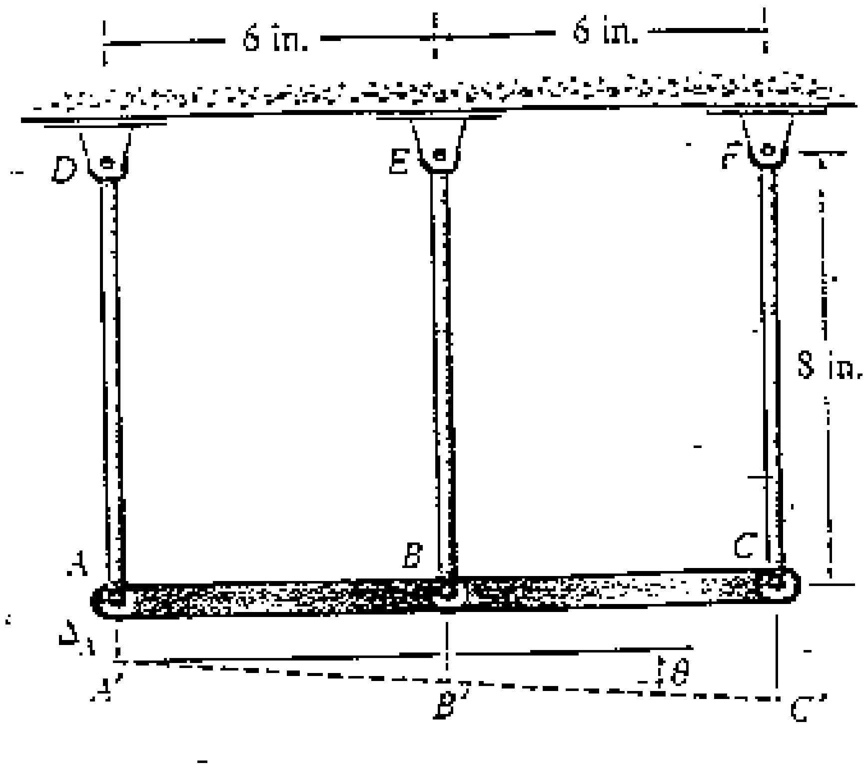
$$\Rightarrow \tau_{avg} = 79.6\ \text{MPa}.$$

* For finding Average Shear Stress we should take Surface Area of the Column [circular punch].

PROBLEM # 3 (2-3):-

SOLUTION:-

2-3. The rigid bar ABC is originally in a horizontal position. If loads cause the end A to be displaced downwards $\Delta_A = 0.002$ in. and the bar rotates $\theta = 0.2°$, determine the average normal strain in the rods AD, BE, and CF.



Prob. 2-3

GIVEN:-

$\Delta_A = 0.002$ in.

$\theta = 0.2°$.

Required:-

ε_{avg} in AD, BE & CF.

$\because \varepsilon_{avg} = \dfrac{\Delta}{L}$.

ROD AD:-

$$\varepsilon_{avg} = \frac{\Delta_{AD}}{L_{AD}} = \frac{0.002}{8} = 0.250 \times 10^{-3} \text{ in/in.}$$

ROD BE:-

$$\because \tan\theta = \frac{\Delta'_{EB}}{AB}$$

$$\Rightarrow \Delta_{EB} = \tan 0.2° \times 6 + \Delta_A = 0.021 + 0.002$$

$$\Rightarrow \Delta_{EB} = 0.023 \text{ in.}$$

$$\therefore \varepsilon_{avg} = \frac{\Delta_{EB}}{L_{EB}} = \frac{0.023}{8} = 2.87 \times 10^{-3} \text{ in/in.}$$

ROD CF:-

$$\because \tan\theta = \frac{\Delta_{CF}}{AC}$$

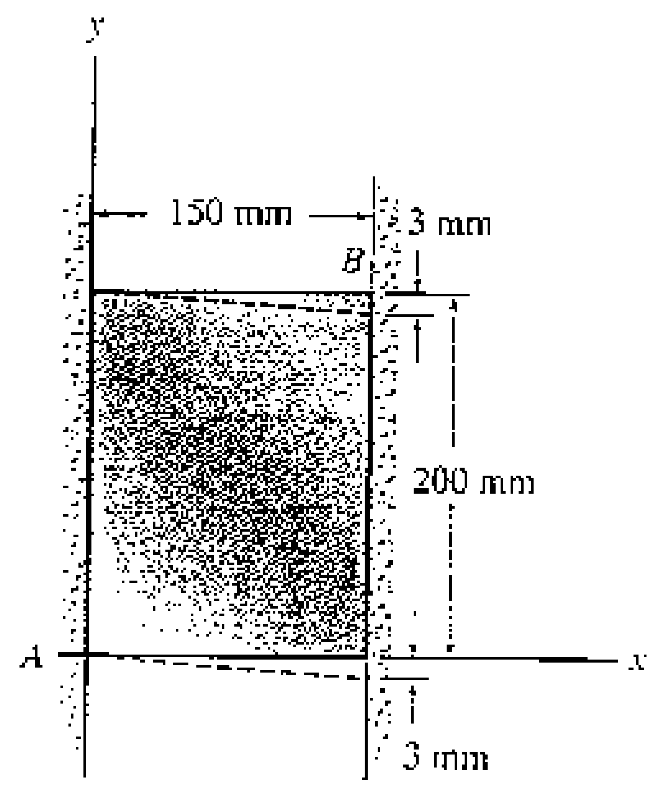
$$\Rightarrow \Delta_{CF} = \tan 0.2° \times 12 + \Delta_A = 0.042 + 0.002$$

$$\Rightarrow \Delta_{CF} = 0.044 \text{ in.}$$

$$\therefore \varepsilon_{avg} = \frac{\Delta_{CF}}{L_{CF}} = \frac{0.044}{8} = 5.49 \times 10^{-3} \text{ in/in.}$$

PROBLEM # 4 (2-13):-

2–13. The rectangular plate is subjected to the deformation shown by the dashed line. Determine the average shear strain γ_{xy} of the plate.



Prob. 2–13

SOLUTION:-

Given:-

Deformation = 3mm.

Required:-

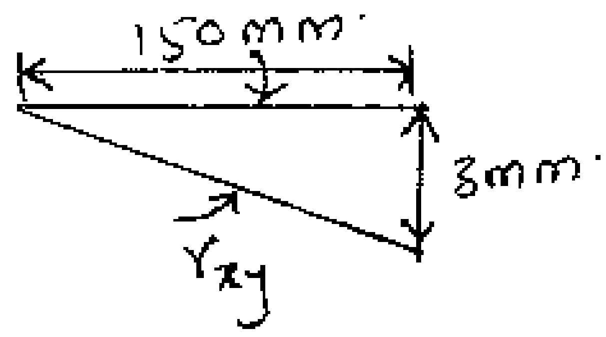
$\gamma_{xy} = ?$

$\because \gamma_{xy} = \tan^{-1}\left(\frac{-3}{150}\right)$

$\Rightarrow \gamma_{xy} = -1.1457^\circ$

$\Rightarrow \gamma_{xy} = -1.1457 \times \frac{\pi}{180}$

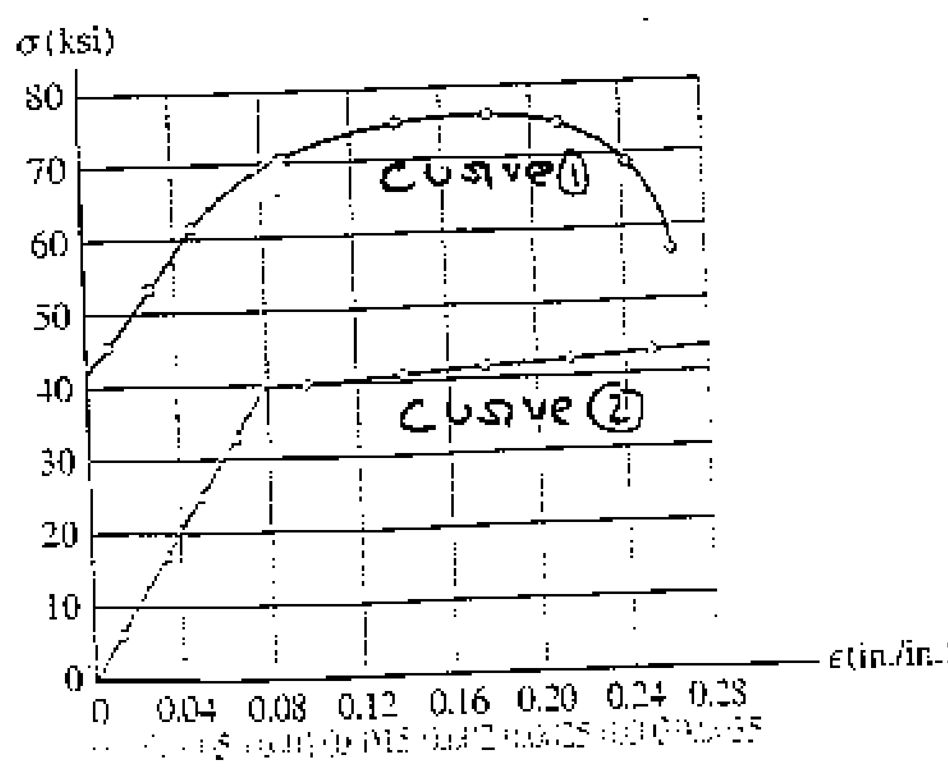
$\Rightarrow \gamma_{xy} = -0.02$ rad.



PROBLEM # 5 (3-7):-

3–7. The stress–strain diagram for a steel alloy having an original diameter of 0.5 in. and a gauge length of 2 in. is given in the figure. If the specimen is loaded until it is stressed to 70 ksi, determine the approximate amount of elastic recovery and the permanent increase in the gauge length after it is unloaded.

***3–8.** The stress–strain diagram for a steel alloy having an original diameter of 0.5 in. and a gauge length of 2 in. is given in the figure. Determine approximately the modulus of elasticity for the material, the load on the specimen that causes yielding, and the ultimate load the specimen will support.



Probs. 3–7/3–8

Solution:-

Given:-

$\sigma = 70$ ksi.

The strain at $\sigma = 70$ ksi is

$\epsilon = 0.09$ in/in (from graph).

First finding Modulus of Elasticity (E) from curve ②

$E = \frac{40}{0.001} = 40000$ ksi.

Now Elastic recovery ϵ_{rec} is

$\epsilon_{rec} = \frac{70}{40000} = 0.00175$ in/in

And the permanent strain is

$$\epsilon_{per} = 0.09 - 0.00175$$

$$\Rightarrow \epsilon_{per} = 0.08825 \text{ in/in.}$$

Permanent increase in guage length.

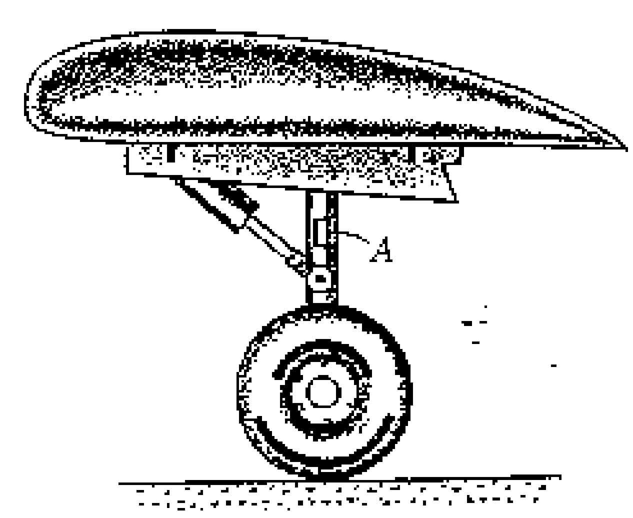
$$\Delta L = \epsilon_{per} \times L$$

$$= 0.08825 \times 2 = 0.1765 \text{ in.}$$

$$\therefore \Delta L = 0.1765 \text{ in.}$$

PROBLEM# 6 (3-13):-

3–13. The change in weight of an airplane is determined from reading the strain gauge A mounted in the plane's aluminum wheel strut. *Before* the plane is loaded, the strain-gauge reading in a strut is $\epsilon_1 = 0.00100$ in./in., whereas after loading $\epsilon_2 = 0.00243$ in./in. Determine the change in the force on the strut if the cross-sectional area of the strut is 3.5 in^2. $E_{al} = 10(10^3)$ ksi.



Prob. 3–13

SOLUTION:-

Given:-

$\varepsilon_1 = 0.001$ in/in.

$\varepsilon_2 = 0.00243$ in/in

$E_{al} = 10 \times 10^3$ ksi

$\Delta P = ?$

$$\because P = \sigma \times A.$$

$$\therefore \Delta P = \Delta\sigma \times A.$$

$$\Delta\sigma = E \times [\varepsilon_2 - \varepsilon_1] = 10 \times 10^3 [0.00243 - 0.001]$$

$$\Rightarrow \Delta\sigma = 14.3 \text{ ksi}$$

$$\therefore \Delta P = 14.3 \times 3.5 = 50.05 \text{ Kip.}$$

$$\therefore \Delta P = 50.05 \text{ Kip.}$$

PROBLEM #7 (3-39)

3–39. A tension test was performed on a steel specimen having an original diameter of 0.503 in. and gauge length of 2.00 in. The data are listed in the table below. Plot the stress–strain diagram and determine approximately the modulus of elasticity, the yield stress, the ultimate stress, and the rupture stress. Use a scale of 1 in. = 20 ksi and 1 in. = 0.05 in./in. Redraw the elastic region, using the same stress scale but a strain scale of 1 in. = 0.001 in./in.

Load (kip)	Elongation (in.)
0	0
1.50	0.0005
4.60	0.0015
8.00	0.0025
11.00	0.0035
11.80	0.0050
11.80	0.0080
12.00	0.0200
16.60	0.0400
20.00	0.1000
21.50	0.2800
19.50	0.4000
18.50	0.4600

Solution:-

Given:-

Diameter of cylinder = 0.503 in.

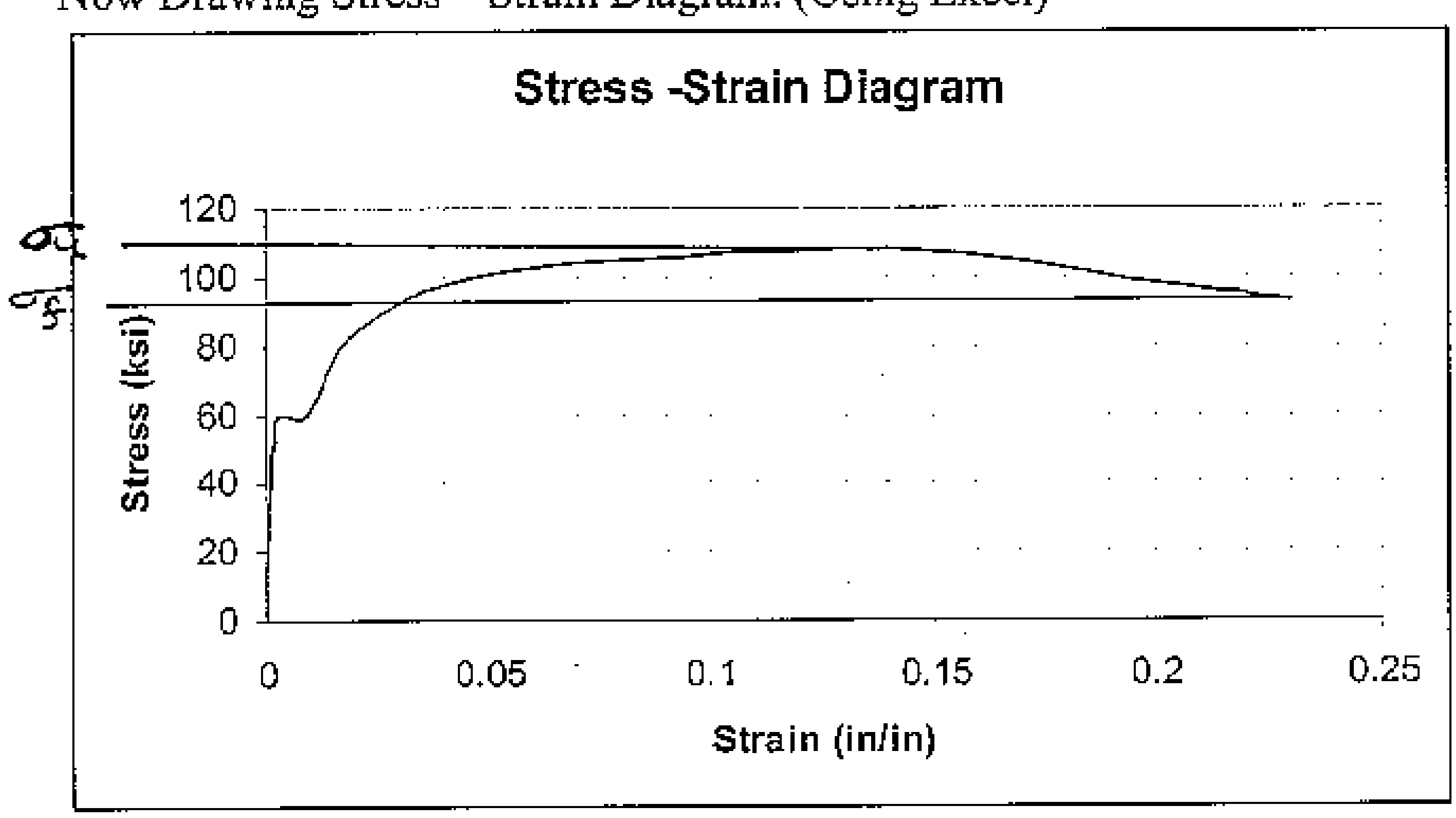
Length = L_O = 2.0in.

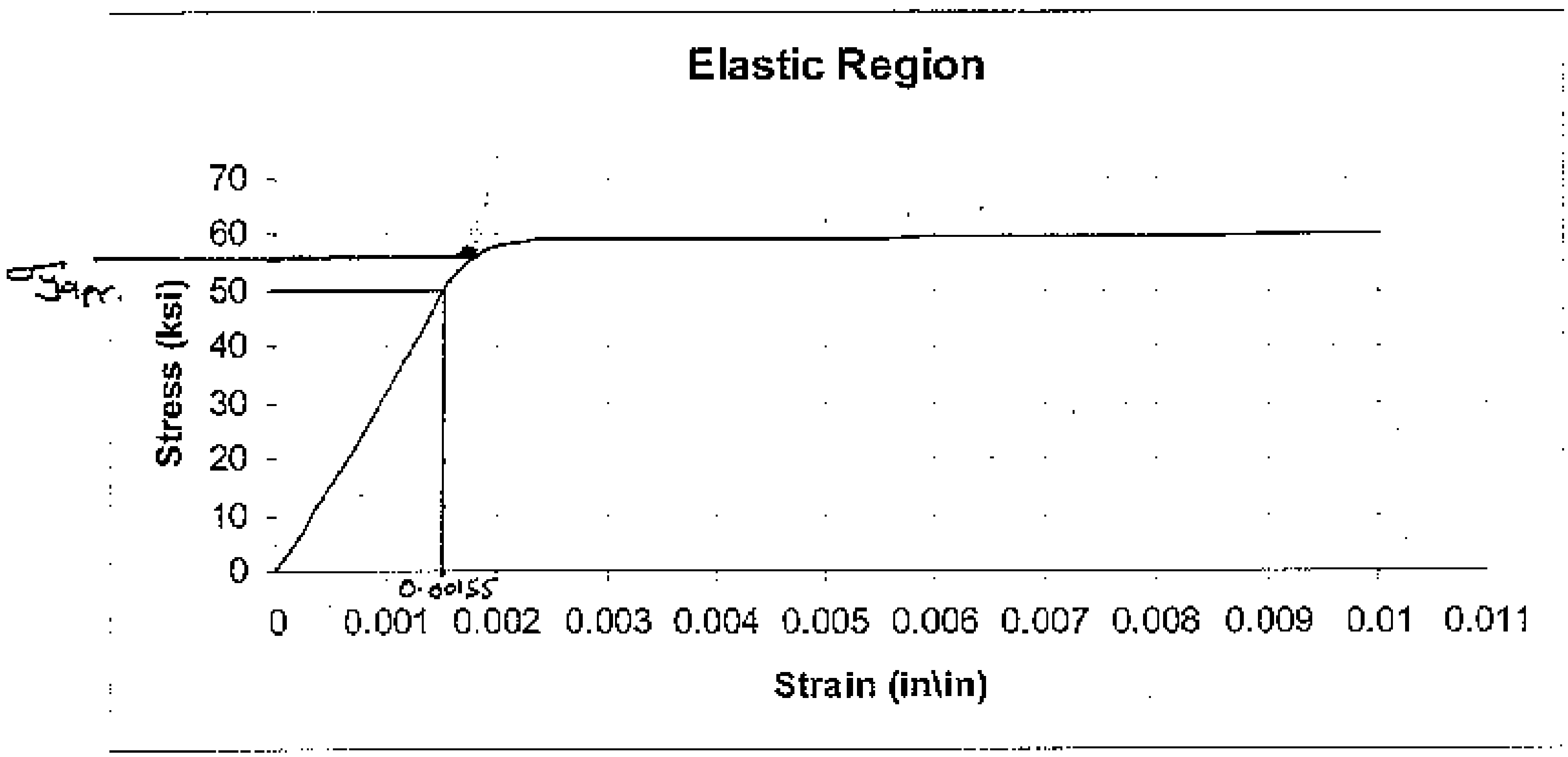
$$\text{Area} = A_O = \frac{\pi}{4}(0.503)^2 = 0.199 in^2$$

Calculating Stresses and Strains:-

Load (P) (KIP)	Stress(P/A_O) (Ksi)	ELONGATION(ΔL)(in.)	Strain ($\Delta L/L_O$) (in/in)
0	0	0	0
1.5	7.55	0.0005	$2.5*10^{-4}$
4.6	23.15	0.0015	$7.5*10^{-4}$
8.0	40.26	0.0025	$1.25*10^{-3}$
11.0	55.36	0.0035	$1.75*10^{-3}$
11.8	59.38	0.0050	$2.5*10^{-3}$
11.8	59.38	0.0080	$4*10^{-3}$
12.0	60.39	0.0200	0.01
16.6	83.54	0.0400	0.02
20.0	100.65	0.1000	0.05
21.5	108.19	0.2800	0.14
19.5	98.13	0.4000	0.2
18.5	93.1	0.4600	0.23

Now Drawing Stress – Strain Diagram. (Using Excel)





Modulus of Elasticity (E) = Slope of straight line of curve

$$\Rightarrow E_{app.} = \frac{\text{stress}}{\text{strain}} = \frac{50}{0.00155} = 32 \times 10^{3} \text{ ksi}.$$

$\sigma_{yapp.} \Rightarrow$

from Elastic Region curve

$\sigma_{yapr} = 55.4$ ksi. $\rightarrow$ approx. yield stress.

from stress-strain diagram.

$\sigma_u = 110$ ksi $\rightarrow$ ultimate stress.

$\sigma_f = 93.1$ ksi $\rightarrow$ Rupture stress.