CLASS 3: SHEAR STRESSES & ALLOWABLE STRESS (CH#1)

READ: CH 1 & CH 4

OBJECTIVE:
1. ILLUSTRATE EXAMPLES OF SHEAR STRESS
2. DEFINE ALLOWABLE STRESS DESIGN
3. DESIGN SIMPLE CONNECTIONS

SHEAR STRESS $\tau_{xy}$ DISTRIBUTION OF FORCE TANGENTIAL TO THE SURFACE OF MATERIAL

FOR ILLUSTRATION, CONSIDER FOLLOWING

$F$  
BAR  
SUPPORT

$F/2$  
EQUVALENT RESULTANT, REALLY SHEAR STRESS

$F/2$  
AREA OF SECTION

$F/2$  
$\tau_{\text{avg}}$

FOR SURFACE TANGENTIAL RESULTANT, $V$,

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

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DIRECT SHEAR DOMINATES DESIGN OF BOLTED CONNECTIONS IN STEEL STRUCTURES

INDUCING SHEAR AT BAR INTERNAL INTERFACE

SINGLE SHEAR CONNECTION

DOUBLE SHEAR CONNECTION

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EQUILIBRIUM OF SHEAR:

Consider bolt:

\[ \tau = \frac{V}{A} \]

Consider 3-D element from surface upon which shear acts:

Box in equilibrium? No

\[ \Sigma F = 0 \]

Equilibrium? No

\[ \therefore \tau_{x} = \tau_{y} \]

\[ \therefore \] All four shear forces are equal magnitude

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ALLOWABLE STRESS

As structural engineers, it is our responsibility to design "safe" structures!

Design Methodology: Add factor of safety (FS) to account for unknown load and/or unknown material properties.

\[
F.S. = \frac{E\text{xpected Failure Level}}{Design Level}
\]

\[
F.S. = \frac{F_{\text{Fail}}}{F_{\text{Allow}}} = \frac{S_{\text{Fail}}}{S_{\text{Allow}}} = \frac{T_{\text{Fail}}}{T_{\text{Allow}}}
\]
What is the maximum possible value of the clamping force \( C \) in the jaws of the pliers shown in the figure if \( a = 3.75 \) in., \( b = 1.60 \) in., and the ultimate shear stress in the 0.20-in. diameter pin is 50 ksi?

What is the maximum permissible value of the applied load \( P \) if a factor of safety of 3.0 with respect to failure of the pin is to be maintained?

\[
\begin{align*}
\text{Consider one piece of pliers:} \\
\Sigma M_p &= R \cdot (3.75) - C \cdot (1.6 + 3.75) = 0 \\
R &= 1.4267 C
\end{align*}
\]

\[
\begin{align*}
\text{Find reaction w.r.t. C} \\
C_{ult} &= \frac{R_{ult}}{1.4267} \\
&= \frac{1100}{1.4267} \\
&= 770 \text{ lb}
\end{align*}
\]

\[
\begin{align*}
\text{F.S.} = 3.0 = \frac{P_{ult}}{P_{design}} \\
\text{Find Pult:} \\
P_{ult} &= R_{ult} (1.6') - P_{ult} (5.35') = 0 \\
P_{ult} &= 469.8 \text{ lb} \\
P_d &= \frac{P_{ult}}{3} = 156.6 \text{ lb} \\
\Rightarrow P_{allow} &= 157 \text{ lb}
\end{align*}
\]