CLASS #22 - SHEAR FLOW IN THIN WALL ELEMENTS

OBJECTIVES:  
1. DEFINE BUILT-UP MEMBERS
2. UNDERSTAND SHEAR FLOW
3. ILLUSTRATE WITH EXAMPLE

READ:  CH 9.6 - 9.10 PHILPOT

1. BUILT UP MEMBERS

MANY CIVIL STRUCTURAL ELEMENTS ARE "BUILT UP"
- e.g. OLD BEAMS (SEE IN RETROFIT)

- e.g. TIMBER JOISTS

IF WANT TO DESIGN BUILT UP MEMBER, WHAT MUST WE BE CONCIOUS OF?

1. TO TAKE MOMENT?
   - CROSS SECTION GEOMETRY
   - MATERIAL PROPERTIES

2. TO TAKE SHEAR?
   - FASTENERS & CONNECTIONS

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2 SHEAR FLOW

To design fasteners, need to know shear taken per unit length:

Shear flow: \( q = \frac{\text{Shear}}{\text{Length}} \)

Consider timber T-beam:

\[ \Sigma F_x \text{ of bottom portion:} \]

\[ dF = \frac{dM}{I} \int_{A'}^{} y \, dA' \]

Shear flow: \( q = \frac{dF}{dx} = \frac{dM}{I} \frac{Q}{dx} \]

\( Q = \frac{VQ}{I} \)

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\[ q = \frac{VQ}{I} \]
A box beam of wood is constructed of two 260 mm × 50 mm boards and two 260 mm × 25 mm boards (see figure). The boards are nailed at a longitudinal spacing $s = 100$ mm.

If each nail has an allowable shear force $F = 1200$ N, what is the maximum allowable shear force $V_{\text{max}}$?
A box beam of wood is constructed of two 260 mm × 50 mm boards and two 260 mm × 25 mm boards (see figure). The boards are nailed at a longitudinal spacing \( s = 100 \text{ mm} \).

If each nail has an allowable shear force \( F = 1200 \text{ N} \), what is the maximum allowable shear force \( V_{\text{max}} \)?

All dimensions in millimeters.

\[
\begin{align*}
 b &= 260 \\
 b_1 &= 260 - 2(50) = 160 \\
 h &= 310 \\
 h_1 &= 260 \\
 s &= \text{nail spacing} = 100 \text{ mm} \\
 F &= \text{allowable shear force} \\
 &\quad \text{for one nail} = 1200 \text{ N} \\
 f &= \text{shear flow between one flange and both webs}
\end{align*}
\]

\[
\begin{align*}
 f_{\text{allow}} &= \frac{2F}{s} = \frac{2(1200 \text{ N})}{100 \text{ mm}} = 24 \text{ kN/m} \\
 f &= \frac{VQ}{I} \\
 V_{\text{max}} &= \frac{f_{\text{allow}}f}{Q} \\
 I &= \frac{1}{12} (bh^3 - b_1h_1^3) = 411.125 \times 10^4 \text{ mm}^4 \\
 Q &= Q_{\text{flange}} = A_f d_f = (260)(25)(142.5) = 926.25 \times 10^3 \text{ mm}^3 \\
 V_{\text{max}} &= \frac{f_{\text{allow}}f}{Q} = \frac{(24 \text{ kN/m})(411.125 \times 10^4 \text{ mm}^4)}{926.25 \times 10^3 \text{ mm}^3} \\
 &= 10.7 \text{ kN}
\end{align*}
\]