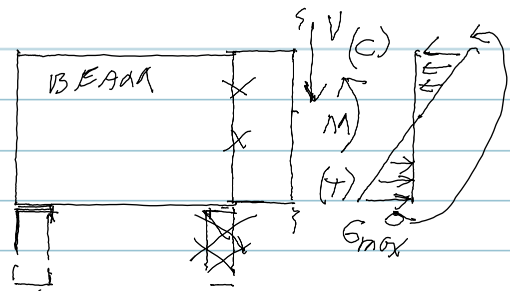
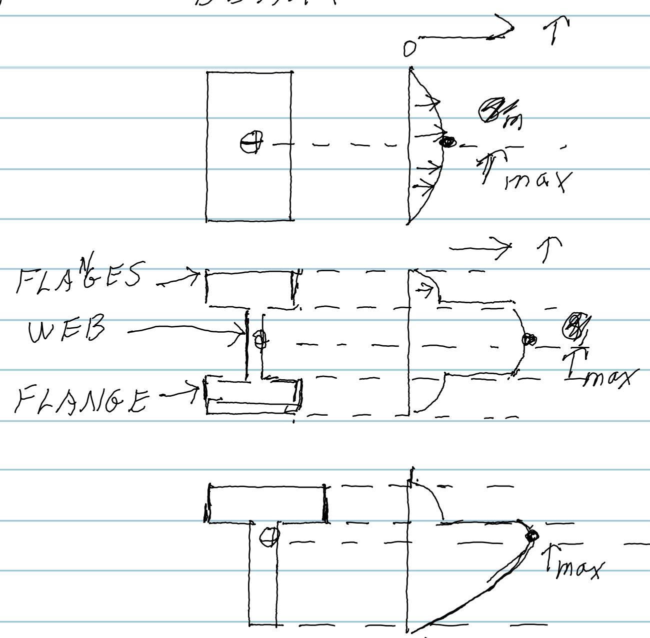
CH. 7.1 - 7.2 SHEAR STRESS INSIDE MATERIAL

INTERNAL STRESS DISTRIBUTIONS IN SHEAR (τ)

BENDING MOMENT "M" PRODUCES FLEXURAL STRESS (NORMAL STRESS σ) DISTRIBUTION INSIDE BEAM

SHEAR FORCE "V" PRODUCES SHEAR STRESS (τ) ~~BA~~ DISTRIBUTION INSIDE BEAM





FORMULA FOR SHEAR STRESS

$$\tau = \frac{V\,Q}{I\;t_{WIDTH}}$$

- τ: PSI, KSI, Pa
- V: SHEAR FORCE FROM SHEAR + MOMENT DIAG.
- Q: STATIC MOMENT (in^3, mm^3, etc.) $Q = \bar{y}'A'$
- I: MOMENT OF INERTIA of CROSS SECTION "CS".
- t: WIDTH OF MEMBER @ HEIGHT WHERE τ IS TO BE FOUND. (in, mm, etc.)

$$Q = \underline{\qquad} = \bar{y}' \cdot A'$$

- Q: STATIC MOMENT (in^3, mm^3)
- $\bar{y}'$: CENTROID OF AREA ABOVE POINT WHERE τ IS TO BE DETERMINED. MEASUE FROM CENTROID OF CROSS SECTION (m, in, etc.)
- A': AREA ABOVE POINT WHERE τ IS TO BE FOUND. (in^2, mm^2, etc.)

TAKE AWAY!

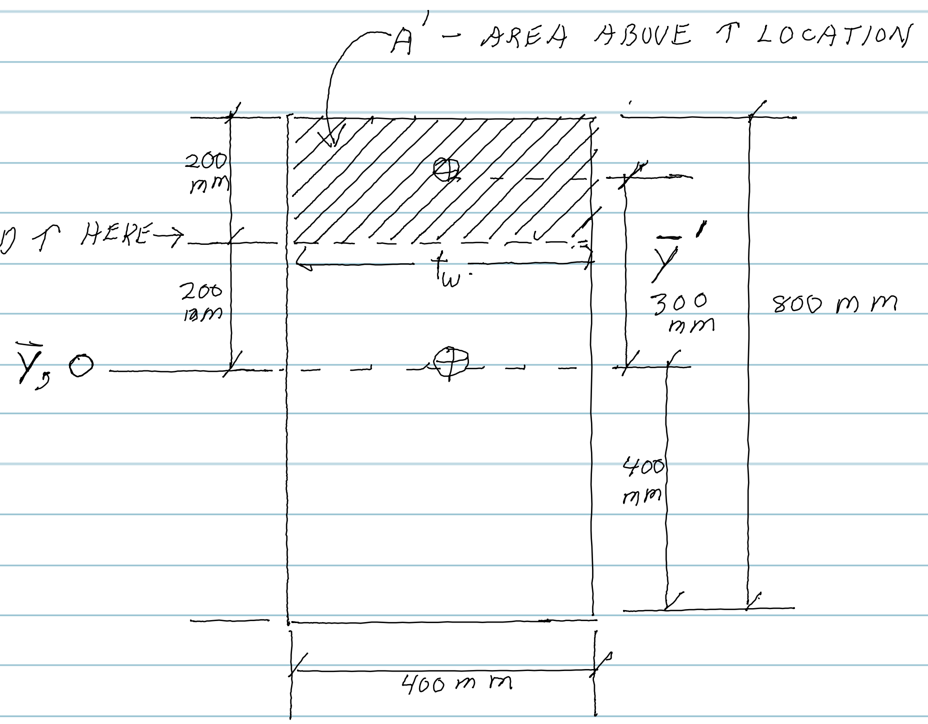
EXAMPLE

GIVEN: RECT. BEAM (400 x 800 mm), V = 5 KN

FIND: SHEAR STRESS τ = ? @ 600 mm ABOVE BASE OF BEAM.

SKETCH

$$\tau = \frac{VQ}{I\, t_{WIDTH}}$$



SOLUTION: $Q = \bar{y}' \cdot A' = (300\,mm)(400\,mm \cdot 200\,mm) = \underline{\underline{24 \cdot 10^6\,mm^3}}$

$$I = \frac{1}{12} b h^3 = \frac{1}{2}(400\,mm)(800\,mm)^3$$

$$\underline{\underline{I = 17.07 \cdot 10^9\,mm^4}}$$

$$\underline{\underline{t_w = 400\,mm}}$$

$$\tau = \frac{VQ}{I\, t_w}$$

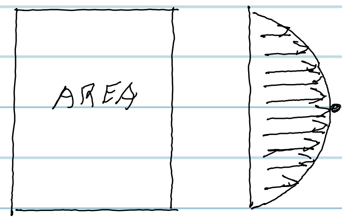
$$\tau = \frac{5000N\,(24 \cdot 10^6\,mm^3)}{(17.07 \cdot 10^9\,mm^4)\,400\,mm}$$

$$\tau = .01757 \frac{N}{mm^2} = 17.6\ KPa$$

NOTE
τ @ 600 mm ABOVE BOTTOM

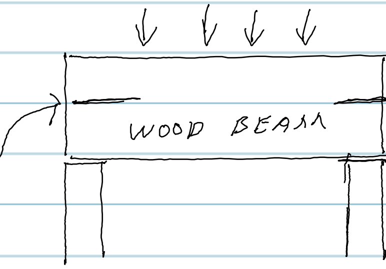
CH. 7.1 – 7.2 SHEAR STRESS (CONT.)

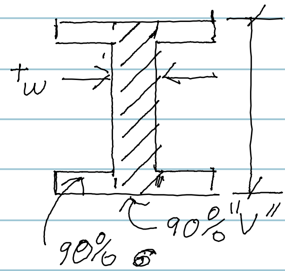
SPECIFIC SHAPES



$$\tau_{max} = 1.5 \frac{V}{A_{AREA}}$$

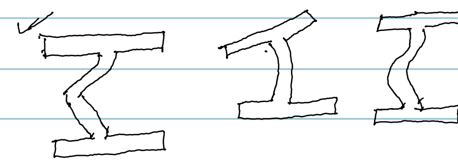
SPLIT IN FROM ENDS





$$\tau_{max} = \frac{V}{A_{WEB}} = \frac{V}{t_w \cdot d}$$

CAN UNDERSTATE τ_{max}
(BAD) WORST CASE ≈ 15%



HIGH SHEARING STRESSES

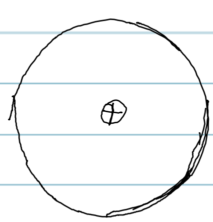
MAY BE PRESENT IN:

1) SHORT SPANS, HEAVILY LOADED BEAMS.

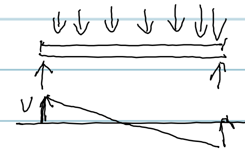
✓2) LARGE CONCENTRATED LOADS CLOSE TO SUPPORT.

✓3) IN WIDE FLANGE STEEL BEAMS ("W" SECTION) SHEAR IS USUALLY NOT THE LIMITING CONDITION. FLEXURE STRESS (σ) FROM BENDING MOMENT "M" OR DEFLECTION LIMITS WILL USUALLY GOVERN.

4) SPECIFIC MEANS TO STRENGTHEN BEAMS IN HIGH SHEAR STRESS AREAS ARE ALLOWED.



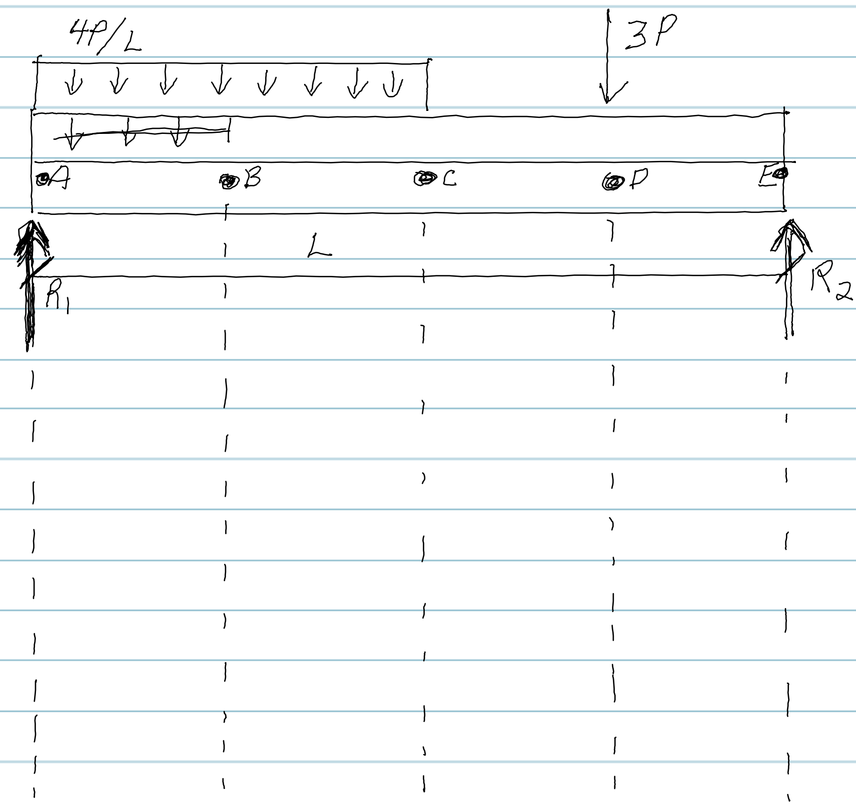
$$\tau_{max} = 1.33 \frac{V}{A}$$



RANKING SHEAR STRESS

THE BEAM IS SIMPLY SUPPORTED. THE W 8x12 BEAM HAS A UNIFORM LOAD INTENSITY OF $\frac{4P}{L}$ KIPS/L (THE TOTAL DISTRIBUTED WEIGHT IS $\frac{4P}{L} \times \frac{1}{2}L = 2P$). IN ADDITION IT HAS A POINT LOAD OF 3P. CONSIDER THE 3P FORCE TO BE APPLIED JUST TO THE LEFT OF POINT "D" + POINTS "A" + "E" TO BE JUST INSIDE THE SUPPORTS. RANK THE SHEAR STRESS @ THE CENTROID OF THE BEAM FOR THE 5 POINT A-E. NOTE ANY TIES. POINTS A-D ARE EQUALLY SPACED ACROSS THE BEAM.

RANK THE ABSOLUTE VALUE OF THE SHEAR STRESS



GREATEST

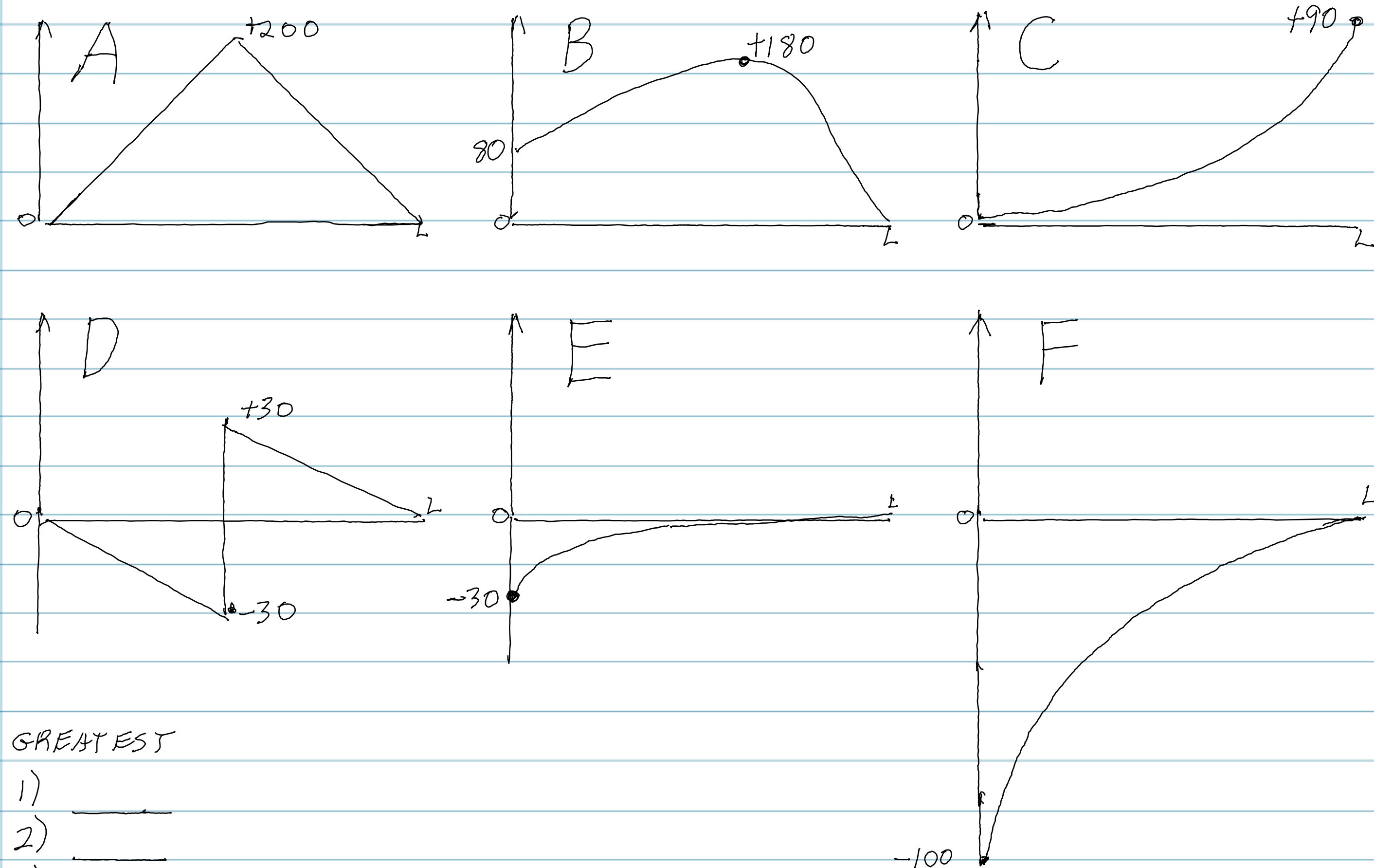
1) ____
2) ____
3) ____
4) ____
5) ____

LEAST

SHOW WORK HERE :

RANKING APPLIED MOMENTS

6 POSSIBLE MOMENT DIAGRAMS ARE SHOWN FOR A SIMPLY SUPPORTED BEAM. IF THE MOMENT DIAGRAMS ARE WORKED BACKWARDS THE EXTERNAL MOMENTS APPLIED TO THE BEAM CAN BE DISCOVERED. PERHAPS ~~THEY~~ THERE'S A SIMPLIER METHOD. RANK THE ABSOLUTE VALUE OF THE APPLIED MOMENTS FROM GREATEST TO LEAST. ALL MOMENTS (VERTICAL SCALE) IN FT·LBS



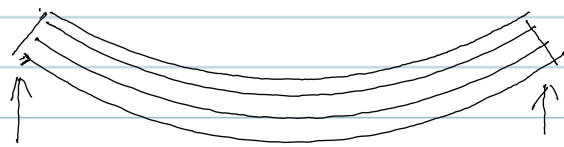
GREATEST

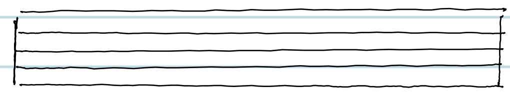
1) ____
2) ____
3) ____
4) ____
5) ____
6) ____

LEAST

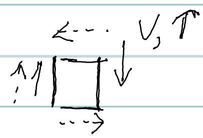
CH. 7.3 SHEAR FLOW IN BUILT-UP MEMBERS

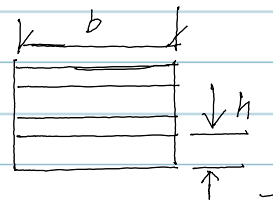
✓

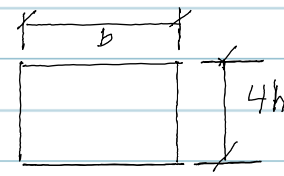




FASTEN TOGETHER







$$I = 4\left[\tfrac{1}{12} b h^3\right] \qquad I_s = \tfrac{1}{12} b (4h)^3$$

$$\frac{I_s}{I} = \frac{\frac{1}{12} b\, 64 h^3}{4\left[\frac{1}{12} b h^3\right]} = \frac{64}{4} = 16$$

SHEAR FLOW

$$q = \frac{VQ}{I}$$

LOOKS FAMILIAR

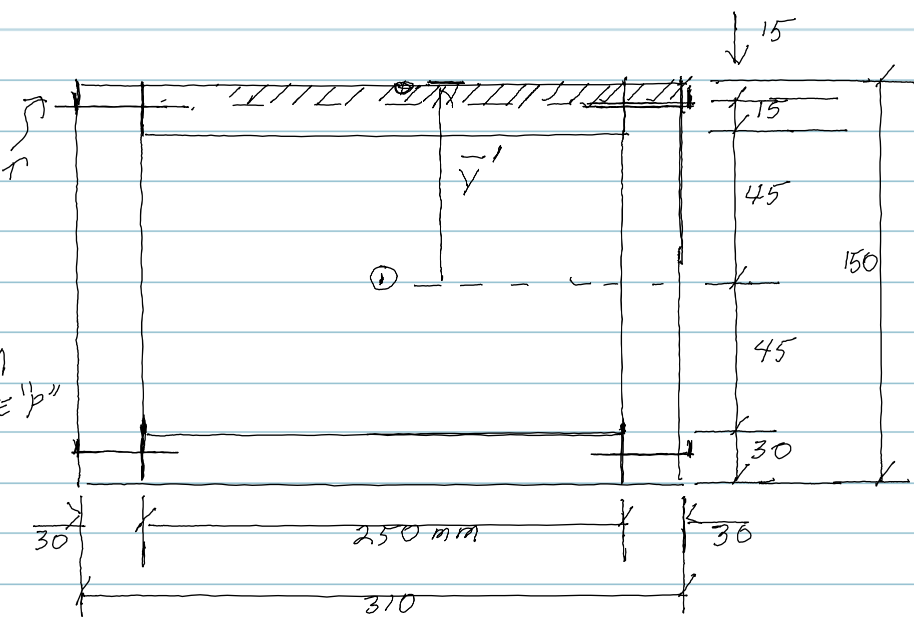
FORCE/LENGTH (N/m, Lbs/FT)

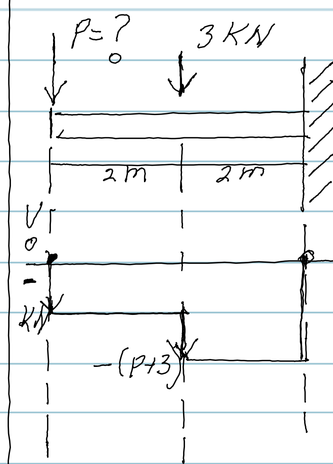
CH 7.3 PROB. 7.45 EXAMPLE

GIVEN: WOOD BOX BEAM. NAILS EVERY 100 mm. EACH NAIL WILL HOLD 3.0 KN. THE BEAM SUPPORTS A LOAD "P" AS SHOWN. FIND THE MAX. VALUE OF "P" AS LIMITED BY SHEAR FLOW. ASSUME THE NAILS (2 TOP SIDES) SHARE THE SHEAR FORCE.

SKETCH ALL DIMENSIONS IN mm.

PLAN
1) q
2) V
3) S+M
4) SOLVE "P"





SOLUTION:

1) $q = \frac{2(3000\,N)}{100\,mm} = 60\,N/mm$, $A' = (15)\,310 = 4650\,mm^2$, $\bar{y}' = 67.5\,mm$

$Q = A' \cdot \bar{y}' = 4650 \cdot 67.5 = 3.139 \cdot 10^5\,mm^3$

$I = \frac{1}{12} b h_{OUT}^3 - \frac{1}{12} b h_{IN}^3 = \frac{1}{12}(310)(150)^3 - \frac{1}{12}(250)\,90^3 = 7.20 \cdot 10^7\,mm^4$

2) $q = \frac{VQ}{I}$ $V = \frac{qI}{Q} = \frac{60\frac{N}{mm} \cdot 7.2 \cdot 10^7\,mm^4}{3.139 \cdot 10^5\,mm^3} = 1.376 \cdot 10^4\,N = \underline{\underline{13.8\ kN}}$

3) $V_{REQ} = P + 3 \Rightarrow 13.8\,kN = P + 3$

$\underline{\underline{P = 10.8\ kN}}$

REALITY CHECK.