Assignment 17 ...

Okay, springing from our lecture today, let's try this. Instead of using a single 2 x 10 as the 'rib' ... let's use TWO 2 x 8s (side by side). (Wood is pretty cheap, last time I checked.) They will be fastened on edge to the 3 x 4.

Also, let's use 5/16 in. diameter lag screws, which have an allowable shear (properly installed) of 200 lb each.

Determine the spacing of 5/16 in. diameter screws, per 2 x 8, to carry the 1200 lb shear.

Report the exact spacing, and then round it to some reasonable number, say, multiples of 1/2 in.

Probably I would require pre-drilling the holes, that the screws be staggered with respect to the 2 x 8s (and, of course, that the screws be centered in the edges of the 2 x 8s). And I would also specify how the 2 x 8s are to be nailed themselves together (but won't worry about that for now).

Also, in light of our lecture today, calculate the S of the new section (vs that of the old), and the I for the new section (vs that of the old). If the S and the I values for the new section are greater than the values for the 3 x 4 plus 2 x 10 then we pretty much know that bending and deflection are already taken care of.

So ...

Find:  a) spacing of 5/16 in. dia. lag screws in EACH of the 2x8s.

b) S of new Section and

c) S of old.

d) I of new Section and I of old (I of old we did in class).

e) Discuss.

Strategy: like in class, let's find the I.A. of the little k shape ... will do this with a moment equation about the top, and will break the shape into rectangles (with a common edge at the top).
Once I get the location of the n.a., I will find the MOT for the whole shape about the neutral axis... and, like in class... I'll get it by taking the MOT of all the pieces about the top, adding them, and then "transferring" the whole thing to the n.a.

Then I'll be able to calculate the shear flow, $f$, at the interface in question... the spacing of lag screws, etc.

And I should also be able to find the other stuff asked for pretty easily.

Okay, let's do it...

Solution:

\[
\begin{align*}
3.5 & \quad 2.5 & \quad 3.0 & \quad 9.75 \\
7.25 & = & & 7.75 \\
1.5 & \quad & & \\
3.0 & \quad & & \\
\end{align*}
\]
Assignment 17.23

Centroid of whole thing

\[ \bar{y} = \sum y_i A_i \]

\[ \bar{y} \left( \frac{29.25 + 1.25}{30.5} \right) = \frac{9.75}{2} (29.25) + \frac{2.5}{2} (1.25) \]

\[ \bar{y} = \frac{144.16}{30.5} = 4.726 \]

Does this make sense?

Disregarding the little 1.5 x 2.5 piece:

\[ \frac{3}{9.75} \]

\[ \frac{9.75}{2} = 4.875 \]

So, yeah, we're a bit high on that. Good.

Continuing

\[ I_{top} = \sum I_{i, top} = \frac{1}{3} (3)(9.75)^3 + \frac{1}{3} (15)(2.5)^3 \]
\[ \frac{1}{3} \left[ 3(9.75)^3 + 1.5(2.5)^3 \right] = 929.5 \text{ ft}^3 \]

Now we need to transfer it down to the n.a. of the whole shape:

\[ 929.5 = I_{n.a.} + Ad^2 \]

\[ 929.5 = I_{n.a.} + 30.5(4.726)^2 \]

\[ I_{n.a.} = 248.24 \text{ in}^4 \]

Now, let's check this against just the 3.0

\[ 9.75 \text{ in} \]

\[ I_{n.a.} = \frac{1}{12} bh^3 = \frac{1}{12}(3)(9.75)^3 = 232 \]

So, yeah, and we're a bit more than that.

Good

Shear force

\[ 1.75 \text{ in} \]

Plane in question

4.726
\[ f = \frac{\sqrt{A}}{I} = \frac{1200 \text{ lb}}{248.24 \text{ in}^3} \]

\[ Q = \left(\frac{3.5 \times 2.5}{8.75}\right) \left(\frac{4.726 - 1.25}{3.476}\right) = \frac{30.42}{\text{in}^3} \]

\[ f = \frac{1200 \text{ lb}}{248.24 \text{ in}^4} \left(\frac{30.42}{\text{in}^3}\right) = \frac{147 \text{ lb}}{\text{lb}} \]

We are going to screw to two 2X8's.

So \( \frac{147}{2} = 73.5 \text{ lb} \) to each in

Using \( \frac{5}{16} \) screws... @ 200 lb screw

\[ \frac{200 \text{ lb}}{\text{screw}} \times \frac{\text{in}}{73.5 \text{ lb}} = \frac{2.72 \text{ in}}{0.0} \]

Round to 2.5 in o.c.

Still lots of screws!
Okay, what is the other stuff we had to answer?

b) S of new. Actually there are two S's.

\[
S_1 = \frac{248.2}{4.726} = 52.5 \text{ in}^3 \\
S_2 = \frac{248.2}{5.024} = 49.4 \text{ in}^3
\]

or vice versa

(c) for the shape, in class

\[
S_1 = \frac{290}{4.85} = 59.8 \text{ in}^3 \\
S_2 = \frac{290}{6.90} = 42.0 \text{ in}^3
\]

d) \( I_{\text{new}} = \frac{248}{6} \text{ in}^4 \) \( \text{see above} \) \[ I_{\text{old}} = 290 \text{ in}^4 \text{ see class notes} \]
e) discuss... since we are not given a distinction between compression or tension in flexure, we should look at the minimum value for each condition.

\[ S_{\text{new}} \quad \text{and} \quad S_{\text{old}} \]

\[ 49.4 \text{ in}^3 \quad \text{and} \quad 42.0 \text{ in}^3 \]

\[ I_{\text{new}} \quad 248 \text{ in}^4 \quad I_{\text{old}} \quad 290 \text{ in}^4 \]

hmmm... as such, we can expect that our new shape will perform better in flexure... but not so better in deflection.

But, that could also be a bit argued, since the original shape has a higher "S" in with regard to the top extreme fiber.
Finally... note that \( \frac{5}{16} \)" lag screws @ 2.5" o.c. could mean a lot of screws. Certainly where our shear drops off, let's increase the spacing.

If this might mean so much labor, even if we allow for increased spacing as the shear drops off...

that a replacement would be the solution.

Answers:  
1) 2.5" o.c. each row (each 2x8)  
2) \( S_1 = 52.5 \text{ in}^3 \), \( S_2 = 49.4 \text{ in}^3 \) or vice versa  
3) \( S_1 = 59.8 \text{ in}^3 \), \( S_2 = 42.0 \text{ in}^3 \) or vice versa  
4) \( T = 248 \text{ in}^4 \) (Old = 290 in^4)  
5) see above for discussion.
Install 5/16 lag screws @ 2.5" C.C. in each piece, staggered with screws in adjacent piece.

Countersink 1/4" max.

Fasten 2x8's per IBC 2.304.9.1 Built-up Beams + Girders
pre-drill screw holes as needed to avoid splitting.