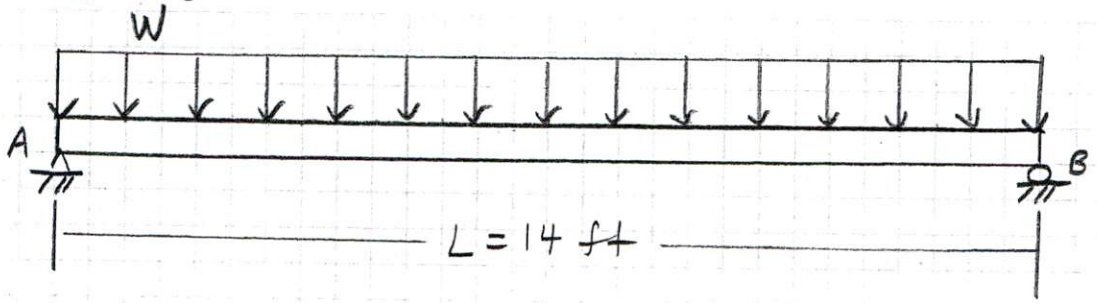
CMGT 350 **Exam #3** **Fall 2022**

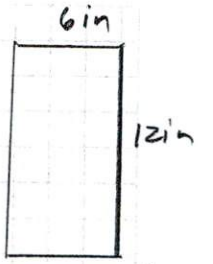
Show all work for full credit. You may work with ONE other person.

Due: December 6, 2022

Name: Solution

3. A nominal size 6 x 12 CA Redwood beam of rectangular cross section is used in a 14-ft simple span. Determine the maximum allowable uniform load w applied to the entire span that the beam can carry. The allowable deflect is L/360. Note: Determine w for deflection, bending moment, and shear to determine the governing factor.





cross-sectional area (nominal)

Table 15-2, CA Redwood

$\sigma_{allow} = 1350$ psi

$\tau_{allow} = 100$ psi

$L = 14\ ft \times \frac{12\ in}{ft} = 168\ in$

Table A-6(a)

Nominal 6 x 12

$S = 121\ in^3$

$I = 697\ in^4$

$A = 63.3\ in^2$

$wt = 17.6\ lb/ft$

Table A-7(a)

$E = 1300$ ksi

$$\delta_{allow} = \frac{L}{360} = \frac{168\ in}{360} = 0.467\ in$$

Deflection

Table 16-1, case 7

$$\delta_{MAX} = \frac{5wL^4}{384EI}$$

$$w = \frac{384\ EI(\delta_{allow})}{5L^4}$$

$$= \frac{384(1300\ ksi)(697\ in^4)(0.467\ in)}{5(168\ in)^4}$$

$$= \frac{162,489,100.8\ kip}{3,982,970,880\ in}$$

$$= 0.040796\ kip/in \times \frac{12\ in}{ft} \times \frac{1000\ lb}{kip}$$

$$= 490\ lb/ft$$

Bending Moment

Table 13-1, case 4

$$M_{MAX} = \frac{WL^2}{8}$$

$$\sigma_{MAX} = \frac{M_{MAX}}{S} = \frac{\frac{WL^2}{8}}{S}$$

$$W = \frac{\sigma_{MAX}(S)(8)}{L^2}$$

$$= \frac{1350\ psi\ (121\ in^3)(8)}{(168\ in)^2}$$

$$= 46.3\ lb/in \times \frac{12\ in}{ft}$$

$$= 556\ lb/ft$$

Shear

Table 13-1, case 4

$$V_{MAX} = \frac{WL}{2}$$

$$\tau_{MAX} = 1.5\frac{V_{MAX}}{A} = \frac{1.5\left(\frac{WL}{2}\right)}{A}$$

$$W = \frac{2A\tau_{MAX}}{1.5(L)} = \frac{2(63.3\ in^2)(100\ lb/in^2)}{1.5(168\ in)}$$

$$= 50.2\ lb/in \times 12\ in/ft$$

$$= 603\ lb/ft$$

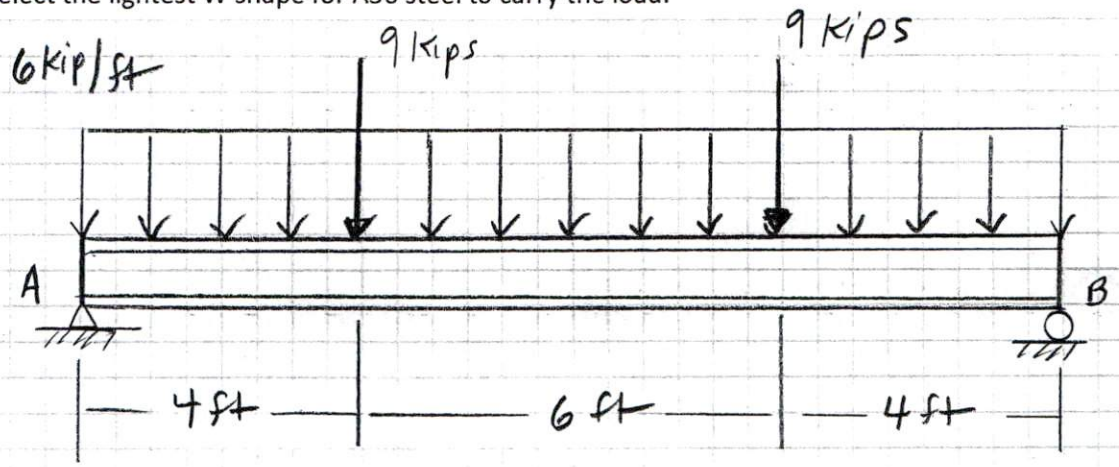
Deflection Governs,

$W = 490\ lb/ft$ — Beam wt

$= 490\ \frac{lb}{ft} - 17.6\ lb/ft$

$W = 472.4\ lb/ft$

4. A simple beam has a span of 14-ft with the load shown. The beam is braced laterally throughout its length. Select the lightest W shape for A36 steel to carry the load.



Step 1. Knowns

$P = 9$ kips
$w = 6$ kip/ft
$L = 14$ ft
$a = 4$ ft

A36 Steel

$\sigma_{allow} = 24$ ksi
$\tau_{allow} = 14.5$ ksi

Step 2. V_{MAX} & M_{MAX}

Table 13-1, case 3 and Case 4 (Superposition)

$$V_{MAX} = P + \frac{wL}{2} = 9 \text{ kips} + \frac{6 \text{ kip/ft}\,(14 \text{ ft})}{2} = 51 \text{ kips}$$

$$M_{MAX} = Pa + \frac{wL^2}{8} = 9 \text{ kips}(4 \text{ ft}) + \frac{6 \text{ k/ft}\,(14 \text{ ft})^2}{8} = 183 \text{ kip ft}$$

Step 3.

$$S_{req} = \frac{M_{MAX}}{\sigma_{allow}} = \frac{183 \text{ kip ft}\left(\frac{12 \text{ in}}{\text{ft}}\right)}{24 \text{ ksi}} = 91.5 \text{ in}^3$$

Step 4. Find W shapes

W 10 X 88	$S = 98.5$ in^3
W 12 X 87	$S = 118$ in^3
W 14 X 68	$S = 103$ in^3
W 16 X 57	$S = 92.2$ in^3
W 21 X 50	$S = 94.5$ in^3 (Lightest)

Check Bending

$$M_{wt} = \frac{wL^2}{8} = \frac{50\ lb/ft\ (14\ ft)^2}{8} = 1225\ lb\cdot ft$$

$$\frac{M_{wt}}{M_{MAX}} = \frac{1225\ lb\cdot ft\left(\frac{Kip}{1000\ lb}\right)}{183\ Kip\cdot ft} = 0.0067 = 0.67\%$$

$$\frac{Extra\ S}{S_{req}} = \frac{94.5 - 91.5}{91.5} = 0.033 = 33\% > 0.67\%$$ ✓

Step 5. Check Shear

$$f_{avg} = \frac{V_{MAX}}{d\,t_w}$$

W21X50

$d = 20.83\ in$

$t_w = 0.380\ in$

$$f_{avg} = \frac{V_{MAX}}{d\,t_w} = \frac{51\ kips}{20.83in\,(0.380in)} = 6.44\ ksi < F_{allow} = 14.5\ ksi$$ ✓

ok, Shear

Use, W21X50