Name: ____________________

University of California, Berkeley
Fall Semester 200X

Department of Civil Engineering
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CE 124 -- DESIGN OF TIMBER STRUCTURES

PRACTICE MIDTERM EXAMINATION NO. 2

This examination is open book and notes. **Please show all calculations and indicate all relevant assumptions.**

Unless indicated otherwise, typical California coastal climatic conditions and standard mill practices may be assumed. When in doubt regarding lumber grading, use **WWPA** rules.

1. ____________(XX)

2. ____________(XX)

3. ____________(XX)

Total: ____________(100)

Problem 1

a. A pin ended column has a 4 x 8 nominal cross-sectional dimension and is No. 2 Douglas Fir-Larch. What is the longest length that is permitted by the National Design Specification regardless of the computed allowable design compression stress?

$K_e = 1.0$ $\quad \frac{K_e \cdot l_e}{d} \leq 50$ $\quad d = 7.25$ in

$l_e \leq 50 \cdot d = 362.5$ in ≈ 30 ft — UNBRACED LENGTH

c. A glulam has been installed upside down. List two potential problems with this situation.

1. COMPRESSION ZONE STRESSED IN TENSION

2. INITIAL CAMBER RESULTS IN INCREASED DEFLECTION

d. When are 3/4 - inch thick laminations used in Glulams?

WHEN THE MEMBER IS SHARPLY CURVED (TO MINIMIZE THE RESIDUAL STRESSES).

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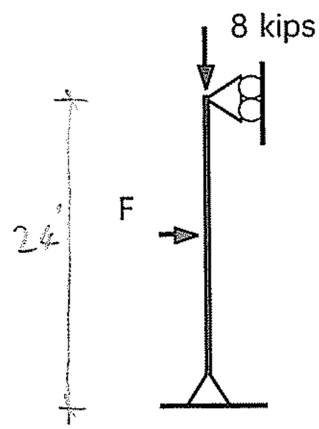
Problem 2

An 8 x 8 inch section (nominal) of No. 2 Douglas Fir - Larch is to be used as a part of a earthquake resistant system. The member is pined ended, has an applied axial load of 8 kips and has a length of 24 ft. A transverse load, F, is applied at the midspan of the member due to gravity effects. **What is the maximum value of F that can be applied simultaneously with the seismic load?** You may ignore bearing, shear and deflection considerations in your calculations.



$$M = \frac{F}{2}\cdot\frac{24}{2} = 6F = f_b \cdot S_x \Rightarrow f_b = \frac{6F}{S_x} = \frac{6\cdot 12\cdot F}{70.31}$$

$$f_b = 1.024\cdot F\ (psi) \qquad F_b = 750\ psi$$

$$f_c = \frac{P}{A} = \frac{8000}{56.25} = 142.2\ psi \qquad F_c = 700\ psi$$

$$K_e = 1.0 \quad l_e = 24\ ft \quad d = 7.5\ in \quad c = 0.8 \quad E_{min} = 470000\ psi$$

$$C_D = 1.6 \quad C_M = C_t = C_L = C_F = C_{fu} = C_i = C_r = C_T = 1.0$$

$$F_b' = 1.6\cdot 750 = 1200\ psi \qquad F_c^* = 1.6\cdot 700 = 1120\ psi$$

$$E'_{min} = E_{min} \qquad F_{cE} = \frac{0.822\cdot E'_{min}}{(l_e/d)^2} = \frac{0.822\cdot 470000}{(24\cdot 12/7.5)^2} = 262\ psi$$

$$C_p = \frac{1+\left(\frac{F_{cE}}{F_c^*}\right)}{2c} - \sqrt{\left(\frac{1+F_{cE}/F_c^*}{2c}\right)^2 - \frac{F_{cE}/F_c^*}{c}} = \frac{1+\frac{262}{1120}}{2\cdot 0.8} - \sqrt{\left(\frac{1+\frac{262}{1120}}{2\cdot 0.8}\right)^2 - \frac{\frac{262}{1120}}{0.8}}$$

$$C_p = 0.7712 - \sqrt{0.30235} = 0.2213$$

$$F_c' = F_c^*\cdot C_p = 1120\cdot 0.2213 = 247.9\ psi$$

$$\left(\frac{f_c}{F_c'}\right)^2 + \frac{f_b}{F_b'\left[1-\frac{f_c}{F_{cE}}\right]} \leq 1.0 \Rightarrow \left(\frac{142.2}{247.9}\right)^2 + \frac{1.024\cdot F}{1200\left[1-\frac{142.2}{262}\right]} \leq 1.0$$

$$0.329 + \left(\frac{1.024}{548.7}\right)\cdot F \leq 1.0 \Rightarrow F \leq \frac{548.7}{1.024}\cdot(1-0.329)$$

$$F \leq 359.6\ lbs$$

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Problem 3

What is the allowable bending moment that can be resisted by a glulam beam with a cross section of 6-3/4 by 36 inches? The beam has a combination symbol 20F-E10. The spacing between lateral supports for the compression face of the beam is 12 feet. The 48-ft. long beam is simply supported at its ends and the ends are braced against torsional rotation. The beam will be used where the equilibrium moisture content will be 24%.

Note: Be prepared ALSO to compute displacements for given immediate or sustained loading conditions, and to compare these results to allowable values.

$L = 48$ ft $\quad \ell_u = 12$ ft $\quad 6\frac{3}{4} \times 36 \quad C_M = 0.8$ FOR BENDING

USE 20F-1.5E $\quad F_b = 2000$ psi ASSUMING TENSION ZONE STRESSED IN TENSION

ASSUME $C_D = C_t = C_c = 1.0 \quad C_{fu} = 1.0 \qquad \frac{\ell_u}{d} = \frac{144}{36} = 4 < 7$

$\ell_e = 2.06 \cdot \ell_u = 24.72$ ft

$C_M = 0.833$ FOR E_{min}

$F_b^* = C_M \cdot F_b = 0.8 \cdot 2000 = 1600$ psi

$E_{min} = 780\,000$ psi $\quad E'_{min} = C_M \cdot E_{min} = 0.833 \cdot 780000 = 649{,}740$ psi

$$F_{bE} = \frac{1.20 \cdot E'_{min}}{\frac{\ell_e \cdot d}{b^2}} = \frac{1.2 \cdot 649{,}740}{\frac{24.72 \cdot 12 \cdot 36}{6.75^2}} = 3326.6 \text{ psi}$$

$$C_L = \frac{1 + \frac{F_{bE}}{F_b^*}}{1.9} - \sqrt{\left[\frac{1 + \left(\frac{F_{bE}}{F_b^*}\right)}{1.9}\right]^2 - \frac{\frac{F_{bE}}{F_b^*}}{0.95}} = \frac{1 + \frac{3326.6}{1600}}{1.9} - \sqrt{\left(\frac{1 + \frac{3326.6}{1600}}{1.9}\right)^2 - \frac{\frac{3326.6}{1600}}{0.95}}$$

$C_L = 1.6206 - \sqrt{0.43777} = 0.959$ $\qquad$ ASSUME DF-L LAMS

$$C_V = \left(\frac{21}{L}\right)^{0.1} \cdot \left(\frac{12}{d}\right)^{0.1} \cdot \left(\frac{5.125}{b}\right)^{0.1} = \left(\frac{21}{48}\right)^{0.1} \cdot \left(\frac{12}{36}\right)^{0.1} \cdot \left(\frac{5.125}{6.75}\right)^{0.1} \quad x = 10$$

$C_V = 0.8023 < C_L \Rightarrow$ USE C_V ONLY PER NDS 5.3.6.

$F'_b = C_V \cdot F_b^* = 0.8023 \cdot 1600 = 1283.9$ psi $\qquad S_x = 1458$ in^3

$M_{max} = F'_b \cdot S_x = 1283.9 \cdot 1458 \cdot \frac{1}{1000} \cdot \frac{1}{12} = 156$ k-ft