Name: _____

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# CEE 124 -- Design of Timber Structures

## "TRIAL" MIDTERM EXAMINATION NO. 1

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

Unless indicated otherwise, typical California coastal (Berkeley) climatic conditions and standard mill practices may be assumed. Cross sectional dimensions given are *nominal*. When in doubt regarding lumber grading, use **WWPA** rules.

1. _____ (45)

2. _____ (25)

3. _____ (30)

Total: _____ (100)

**Problem 1**

a. A 4x12 Western Woods (No. 2 or better) is to be used on its side (weak axis bending) in an industrial application where the EMC is 25%.

i. What is the allowable shear stress for this member? $F_v = 135$ ; $C_M = 0.97$

$C_D = 1.0$ (ASSUME) ; $C_t = 1.0$ ; $C_i = 1.0$

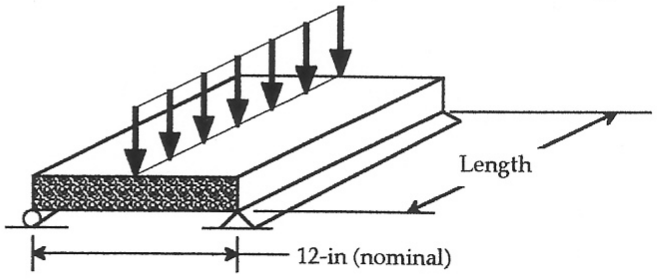
$F_v' = C_D \cdot C_M \cdot C_t \cdot C_i \cdot F_v = 130.95$ psi

ii. What is its Modulus of Elasticity? $E = 1\,000\,000$ psi $C_M = 0.90$

$E_c' = C_M \cdot C_t \cdot C_i \cdot C_T = 0.90 \cdot 1 \cdot 1 \cdot 1 \cdot 1000000$

$E_c' = 900\,000$ psi

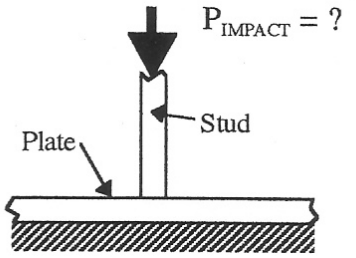
d. According to the NDS, what is the maximum load that can be applied to the 2x12 - in (nominal) plank shown below. Consider bending effects only! The material is graded as #2, Western Woods, S-Dry. Express your answer in terms of pounds per foot of length of plank. Although point loads and supports are indicated, adequate bearing areas may be assumed. The grain runs parallel to the length of the plank.



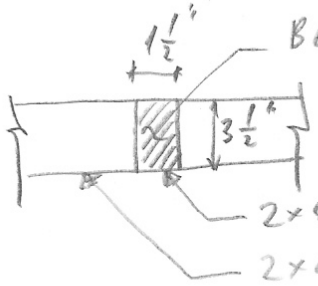

CROSS-GRAIN BENDING CREATES TENSION PERPENDICULAR TO GRAIN. PER NDS 3.8.2 THIS IS NOT ALLOWED. THUS CAPACITY IS

$F_{b\perp}' = 0$ psi

b. Considering bearing stresses only, what is the maximum IMPACT load that can be transferred from the stud to the bottom plate shown in the figure below? All of the members are 2x4 nominal constructed from No. 2 Western Woods marked S-DRY.




$C_D = 2.0$ · $C_M = 1.0$




$A = 1.5 \cdot 3.5 = 5.25\ in^2$

BEARING STRESS PERPENDICULAR TO GRAIN:

$C_b = \frac{1.5 + 0.375}{1.5} = 1.25$ $C_M = 1.0$; $C_t = 1.0$

$C_i = 1.0$ $F_{c\perp} = 335\ psi$ TABLE 4A

$F'_{c\perp} = C_M \cdot C_t \cdot C_i \cdot C_b = 418.75$

$P_{MAX1} = A \cdot F'_{c\perp} = 5.25 \cdot 418.75 = 2198\ lb$

BEARING STRESS PARALLEL TO GRAIN:

NO STEEL PLATE $\Rightarrow f_c < 0.75 F'_c$

$F_c = 900\ psi$ FROM TABLE 4A $C_F = 1.15$ $C_p = 1.0$

$F'_c = C_D \cdot C_M \cdot C_t \cdot C_F \cdot C_i \cdot C_p \cdot F_c$

$F'_c = 0.75 \cdot 2 \cdot 1 \cdot 1.15 \cdot 1 \cdot 1 \cdot 900 = 1552.5\ psi$

$P_{MAX2} = A \cdot F'_c = 5.25 \cdot 1552.5 = 8150.6\ lb$

BEARING PERPENDICULAR TO GRAIN GOVERNS

$P_{MAX1} < P_{MAX2}$

$P_{IMPACT} = 2198\ lb$

**Problem 2**

a. What is the likely maximum change in height (larger dimension) over time of a 8x14, solid sawn, **Douglas Fir-Larch**, S-GRN, timber that will have an EMC of 5% in use. Please state any assumptions you make.

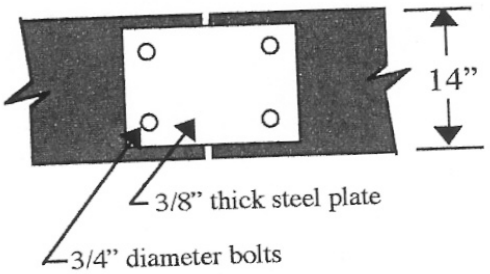
ASSUME: FSP = 30% $PS_t = 7.8\%$ PERCENT SHRINKAGE

$\Delta MC = 30 - 5 = 25\%$ CHANGE IN MOISTURE

$\varepsilon_t = \frac{PS_t}{FSP} \cdot \Delta MC = \frac{7.8}{30} \cdot 25 \cdot \frac{1}{100} = 0.065$ STRAIN

$\Delta h = h \cdot \varepsilon_t = 13.5 \text{ IN} \cdot 0.065 = 0.8775 \text{ IN}$

b. Can you envision any difficulties with the steel connection shown below used to connect two of the timbers described in part a? No calculations are needed for your answer. Just describe what you anticipate as the potential problem.




AS THE WOOD SHRINKS, THE BOLTS MAY NOT MOVE RELATIVE TO EACH OTHER SUFFICIENTY TO RELIEVE THE STRESS AND THE WOOD MAY SPLIT ALONG THE GRAINS AT BOLTS.

SOLUTION: CHANGE THE CONNECTION TYPE OR PROVIDE SLOTTED BOLT HOLES TO ALLOW FOR MOVEMENT.

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**Problem 3**

What is the maximum combined dead and ***roof*** live load that can be carried by a simply supported, 6 x 8 inch (nominal) beam spanning 12-ft. The load is uniformly distributed so express your answer in kips/ft. The beam is bend in strong axis bending and No. 2 **Western Woods** will be used. The member is in Berkeley. Lateral support is provided continuously along the compression face of the member. *Deflection and bearing stresses need not be checked.* You may ignore the self-weight of the member.

*Note: You may be asked to do a similar problem involving deflection, or bearing stresses.*

ASSUME: EMC = 12% $C_D = 1.15$ FOR ROOF LIVE LOAD

$C_M = 1.0$ ; $C_t = 1.0$ ; $C_{fu} = 1.0$ ; $C_i = 1.0$ ; $C_r = 1.0$

$C_F = 1.0$ $\frac{8}{6} = 1.33 \Rightarrow$ NDS 4.6.1 CASE (a) NO LATERAL SUPPORT NEEDED

$C_L = 1.0$

$F_b = 575$ psi $F_v = 125$ psi

$F'_b = C_D \cdot C_M \cdot C_t \cdot C_L \cdot C_{fu} \cdot C_i \cdot C_r \cdot F_b = 1.15 \cdot 575 = 661.25$ p

$F'_v = C_D \cdot C_M \cdot C_t \cdot C_i \cdot F_v = 1.15 \cdot 125 = 143.75$ psi

$A = 5.5 \cdot 7.5 = 41.25$ in$^2$ SECTION AREA

$S_x = \frac{5.5 \cdot 7.5^2}{6} = 51.56$ in$^2$ SECTION MODULUS

$M_{MAX} = S_x \cdot F'_b = 51.56 \cdot 661.25 \cdot \frac{1}{12 \cdot 1000} = 2.841$ k-ft

$M = \frac{w \cdot L^2}{8} \Rightarrow w_1 = \frac{8 \cdot M_{MAX}}{L^2} = \frac{8 \cdot 2.841}{12^2} = 0.158$ k/ft

$V_{MAX} = \frac{2}{3} \cdot A \cdot F'_v = \frac{2}{3} \cdot 41.25 \cdot 143.75 = 3.953$ k

$V = \frac{L}{2} \cdot w \Rightarrow w_2 = \frac{2 V_{MAX}}{L} = \frac{2 \cdot 3.953}{12} = 0.659$ k/ft

BENDING GOVERNS

$w_{MAX} = 0.158$ k/ft