Name: SOLUTION

University of California, Berkeley
Fall Semester 2008

Department of Civil and Environmental Engineering
Instructor: S. A. Mahin

CEE 124 -- Design of Timber Structures

MIDTERM EXAMINATION NO. 1

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

Unless indicated otherwise, typical California coastal (Berkeley) climatic conditions and standard mill practices may be assumed. The cross sectional dimensions given are *nominal, but you should use actual dimensions when performing calculations*. When in doubt regarding lumber grading, use **WWPA** rules.

Where appropriate, indicate all adjustment factors that need to be considered for a problem (including factors that have a value of one.

1.	____________	(50)
2.	____________	(15)
3.	____________	(35)
Total:	____________	(100)

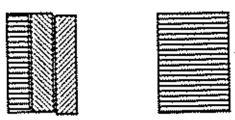
Good Luck

median (88)
AVERAGE (85)

Problem 1

20

a. Which of the following two combinations of members can carry the larger allowable bending moment: (i) three 2x10 acting in parallel or (ii) one 6x10? All members are No. 1 Douglas Fir-Larch used under normal load and moisture conditions. Assume that all members are bent about their strong axis. The members in case "i" are nailed together so that they act together as a unit. Show all calculations and assumptions!



Case "i" Case "ii"

CASE "i"

$S = 21.4 \text{ in}^3$

$\Sigma S = 3(21.4) = 64.2 \text{ in}^3$

$F_b = 1000$ psi (TABLE 4A)

ADJUSTMENT FACTORS

$C_D = 1$ $C_m = 1$ $C_{fu} = 1$

$C_t = 1$ $C_L = 1$ $C_i = 1$

$C_F = 1.1$ from TABLE 4A preface

$C_r = 1.15$ (3 members, nailed, etc)

$M = (\Sigma S) F_b' = 64.2 \text{ in}^3 (1000)(1.1)(1.15)$
$= 64.2(1265) = 81,213$ #-in ---→

CASE "ii"

$S = 82.7 \text{ in}^3$ beam & STRINGER

$F_b = 1350$ psi (WWPA or WCLIB) TABLE 4D

ADJUSTMENT FACTORS:

$C_D = 1.0$ $C_M = 1.0$

$C_t = 1.0$ $C_L = 1$ (laterally braced)

$C_F = 1.0$ (12" = d) $C_{fu} = 1.0$

$C_i = 1.0$ (not incised) $C_r = 1.0$

$M = SF_b' = 82.7(1350)(1 \ldots)$
$= 111,685$ #-in

6x10 is STRONGER

b. A 6x12 Douglas Fir-Larch member (No. 1) is to be used on its side (weak axis bending) in an industrial application where the EMC is 35%. The loading condition being considered is due to a construction load lasting less than 7 days.

i. What is the allowable bending stress for this member? BEAM & STRINGER

TABLE 4D $F_b = 1350$ psi

(10)

$C_D = 1.25$ $C_m = 1$ (TABLE 4D preface)? $C_t = 1$ $C_L = 1$ $C_F = 0.74$ ( ) $C_{FU} = 1.0$ $C_i = 1.0$ $C_r = 1.0$

$F_b' = 1350(1.25)(0.74) = \underline{1249\text{ psi}}$

ii. What value of Compression Perpendicular to Grain should be used? B & S

TABLE 4D $F_{c\perp} = 625$

(10)

$C_D = NA$, $C_m = 0.67$, $C_t = 1$, $C_F = 1.0$ (preface to 4D) $C_i = 1$, $C_p = 1$

$F_{c\perp}' = 625(0.67) = \underline{419\text{ psi}}$

c. A 6x6 column is to be used to support a 6x12 beam (both may be taken to be No. 1 Douglas Fir-Larch). No metal plate will be used between the two surfaces. Check the maximum bearing load that can be transferred across the 5.5" by 5.5" contact surface considering dead load plus occasional roof live loading. Show separate calculations for both the beam **and** the post. Indicate which surface controls the maximum load that can be transferred. The equilibrium moisture content is 12%.

POST →

(6)

$F_{c\parallel}$ (POST & TIMBER) = 1000
C_D = 1.25
75% Limit for no metal plate = 0.75
$F_{c\parallel}'$ 938 psi
BEARING AREA 30.25 in²
$P \le F_{c\parallel}' A$ 28,360#

BEAM →

(4)

$F_{c\perp}$ (B&S) = 625 psi
C_D = 1.0
$F_{c\perp}'$ 625 psi
A = 30.25 in²
$P \le F_{c\perp}' A = \underline{18,906\#}$

CONTROLS

18.9 KIPS

Problem 2

a. Axial shrinkage in solid sawn wood members is generally ignored. Please list one situation where this deformation should be considered, and briefly explain why.

1. IF THE MEMBER (OR SERIES OF MEMBERS) IS LONG.
2. WHERE DISPLACEMENTS ARE ESPECIALLY CRITICAL
3. When parallel to an element that does not shrink.

2

b. S-GRN and S-Dry light framing members generally have the same tabulated design values. S-Dry material tends to cost a little more. Please list one reason one might prefer the more expensive lumber.

1. LESS SHRINKAGE
2. LESS CREEP RELATED DISPLACEMENT

3

c. A 6x16, solid sawn, **Douglas Fir-Larch**, S-GRN, timber will be used as a beam in strong axis bending. The initial moisture content is 67%. The equilibrium EMC expected in use is 10%.

What is the **maximum** change in vertical (the larger) dimension that might occur? Please state any assumptions you make.

NO CHANGE IN DIMENSION WILL OCCUR UNTIL $MC \leq FSP = 30\%$

$$\epsilon_{SHRINK} = \epsilon_{SH_0}\left(\frac{30-10}{30}\right) = 7.8\left(\frac{20}{30}\right) = 5.2\%$$

ϵ_{MAX} = TANGENTIAL DIRECTION $\cong 7.8\%$

10

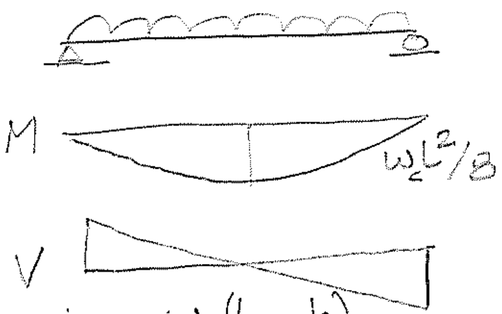
MAX CHANGE IN DIMENSION

$$\Delta L = \epsilon_{SHRINK}(15.5'') = \underline{0.81''}$$

Problem 3

Consider a simply supported, 4 x 12 inch (nominal) roof beam spanning 15-ft. It supports a dead load of 30 plf. It may be assumed that the critical load combination is snow loading plus dead load. The member is oriented so it acts in strong axis bending and No. 1 **Douglas Fir-Larch** is used. An EMC corresponding to typical Berkeley conditions may be assumed. Lateral support is provided continuously along the compression face of the member, and the ends of the member are restrained laterally. ***Deflection and bearing stresses need not be checked.***

How much snow load can this beam carry? Express your answer in pounds per foot.



$V = w_c\left(\frac{L}{2} - h\right)$

$DL = 30\,plf$ $C_m = 1$

$\omega_{critical} = DL + SNOW$ $C_t = 1$

$C_i = 1$

FIND $SNOW = \omega_{capacity} - DL$

MOMENT

$S = 73.83\,in^3$

$F_b = 1000$

$C_F = 1.1$

$C_D = 1.15$

$M_{allowable} = SF_b' = 73.83(1000)(1.1)(1.15)$

$= 93,395\ \#\text{-}in$

$M_{allowable} = w_c L^2/8$ SO

$w_c = \frac{8 M_{allowable}}{L^2}$

$= \frac{8(93,395\ \#\text{-}in)}{(15' \cdot 12'')^2} = 23.06\ \#/in$

$= 276.7\ \#/ft$

smaller controls

SHEAR

$A = 39.38\,in^2$

$F_v = 180\,psi$

$C_D = 1.15$

$C_F = NA$

$V_{allowable} = \frac{2}{3} A F_v'$

$= \frac{2}{3}(39.4)\,180(1.15)$

$= 5,437\ \#$

$V = w_c\left(\frac{L}{2} - h\right)$ SO

$w_c = \frac{V_{allowable}}{\left(\frac{L}{2} - h\right)}$

$= \frac{5437\ \#}{\left(7.5' - \frac{11.25}{12}\right)}$ (6.563')

$= 828\ \#/ft$

$w_{snow} = 276.7 - 30$ (DL) $=$

$= 246.7\ \#/ft$

Extra Page for Calculations