The University of Texas at San Antonio: Department of Civil and Environmental Engineering
CE 4253 Introduction to Timber and Masonry Design

**Midterm Exam**

**Name:** KEY

**Short Problems (5 pts each). Select the most appropriate answer.**

**1.** The tension parallel to grain reference design value of a 2 in. X 12 in. No.2 Non-Dense Southern Pine lumber is:

(a) 400 psi

b) 425 psi

c) 525 psi

d) 600 psi

Table 4B pg 40 - NDS supplement
12" wide - row

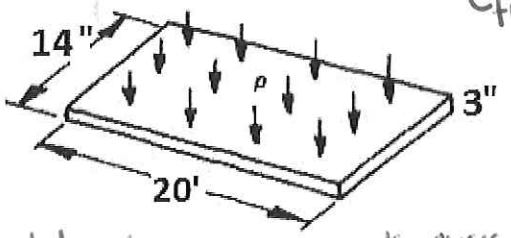
**2.** A ~~3~~ 4 in. X 12 in simply supported No.1 Douglas Fir-Larch member is loaded as shown below. The following section modulus and flat use factor must be used to check if the bending capacity of the beam is greater than the demand:

a) S =13.80 $in^3$ ; $C_{fu}$=1.0

(b) S =13.80 $in^3$ ; $C_{fu}$=1.2

c) S =73.15 $in^3$ ; $C_{fu}$=1.0

d) S =73.15 $in^3$ ; $C_{fu}$=1.2




$C_{fu}$ → Table 4A pg 32
= 1.2

loaded w/ respect to weak axis, use $S_y$
Table 1B, $S_y$ = 13.80 $in^3$

**3.** (Two) 3 in. X 8 in. Alaska Cedar sawn lumber truss chords are spaced 22 in on center, the repetitive size factor is :

a) 1.15

(b) 1.0

c) 0.9

d) 0.8

Members are less than 3 in number
Table 4A pg 32. Thus, use $C_r$ = 1.0

**4.** The MC of a 5-1/2 in. X 6 in. 16F-V2 Southern Pine glued laminated timber member is 17%. The member is exposed to sustained temperatures of 110° F. The adjusted design shear value will be obtained by multiplying the reference value by the following temperature factor:

a) 1.0

b) 0.8

c) 0.7

d) 0.5

Glulam beams are wet for MC ≥ 16%. (Table 5A)
Table 2.3.3 for T = 110° F.

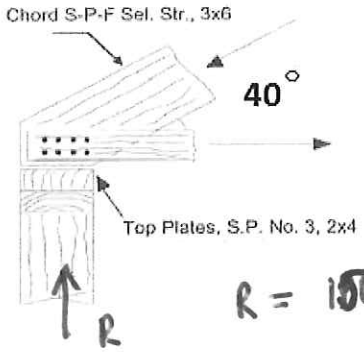
**5.** The axial compressive force in the top chord is based on 500 lbs of dead load and 1000 lbs of wind load. The bearing load to be used in checking the bearing capacity for both the top chord and the top plate is:

a) 500 lbs

b) 964 lbs

c) 1,149 lbs

d) 1500 lbs




R = 1500 sin (40) = 964 lbs

**6.** Two glued laminated beams have identical dimensions, 20 ft. long and cross-section of 6-3/4 in X 33 in.; however, one of them is a southern pine specie and the other one is a western specie. The beams are fully braced throughout its length and are under the same ambient conditions. Which of the statements is true?

a) The western specie beam has the same adjusted bending design value than the southern specie beam.

b) The southern specie beam has a higher adjusted bending design value than the western specie beam.

c) The western specie beam has a higher adjusted bending design value than the southern specie beam.

d) The southern specie beam has twice the adjusted bending design value than the western specie beam.

$C_V$ for western ≠ $C_V$ southern

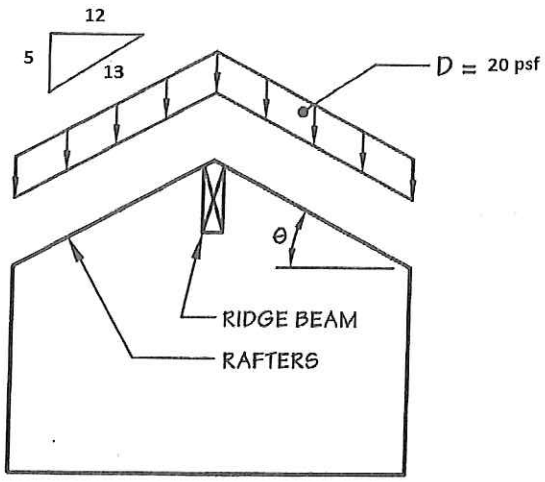
**7.** 20 ft-long 4 in. X 4 in. DF-L rafters will be spaced at 5 ft. o.c. If the horizontal plane method is followed, the rafters must be designed to resist a shear stress of:

a) 24.49 psi

b) 113.03 psi

c) 122.45 psi

d) 132.65 psi




**8.** A 36-ft long 3 in. X 10 in. Select Structural Cottonwood single span beam has concentrated loads at 1/6 points and bracings that provide lateral supports at the same points. The slenderness ratio of the member is:

a) 11.76

b) 28.82

c) 33.26

d) 13.58

$$R_B = \sqrt{\frac{l_e\, d}{b^2}}$$

$$= \sqrt{\frac{(124.56)\,9.25}{2.5^2}}$$

$$= 13.58$$

$d = 9.25$ (Table 1B-Supplement)

$b = 2.5$

$l_e = 1.73\, l_u$ (Table 3.3.3 NDS)

$l_u$ = distance between points of lateral support

$= \frac{1}{6}(36) = 6\text{ ft} = 72\text{ in}$

$l_e = 1.73(72) =$

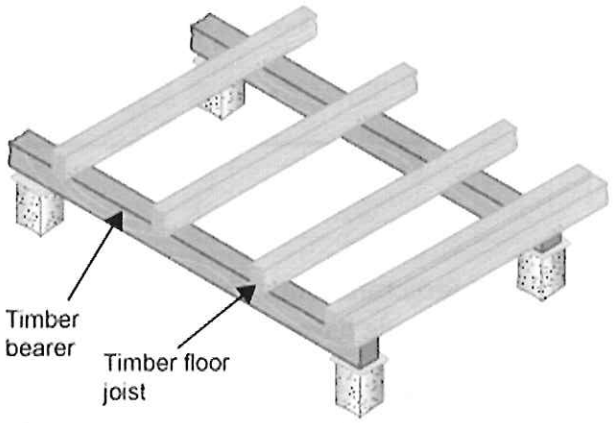
$= 124.56\text{ in}$

**Long Problems. Show all your work. (30 pts each)**

**9.** 2 in X 12 in. No. 2 Hem-Fir joists will be spaced at 16 inches on center to carry a dead load of 10 psf and live load of 40 psf. The members are simply supported and the moisture content is less than 19%. Bracing conditions will be continuous; such that buckling is not a concern. Camber will be used if needed. Thus, ignore deflection criteria and self-weight.

a) Find the maximum span for the joist members.

b) Using the answer to part (a), determine the required width of the timber bearer.



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# Midterm Exam

**Name:** KEY

**Short Problems (5 pts each). Select the most appropriate answer.**

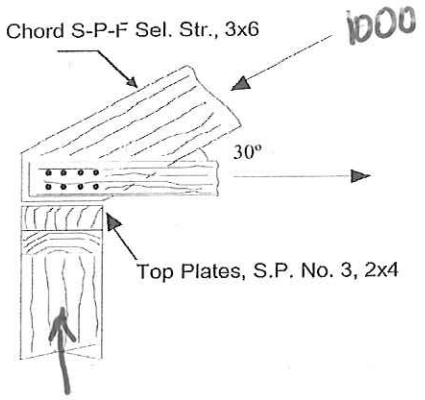
**1.** The axial compressive force in the top chord is based on 300 lbs of dead load and 700 lbs of wind load. The bearing load to be used in checking the bearing capacity for both the top chord and the top plate is:

a) 1000 lbs

b) 866 lbs

c) 500 lbs

d) 700 lbs




$1000 \sin(30)$

**2.** A 25-ft long 3 in. X 10 in. Select Structural Cottonwood single span beam has concentrated loads at 1/5 points and bracings that provide lateral supports at the same points. The slenderness ratio of the member is:

a) 10.58

b) 12.21

c) 3.53

d) 27.31

$R_B = \sqrt{\frac{l_e\, d}{b^2}}$ $\quad d = 9.25$ (Table 1B-Suppl)

$b = 2.5$

$= \sqrt{\frac{100(9.25)}{2.5^2}}$ $\quad l_e = 1.68\, l_u$ (Table 3.3.3 NDS)

$=$

$l_u$ = distance between points of lateral support

$= \frac{1}{5}(25) = 5\text{ ft} = 60\text{ in}$

**3.** The MC of a 5-1/2 in. X 6 in. 16F-V2 Southern Pine glued laminated timber member is 17%. The member is exposed to sustained temperatures of 140° F. The adjusted design shear value will be obtained by multiplying the reference value by the following temperature factor:

$l_e = 1.68(60) = 100.8\text{ in}$

a) 0.5

b) 0.7

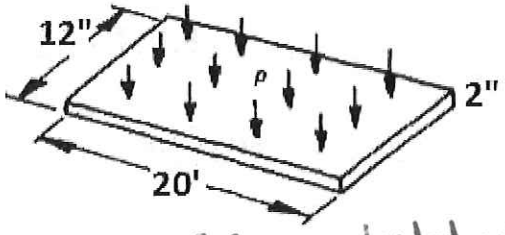
c) 0.8

d) 1.0

Glulam beams are wet for MC ≥ 16%. (Table 5A)

Table 2.3.3 for T = 140°F, $C_t$ = 0.5

**4.** A 2 in. X 12 in simply supported No.1 Douglas Fir-Larch member is loaded as shown below. The following section modulus and flat use factor must be used to check if the bending capacity of the beam is greater than the demand:




a) S =31.64 $in^3$ ;$C_{fu}$=1.2

b) S =31.64 $in^3$ ; $C_{fu}$=1.0

c) S =4.219 $in^3$ ; $C_{fu}$=1.2

d) S =4.219 $in^3$ ; $C_{fu}$=1.0

Cfu → Table 4A pg 32
=1.2

loaded w/ respect to weak axis, use Sy= 4.219 Table 1B -Supplement

**5.** The tension parallel to grain reference design value of a 3 in. X 10 in. No.1 Dense Southern Pine lumber is:

Table 4B pg 40 -NDS supplement
10" wide-row

a) 800 psi

b) 900 psi

c) 1000 psi

d) 1100 psi

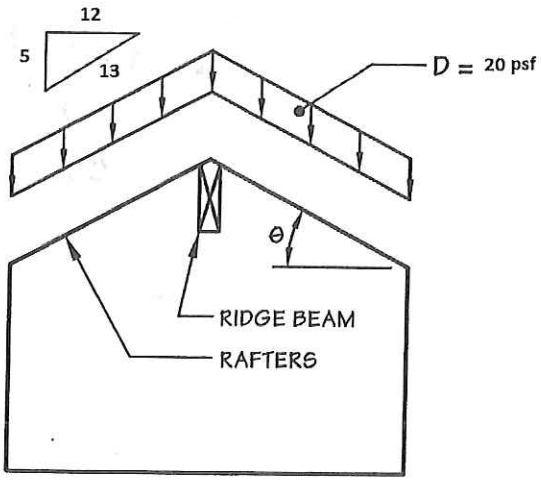
**6.** 20 ft-long 4 in. X 4 in. DF-L rafters will be spaced at 5 ft. o.c. If the horizontal plane method is followed, the rafters must be designed to resist a shear stress of:

a) 24.49 psi

b) 113.03 psi

c) 122.45 psi

d) 132.65 psi



**7.** Two 2 in. X 8 in. Alaska Cedar sawn lumber truss chords are spaced 20 in on center, the repetitive size factor is :

a) 0.8

b) 0.9

c) 1.0

d) 1.15

Members are less than 3 in number. Thus, use $C_r = 1.0$
Table 4A pg 32

**8.** Two glued laminated beams have identical dimensions, 30 ft. long and cross-section of 5-1/2 in X 11-1/4 in.; however, one of them is a southern pine specie and the other one is a western specie. The beams are fully braced throughout its length and are under the same ambient conditions. Which of the statements is true?

a) The southern specie beam has a higher adjusted bending design value than the western specie beam.

b) The western specie beam has a higher adjusted bending design value than the southern specie beam.

c) The western specie beam has the same adjusted bending design value than the southern specie beam.

d) The southern specie beam has twice the adjusted bending design value than the western specie beam.

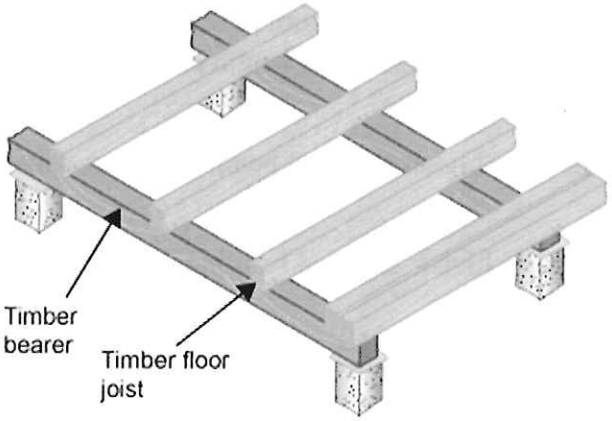
$C_V$ for southern $>$ $C_V$ for western

**Long Problems. Show all your work. (30 pts each)**

**1.** 2 in X 12 in. No. 2 Hem-Fir joists will be spaced at 16 inches on center to carry a dead load of 10 psf and live load of 40 psf. The members are simply supported and the moisture content is less than 19%. Bracing conditions will be continuous; such that buckling is not a concern. Camber will be used if needed. Thus, ignore deflection criteria and self-weight.

a) Find the maximum span for the joist members.

b) Using the answer to part (a), determine the required width of the timber bearer.



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a) 0.8

b) 0.9

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**8.** Two glued laminated beams have identical dimensions, 30 ft. long and cross-section of 5-1/2 in X 11-1/4 in.; however, one of them is a southern pine specie and the other one is a western specie. The beams are fully braced throughout its length and are under the same ambient conditions. Which of the statements is true?

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c) The western specie beam has the same adjusted bending design value than the southern specie beam.

d) The southern specie beam has twice the adjusted bending design value than the western specie beam.

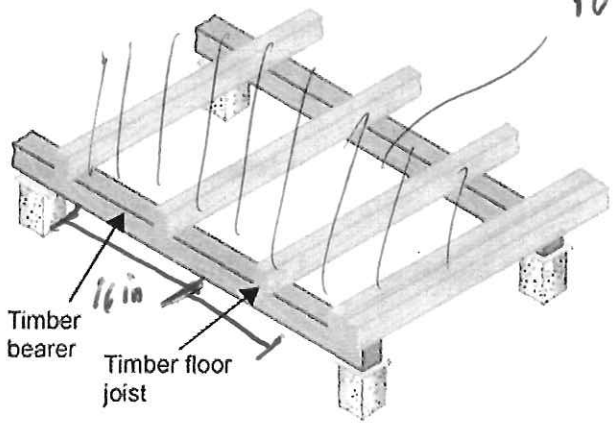
(5) (16)

**Long Problems. Show all your work. (30 pts each)**

**1.** 2 in X 12 in. No. 2 Hem-Fir joists will be spaced at 16 inches on center to carry a dead load of 10 psf and live load of 40 psf. The members are simply supported and the moisture content is less than 19%. Bracing conditions will be continuous; such that buckling is not a concern. Camber will be used if needed. Thus, ignore deflection criteria and self-weight.

a) Find the maximum span for the joist members. (20 pts)

b) Using the answer to part (a), determine the required width of the timber bearer. (10 pts)




10 psf + 40 psf

$w = 50 \frac{lb}{ft^2} \times \frac{16\ in}{12\ in} \times 1\ ft$

$= 66.67 \frac{lb}{ft}$ — 2 pts

Capacity > Demand

$$F_b' > \frac{M_{max}}{S_x}$$

$$F_b' = F_b (C_D \cdot C_M\ C_t\ C_L\ C_F\ C_{Fu}\ C_i\ C_r)$$

$$M_{max} = \frac{wL^2}{8}$$

$S_x = 31.64\ in^3$

4 pts

Adjustment factors → $C_D \Rightarrow D+L$, $C_D = 1.0$

$C_M = 1.0$ (MC < 19%)

$C_L = 1.0$ (full-bracing)

$C_t = 1.0$

$C_F = 1.0$ (2x12, Table 4A, Sup)

$C_{Fu} = 1.0$

$C_i = 1.0$

$C_r = 1.15$ (4A, spaced ≤24")

$$F_b' = F_b(1.15) = 850(1.15) = 977.5 \text{ psi}$$

$M_{max}$ in in, $\quad w = 66.67 \frac{lb}{ft} \times \frac{1 ft}{12 in} = 5.5558 \frac{lb}{in}$

$$F_b' > \frac{\frac{wL^2}{8}}{S_x}$$ — 8 pts

Solve for span, L

$$\frac{8 F_b' S_x}{w} > L^2$$

$$L_{max} = \sqrt{\frac{8 F_b' S_x}{w}}$$ — 6 pts

$$= \sqrt{\frac{8(977.5)(31.64)}{5.5558}}$$

$$= 211.03 in \times \frac{1 ft}{12 in} = 17.6 ft$$

Also check $F_v$

$F_v' > \frac{wL}{2}$

but bending will control.

b) $F_{c\perp}' \geq \frac{R}{A_{bearing}}$ — 5 pts

$F_{c\perp} = F_{c\perp} C_M C_t C_i C_b$ ($C_M = 1.0$, $C_t = 1.0$, $C_i = 1.0$, $C_b = 1.0$ (ends))

$= 405$ — 2 pts

~~$F_{c\perp}' = F_{c\perp} C_M C_t$~~

$$405 \geq \frac{586.5 lbs}{1.5 w_{bearing}}$$

$$w_{bearing} \geq \frac{586.5}{1.5(405)}$$

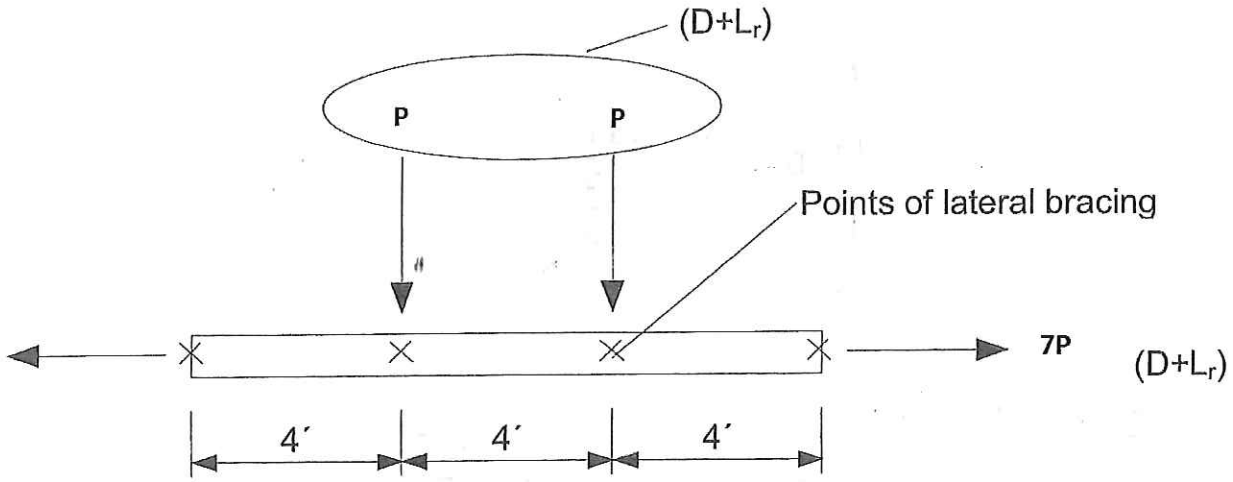
$\geq 0.96 in$ — 1 pt

$$R = \frac{wL}{2} = \frac{5.5558 \times 211.03}{2} = 586.5 lbs$$ — 2 pts

$A_{bearing} = b \times w_{bearing}$

$= 1.5 w_{bearing}$

**2.** A 5 in X 20-5/8 in 24F-E1 Southern Pine Glulam beam will serve as a bottom chord of a truss carrying the loads shown below due to dead load and roof live load. Lateral supports are provided every 4 ft by bracing. What is the maximum load **P** that this member can carry? The beam stability factor has been calculated to be 0.988. Ignore self-weight.




bending and axial tension member

$$\frac{f_t}{F_t'} + \frac{f_b}{F_b^{*}} \leq 1.0 \quad (1)$$

$$\frac{f_b - f_t}{F_b^{**}} \leq 1.0 \quad (2)$$

10 pts

$$f_t = \frac{7P}{A} = \frac{7P}{103.1}$$ 3pts

$F_t = 1150$ psi

$F_b^{+} = 2400$ psi

$F_t' = F_t(C_D\ C_M\ C_t)$

$F_t' = 1,150\ (1.25)$
$= 1,437.5$ psi

$C_D \Rightarrow D + L_r \Rightarrow C_D = 1.25$
$C_M = 1.0$
$C_t = 1.0$

3pts

$F_b^* = F_b (C_D C_M C_t \cancel{C_L} C_V \cancel{C_{fu}} \cancel{C_c} \cancel{C_I})$

$F_b^* = F_b C_D C_M C_t C_V$

$C_V = \left(\frac{21}{L}\right)^{1/20} \left(\frac{12}{d}\right)^{1/20} \left(\frac{5.125}{b}\right)^{1/20}$

$= \left(\frac{21}{12}\right)^{1/20} \left(\frac{12}{20\ 5/8}\right)^{1/20} \left(\frac{5.125}{5}\right)^{1/20}$

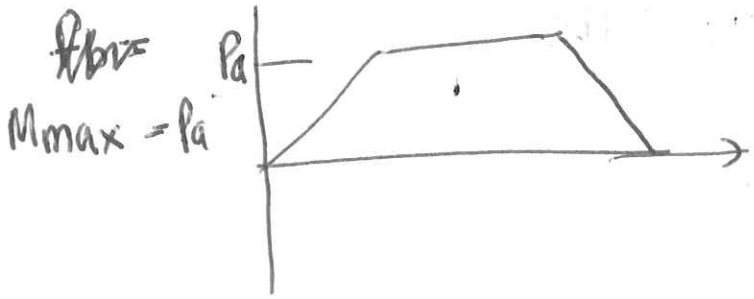
$= 1.0021 \leq 1.0$

$C_V = 1.0$

$F_b^* = F_b(C_D) = 2{,}400(1.25) = 3000$ psi

$F_b^{**} = F_b C_D C_M C_t C_L = 2400 \times 1.25 \times 0.988$

↳ given $= 2964$ psi




$M_{max} = Pa$

$f_b = \frac{M_{max}}{S_x} = \frac{Pa}{354.5}$

$= \frac{P(4 \times 12)}{354.5}$

$= \frac{48P}{354.5}$

Eqn (1)

$$\frac{\frac{7P}{103.1}}{1{,}437.5} + \frac{\frac{48P}{354.5}}{3000} \leq 1.0$$

~~0.00679P + 4.5134e-05P ≤ 1.0~~

$4.7231e\text{-}05P + 4.5134e\text{-}05P \leq 1.0$

$9.2365e\text{-}05P \leq 1.0$

$\boxed{P \leq 10{,}827 \text{ lbs}}$ — 5pts

(2) ~~$\frac{P_a}{37}$~~

$$\frac{\frac{48P}{354.5} - \frac{7P}{103.1}}{2964} \leq 10.$$

$$\frac{2964}{0.1354P - 0.0679P} \leq 2964$$

$$0.0675P \leq 2964$$

$$P \leq \frac{2964}{0.0675}$$

$$\leq 43911 \text{ lbs}$$

Criteria 1 controls

$$\boxed{P \leq 10{,}827 \text{ lbs}}$$