Arch324

STRUCTURES II

Winter 2026
Recitation

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Recitation Guidelines

Homework Problem

Lab (Groups of 1–3 students)

- Please complete the lab sheet **during recitation** and hand it in **before leaving**.

- Try to attend all sessions. Unexcused absences will **affect your grade** starting from the second missed class.

Answer Example - HW

#	Question	Your Response	Correct Answer	Score
1	Tabulated Allow. Bending Stress, Fb	725 PSI	725 PSI	5
2	Tabulated Allow. Shear Stress, Fv	155 PSI	155 PSI	5
3	Tabulated Wood Dry Density (specific gravity)	0.36	0.36	5
4	Total Actual Applied Point Load, P	2016 LBS	2016 LBS	5
5	Wood Density (Including M.C.)	25.32 PCF	24.63627694 PCF	5
6	Beam Selfweight (Including M.C.), w	9.13 PLF	9.131675567 PLF	5
7	Actual Beam Bending Moment, M	12753.4 FT-LB	12753.48064 FT-LB	5
8	Actual Maximum Shear Force (at reaction) , V	1117.56 LBS	1117.580107 LBS	5
9	Size Factor, CF	1	1	5
10	Wet Service Factor for Fb, CM_b	1	1	5
11	Wet Service Factor for Fv, CM_v	1	1	5
12	Factored Allow. Bending Stress, F'b	708.69 PSI	725 PSI	5
13	Factored Allow. Shear Stress, F'v	155 PSI	155 PSI	5
14	Actual Bending Stress, fb_actual	1128.12 PSI	1128.115307 PSI	5
15	Actual Shear Stress, fv_actual	31.4 PSI	31.40740347 PSI	5
16	Bending Stress Passing: enter "1" for pass or "0" for fail	0 (1 or 0)	0 (1 or 0)	5
17	Shear Stress Passing: enter "1" for pass or "0" for fail	1 (1 or 0)	1 (1 or 0)	5
			Current Score:	85 / 85

Your answer may have up to a 2% margin of error

It is recommended to keep four significant figures

Analysis Example - HW1

Given: material, span, loading, member size

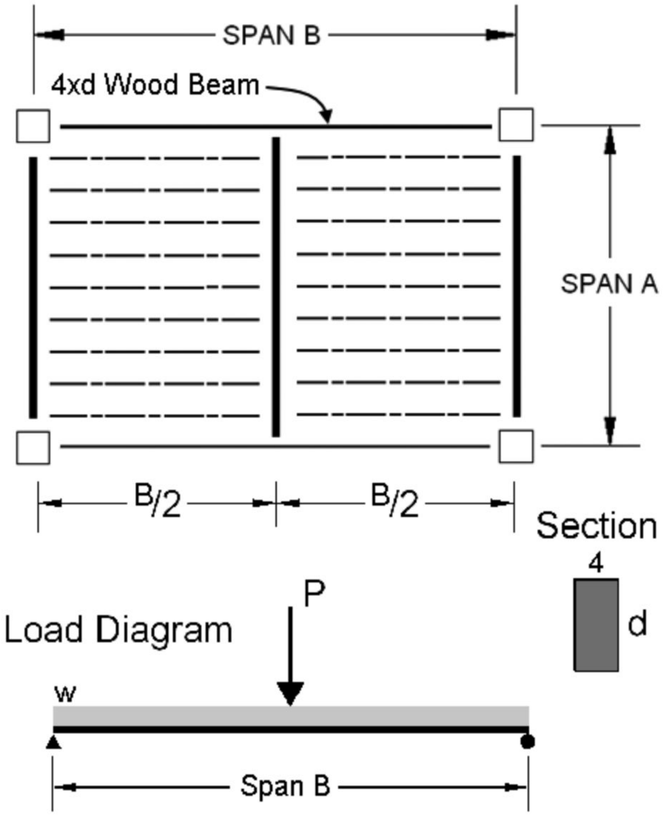
Analyze: Safe or Unsafe

1. Wood Beam Analysis

Analyze the given 4x dimensioned lumber beam to determine if it passes or fails the NDS code criteria. The beam carries both dead and live floor load plus its own selfweight. Check the actual shear and bending stresses against the factored allowable stresses including all applicable factors from the NDS. Load duration is based on the live load (CD = 1.0). Assume normal temperature"," and no incising (Ct = Ci = 1.0). Find the beam selfweight including the given moisture content. The beam is braced at the ends and the C.L. (meets criteria in 4.4.1) so CL = 1.0.

DATASET: 1 -2- -3-

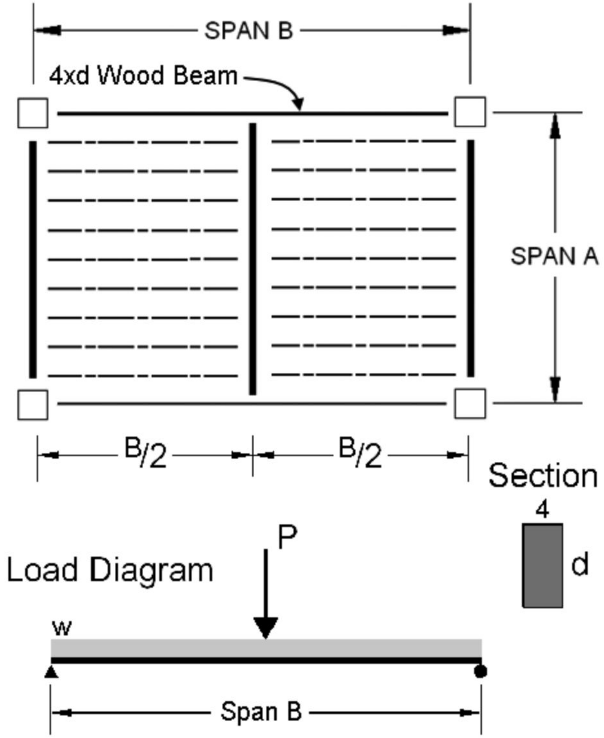
Wood Species	WESTERN CEDARS
Wood Grade	No.1
Span A	8 FT
Span B	24 FT
Nominal Depth of Beam, d	16 IN
Moisture Content, m.c.	15 %
Floor DL	7 PSF
Floor LL	35 PSF



Analysis Example - HW1

17 Questions

#	Question	Your Response	
1	Tabulated Allow. Bending Stress, Fb		PSI
2	Tabulated Allow. Shear Stress, Fv		PSI
3	Tabulated Wood Dry Density (specific gravity)		
4	Total Actual Applied Point Load, P		LBS
5	Wood Density (Including M.C.)		PCF
6	Beam Selfweight (Including M.C.), w		PLF
7	Actual Beam Bending Moment, M		FT-LB
8	Actual Maximum Shear Force (at reaction) , V		LBS
9	Size Factor, CF		
10	Wet Service Factor for Fb, CM_b		
11	Wet Service Factor for Fv, CM_v		
12	Factored Allow. Bending Stress, F'b		PSI
13	Factored Allow. Shear Stress, F'v		PSI
14	Actual Bending Stress, fb_actual		PSI
15	Actual Shear Stress, fv_actual		PSI
16	Bending Stress Passing: enter "1" for pass or "0" for fail		(1 or 0)
17	Shear Stress Passing: enter "1" for pass or "0" for fail		(1 or 0)



Analysis Example - HW1

Q1-Q3

Wood Species	WESTERN CEDARS
Wood Grade	No.1

1	Tabulated Allow. Bending Stress, Fb
2	Tabulated Allow. Shear Stress, Fv
3	Tabulated Wood Dry Density (specific gravity)

Q1 Fb=725 PSI

Q2 Fv=155 PSI

Q3 G=0.36

Species and commercial grade	Size classification	Design values in pounds per square inch (psi): Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E	Modulus of Elasticity E_{min}	Specific Gravity[4] G	Grading Rules Agency
RED OAK										
Select Structural	2" & wider	1,150	675	170	820	1,000	1,400,000	510,000	0.67	NELMA
No. 1		825	500	170	820	825	1,300,000	470,000		
No. 2		800	475	170	820	625	1,200,000	440,000		
No. 3		475	275	170	820	375	1,100,000	400,000		
Stud	2" & wider	625	375	170	820	400	1,100,000	400,000		
Construction	2" - 4" wide	925	550	170	820	850	1,200,000	440,000		
Standard		525	300	170	820	650	1,100,000	400,000		
Utility		250	150	170	820	425	1,000,000	370,000		
REDWOOD										
Select Structural	2" & wider	1,100	625	160	425	1,100	1,100,000	400,000	0.37	RIS
No. 1		775	450	160	425	900	1,100,000	400,000		
No. 2		725	425	160	425	700	1,000,000	370,000		
No. 3		425	250	160	425	400	900,000	330,000		
Stud	2" & wider	575	325	160	425	450	900,000	330,000		
Construction	2" - 4" wide	825	475	160	425	925	900,000	330,000		
Standard		450	275	160	425	725	900,000	330,000		
Utility		225	125	160	425	475	800,000	290,000		
SPRUCE-PINE-FIR										
Select Structural	2" & wider	1,250	700	135	425	1,400	1,500,000	550,000	0.42	NLGA
No. 1/ No. 2		875	450	135	425	1,150	1,400,000	510,000		
No. 3		500	250	135	425	650	1,200,000	440,000		
Stud	2" & wider	675	350	135	425	725	1,200,000	440,000		
Construction	2" - 4" wide	1,000	500	135	425	1,400	1,300,000	470,000		
Standard		550	275	135	425	1,150	1,200,000	440,000		
Utility		275	125	135	425	750	1,100,000	400,000		
SPRUCE-PINE-FIR (SOUTH)										
Select Structural	2" & wider	1,300	575	135	335	1,200	1,300,000	470,000	0.36	NELMA WCLIB WWPA
No. 1		875	400	135	335	1,050	1,200,000	440,000		
No. 2		775	350	135	335	1,000	1,100,000	400,000		
No. 3		450	200	135	335	575	1,000,000	370,000		
Stud	2" & wider	600	275	135	335	625	1,000,000	370,000		
Construction	2" - 4" wide	875	400	135	335	1,200	1,000,000	370,000		
Standard		500	225	135	335	1,000	900,000	330,000		
Utility		225	100	135	335	675	900,000	330,000		
WESTERN CEDARS										
Select Structural	2" & wider	1,000	600	155	425	1,000	1,100,000	400,000	0.36	WCLIB WWPA
No. 1		725	425	155	425	825	1,000,000	370,000		
No. 2		700	425	155	425	650	1,000,000	370,000		
No. 3		400	250	155	425	375	900,000	330,000		
Stud	2" & wider	550	325	155	425	400	900,000	330,000		
Construction	2" - 4" wide	800	475	155	425	850	900,000	330,000		
Standard		450	275	155	425	650	800,000	290,000		
Utility		225	125	155	425	425	800,000	290,000		

Analysis Example - HW1

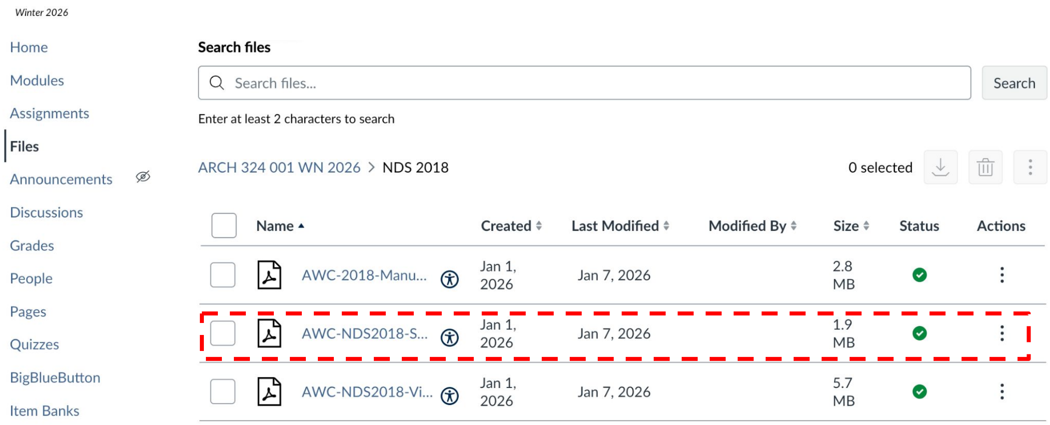
Other wood species (Table 4A)

Table 4A (Cont.) **Reference Design Values for Visually Graded Dimension Lumber (2" - 4" thick)[1,2,3]**

(All species except Southern Pine—see Table 4B) (Tabulated design values are for normal load duration and dry service conditions. See NDS 4.3 for a comprehensive description of design value adjustment factors.)

USE WITH TABLE 4A ADJUSTMENT FACTORS

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)							Specific Gravity[4]	Grading Rules Agency
		Bending	Tension parallel to grain	Shear parallel to grain	Compression perpendicular to grain	Compression parallel to grain	Modulus of Elasticity			
		F_b	F_t	F_v	$F_{c\perp}$	F_c	E	E_{min}	G	



Canvas - Files - NDS 2018 - AWC NDS2018 Supplement - Page 33 to 38

Analysis Example - HW1

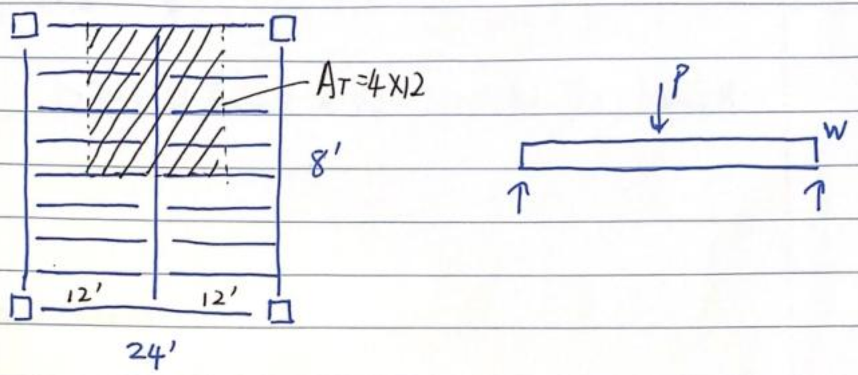
Q4-Q6

4	Total Actual Applied Point Load, P		LBS
5	Wood Density (Including M.C.)		PCF
6	Beam Selfweight (Including M.C.), w		PLF

Tributary area:

$A_T = 4' \times 12' = 48\ SF$

$P = (DL + LL) \times A_T = (7 + 35) \times 48 = 2016\ LBS$ Q4



Analysis Example - HW1

Q4-Q6

Table 1B Section Properties of Standard Dressed (S4S) Sawn Lumber

Nominal Size b x d	Standard Dressed Size (S4S) b x d in. x in.	Area of Section A in.^{2}	X-X AXIS Section Modulus S_{xx} in.^{3}	X-X AXIS Moment of Inertia I_{xx} in.^{4}	Y-Y AXIS Section Modulus S_{yy} in.^{3}	Y-Y AXIS Moment of Inertia I_{yy} in.^{4}	Approximate weight in pounds per linear foot (lbs/ft) of piece when density of wood equals: 25 lbs/ft^3	30 lbs/ft^3	35 lbs/ft^3	40 lbs/ft^3	45 lbs/ft^3	50 lbs/ft^3
Boards[1]												
1 x 3	3/4 x 2-1/2	1.875	0.781	0.977	0.234	0.088	0.326	0.391	0.456	0.521	0.586	0.651
1 x 4	3/4 x 3-1/2	2.625	1.531	2.680	0.328	0.123	0.456	0.547	0.638	0.729	0.820	0.911
1 x 6	3/4 x 5-1/2	4.125	3.781	10.40	0.516	0.193	0.716	0.859	1.003	1.146	1.289	1.432
1 x 8	3/4 x 7-1/4	5.438	6.570	23.82	0.680	0.255	0.944	1.133	1.322	1.510	1.699	1.888
1 x 10	3/4 x 9-1/4	6.938	10.70	49.47	0.867	0.325	1.204	1.445	1.686	1.927	2.168	2.409
1 x 12	3/4 x 11-1/4	8.438	15.82	88.99	1.055	0.396	1.465	1.758	2.051	2.344	2.637	2.930
Dimension Lumber (see NDS 4.1.3.2) and Decking (see NDS 4.1.3.5)												
2 x 3	1-1/2 x 2-1/2	3.750	1.56	1.953	0.938	0.703	0.651	0.781	0.911	1.042	1.172	1.302
2 x 4	1-1/2 x 3-1/2	5.250	3.06	5.359	1.313	0.984	0.911	1.094	1.276	1.458	1.641	1.823
2 x 5	1-1/2 x 4-1/2	6.750	5.06	11.39	1.688	1.266	1.172	1.406	1.641	1.875	2.109	2.344
2 x 6	1-1/2 x 5-1/2	8.250	7.56	20.80	2.063	1.547	1.432	1.719	2.005	2.292	2.578	2.865
2 x 8	1-1/2 x 7-1/4	10.88	13.14	47.63	2.719	2.039	1.888	2.266	2.643	3.021	3.398	3.776
2 x 10	1-1/2 x 9-1/4	13.88	21.39	98.93	3.469	2.602	2.409	2.891	3.372	3.854	4.336	4.818
2 x 12	1-1/2 x 11-1/4	16.88	31.64	178.0	4.219	3.164	2.930	3.516	4.102	4.688	5.273	5.859
2 x 14	1-1/2 x 13-1/4	19.88	43.89	290.8	4.969	3.727	3.451	4.141	4.831	5.521	6.211	6.901
3 x 4	2-1/2 x 3-1/2	8.75	5.10	8.932	3.646	4.557	1.519	1.823	2.127	2.431	2.734	3.038
3 x 5	2-1/2 x 4-1/2	11.25	8.44	18.98	4.688	5.859	1.953	2.344	2.734	3.125	3.516	3.906
3 x 6	2-1/2 x 5-1/2	13.75	12.60	34.66	5.729	7.161	2.387	2.865	3.342	3.819	4.297	4.774
3 x 8	2-1/2 x 7-1/4	18.13	21.90	79.39	7.552	9.440	3.147	3.776	4.405	5.035	5.664	6.293
3 x 10	2-1/2 x 9-1/4	23.13	35.65	164.9	9.635	12.04	4.015	4.818	5.621	6.424	7.227	8.030
3 x 12	2-1/2 x 11-1/4	28.13	52.73	296.6	11.72	14.65	4.883	5.859	6.836	7.813	8.789	9.766
3 x 14	2-1/2 x 13-1/4	33.13	73.15	484.6	13.80	17.25	5.751	6.901	8.051	9.201	10.35	11.50
3 x 16	2-1/2 x 15-1/4	38.13	96.90	738.9	15.89	19.86	6.619	7.943	9.266	10.59	11.91	13.24
4 x 4	3-1/2 x 3-1/2	12.25	7.15	12.51	7.146	12.51	2.127	2.552	2.977	3.403	3.828	4.253
4 x 5	3-1/2 x 4-1/2	15.75	11.81	26.58	9.188	16.08	2.734	3.281	3.828	4.375	4.922	5.469
4 x 6	3-1/2 x 5-1/2	19.25	17.65	48.53	11.23	19.65	3.342	4.010	4.679	5.347	6.016	6.684
4 x 8	3-1/2 x 7-1/4	25.38	30.66	111.1	14.80	25.90	4.405	5.286	6.168	7.049	7.930	8.811
4 x 10	3-1/2 x 9-1/4	32.38	49.91	230.8	18.89	33.05	5.621	6.745	7.869	8.993	10.12	11.24
4 x 12	3-1/2 x 11-1/4	39.38	73.83	415.3	22.97	40.20	6.836	8.203	9.570	10.94	12.30	13.67
4 x 14	3-1/2 x 13-1/4	46.38	102.41	678.5	27.05	47.34	8.051	9.661	11.27	12.88	14.49	16.10
4 x 16	3-1/2 x 15-1/4	53.38	135.66	1034	31.14	54.49	9.266	11.12	12.97	14.83	16.68	18.53

Given: $b \times d = 4 \times 16$ in

Area = 53.38 in^2

S_x = 135.66 in^3

Analysis Example - HW1

Q4-Q6

Given: $b \times d = 4 \times 16$ in

m.c. = 15%

From table:

Area = 53.38 in²

G = 0.36 Q3

The following formula shall be used to determine the density in lbs/ft³ of wood:

$$\text{density} = 62.4\left[\frac{G}{1+G(0.009)(m.c.)}\right]\left[1+\frac{m.c.}{100}\right]$$

where:

G = specific gravity of wood

m.c. = moisture content of wood, %

w (PLF) = D (PCF) x Area (IN²)/144

$$D = 62.4\left[\frac{0.36}{1+0.36(0.009)(15)}\right]\left[1+\frac{15}{100}\right] = 24.64 \text{ PCF}$$

Q5

$$w = 24.64 \cdot \frac{53.38}{144} = 9.13 \text{ PLF}$$

Q6

Analysis Example - HW1

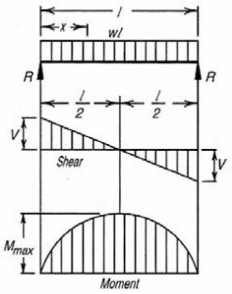
Q7-Q8

7	Actual Beam Bending Moment, M		FT-LB
8	Actual Maximum Shear Force (at reaction) , V		LBS

Determine Beam Forces

by superposition equations

1. SIMPLE BEAM—UNIFORMLY DISTRIBUTED LOAD



Total Equiv. Uniform Load . . . . . . $= wl$

$R = V$ . . . . $= \frac{wl}{2}$

V_x . . . . $= w\left(\frac{l}{2} - x\right)$

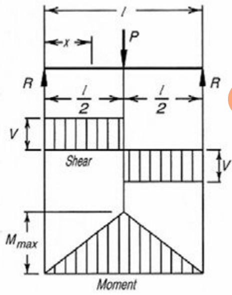
M_{max} (at center) . . . . $= \frac{wl^2}{8}$

M_x . . . . $= \frac{wx}{2}(l - x)$

Δ_{max} (at center) . . . . $= \frac{5wl^4}{384EI}$

Δ_x . . . . $= \frac{wx}{24EI}(l^3 - 2lx^2 + x^3)$

7. SIMPLE BEAM—CONCENTRATED LOAD AT CENTER



Total Equiv. Uniform Load . . . . $= 2P$

$R = V$ . . . . $= \frac{P}{2}$

M_{max} (at point of load) . . . . $= \frac{Pl}{4}$

M_x $\left(\text{when } x < \frac{1}{2}\right)$ . . . . $= \frac{Px}{2}$

Δ_{max} (at point of load) . . . . $= \frac{Pl^3}{48EI}$

Δ_x $\left(\text{when } x < \frac{1}{2}\right)$ . . . . $= \frac{Px}{48EI}(3l^2 - 4x^2)$

$R = \frac{wl}{2} + \frac{P}{2} = \frac{9.13 \cdot 24}{2} + \frac{2016}{2} = 1117.56$ LBS Q8

$M_d = \frac{wl^2}{8} + \frac{Pl}{4} = \frac{9.13 \cdot 24^2}{8} + \frac{2016 \cdot 24}{4} = 12753.36$ Ft-lbs Q7

12753.36 FT-LB × 12 = 153040.32 IN-LB Moment,M (IN-LB)

Analysis Example - HW1

Q9-Q11

9	Size Factor, CF	
10	Wet Service Factor for Fb, CM_b	
11	Wet Service Factor for Fv, CM_v	

Size Factor, C_F

Tabulated bending, tension, and compression parallel to grain design values for dimension lumber 2" to 4" thick shall be multiplied by the following size factors:

Size Factors, C_F

Grades	Width (depth)	F_b Thickness (breadth) 2" & 3"	F_b Thickness (breadth) 4" (4)	F_t	F_c
Select Structural, No.1 & Btr, No.1, No.2, No.3	2", 3", & 4"	1.5	1.5	1.5	1.15
	5"	1.4	1.4	1.4	1.1
	6"	1.3	1.3	1.3	1.1
	8"	1.2	1.3	1.2	1.05
	10"	1.1	1.2	1.1	1.0
	12"	1.0	1.1	1.0	1.0
	16 14" & wider	0.9	1.0 Q9	0.9	0.9
Stud	2", 3", & 4"	1.1	1.1	1.1	1.05
	5" & 6"	1.0	1.0	1.0	1.0
	8" & wider	Use No.3 Grade tabulated design values and size factors			
Construction, Standard	2", 3", & 4"	1.0	1.0	1.0	1.0
Utility	4"	1.0	1.0	1.0	1.0
	2" & 3"	0.4	—	0.4	0.6

Wet Service Factor, C_M

When dimension lumber is used where moisture content will exceed 19% for an extended time period, design values shall be multiplied by the appropriate wet service factors from the following table:

Wet Service Factors, C_M

F_b	F_t	F_v	$F_{c\perp}$	F_c	E and E_{min}
0.85*	1.0	0.97	0.67	0.8**	0.9

* when $(F_b)(C_F) \leq 1{,}150$ psi, $C_M = 1.0$

** when $(F_c)(C_F) \leq 750$ psi, $C_M = 1.0$

m.c.≤19% Cm=1.0

Q10 and Q11

Analysis Example - HW1

Q12-Q13

12	Factored Allow. Bending Stress, F'b		PSI
13	Factored Allow. Shear Stress, F'v		PSI

Adjustment Factors

Table 4.3.1 – Applicability of Adjustment Factors for Sawn Lumber

		ASD only	ASD and LRFD											LRFD only		
		Load Duration Factor	Wet Service Factor	Temperature Factor	Beam Stability Factor	Size Factor	Flat Use Factor	Incising Factor	Repetitive Member Factor	Column Stability Factor	Buckling Stiffness Factor	Bearing Area Factor	Format Conversion Factor	Resistance Factor	Time Effect Factor
													K_F	ϕ	
$F_b' = F_b$	x	C_D	C_M	C_t	C_L	C_F	C_{fu}	C_i	C_r	-	-	-	2.54	0.85	λ
$F_t' = F_t$	x	C_D	C_M	C_t	-	C_F	-	C_i	-	-	-	-	2.70	0.80	λ
$F_v' = F_v$	x	C_D	C_M	C_t	-	-	-	C_i	-	-	-	-	2.88	0.75	λ
$F_c' = F_c$	x	C_D	C_M	C_t	-	C_F	-	C_i	-	C_P	-	-	2.40	0.90	λ
$F_{c\perp}' = F_{c\perp}$	x	-	C_M	C_t	-	-	-	C_i	-	-	-	C_b	1.67	0.90	-
$E' = E$	x	-	C_M	C_t	-	-	C_{fu}[1]	C_i	-	-	-	-	-	-	-
$E_{min}' = E_{min}$	x	-	C_M	C_t	-	-	C_{fu}[1]	C_i	-	-	C_T	-	1.76	0.85	-

[1] Where sawn lumber of Beam and Stringer grades is subject to loads causing flatwise bending or buckling, reference modulus of elasticity (E or E_{min}) shall be multiplied by the flat use factor, C_{fu}, specified in Table 4D of the NDS Supplement; otherwise, C_{fu} = 1.0.

Repetitive Member Factor, C_r

Bending design values, F_b, for dimension lumber 2" to 4" thick shall be multiplied by the repetitive member factor, C_r = 1.15, when such members are used as joists, truss chords, rafters, studs, planks, decking, or similar members which are in contact or spaced not more than 24" on center, are not less than 3 in number and are joined by floor, roof, or other load distributing elements adequate to support the design load.

Flat Use Factor, C_{fu}

Bending design values adjusted by size factors are based on edgewise use (load applied to narrow face). When dimension lumber is used flatwise (load applied to wide face), the bending design value, F_b, shall also be permitted to be multiplied by the following flat use factors:

Flat Use Factors, C_{fu}

Width (depth)	Thickness (breadth) 2" & 3"	4"
2" & 3"	1.0	—
4"	1.1	1.0
5"	1.1	1.05
6"	1.15	1.05
8"	1.15	1.05
10" & wider	1.2	1.1

Given:

CD=1.0 Ct=1.0

Ci=1.0 CL=1.0

CF=1.0 Q9

CM=1.0 Q10 Q11

Cfu=1.0 (Beam)

Cr=1.0 (not flat)

Q1 Q2

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

$= 725 \cdot 1 = 725$ psi Q12

$F_v' = F_v(C_D C_M C_t C_i)$

$= 155 \cdot 1 = 155$ psi Q13

Analysis Example - HW1

Q14-Q15

14	Actual Bending Stress, fb_actual		PSI
15	Actual Shear Stress, fv_actual		PSI

Determine actual stresses

- $f_b = M/S$
- $f_v = 1.5\ V/A$

From Table 1B:

Area=53.38 in²
Sx=135.66 in³

Actual Stress:

Q7×12

$$F_{b\_actual} = \frac{M}{S_x} = \frac{153040.32}{135.66} = 1128.12 \text{ PSI}$$ Q14

$$F_{v\_actual} = \frac{3}{2} \cdot \frac{V}{A} = 1.5 \cdot \frac{1117.56}{53.38} = 31.40 \text{ psi}$$ Q15

Q8

Analysis Example - HW1

Q16-Q17

16	Bending Stress Passing: enter "1" for pass or "0" for fail		(1 or 0)
17	Shear Stress Passing: enter "1" for pass or "0" for fail		(1 or 0)

Check that actual ≤ allowable

- $f_b \leq F'_b$
- $f_v \leq F'_v$

Q14 Q12

$F_{b\_actual} = 1128.12$ Psi $>$ $F_b = 725$ Psi — Q16 — 0 for Fail

$F_{v\_actual} = 31.4$ Psi $<$ $F'_v = 155$ Psi — Q17 — 1 for Pass

Q15 Q13