ARCH 324 STRUCTURE II

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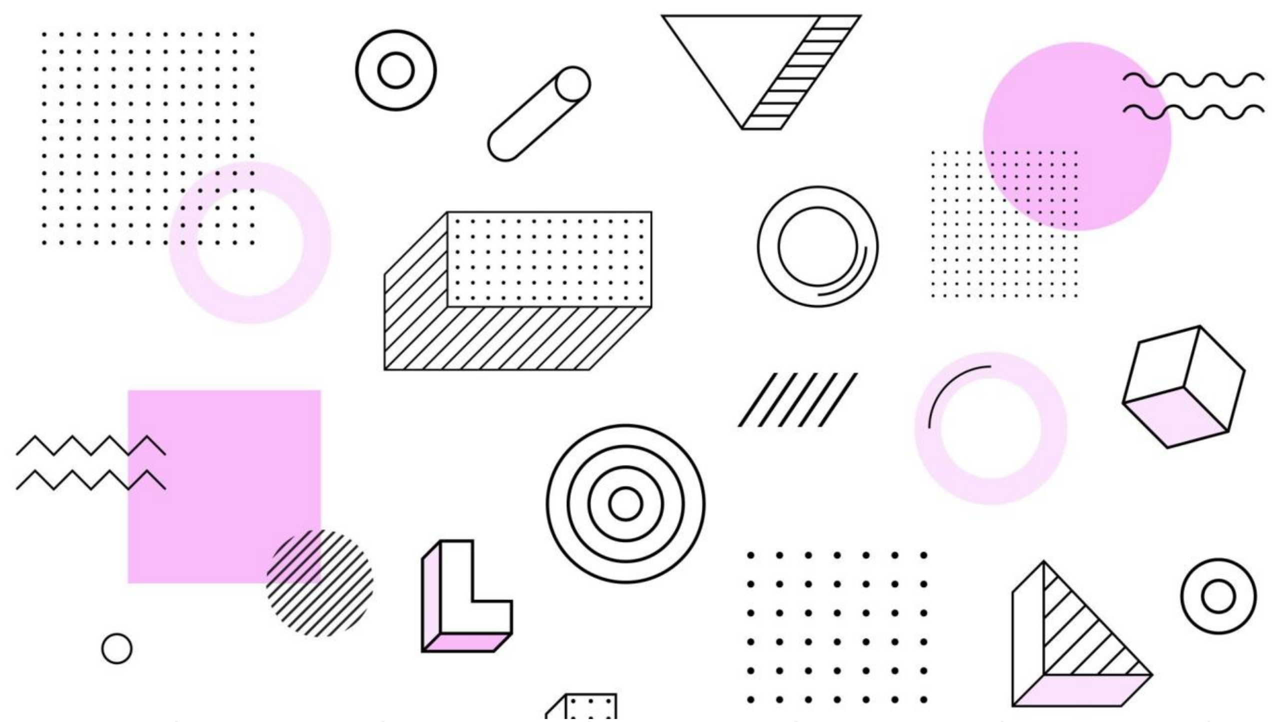
Recitation

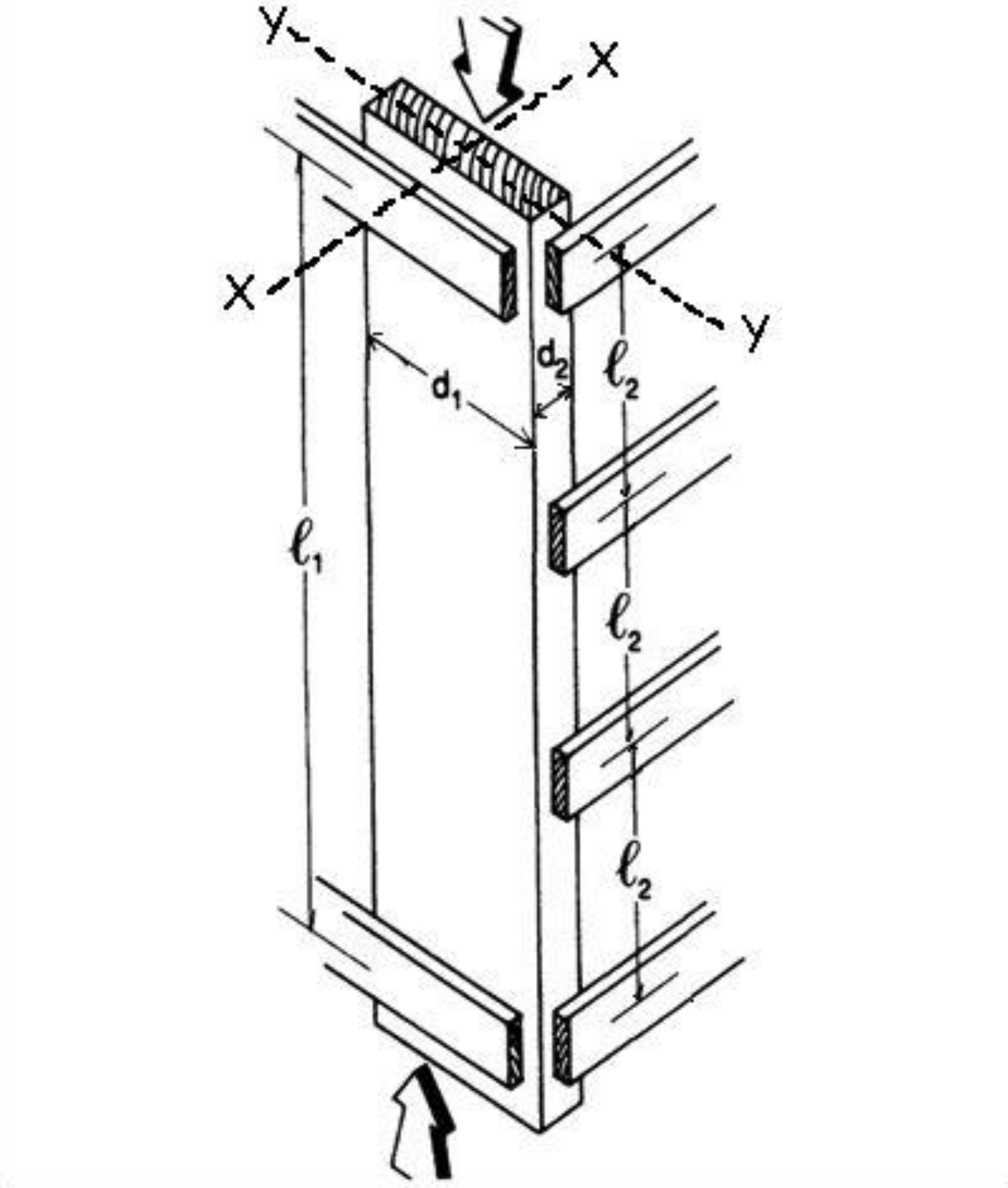


3. Wood Column Analysis

For the given dimensioned lumber column with 1/3 point weak axis bracing, determine the maximum load capacity of the given load type. Moisture Content = 15%. Ct = Ci = 1.0. Assume pinned end conditions (K=1).

DATASET: 3 -1- -2-

Wood Species	REDWOOD
Wood Grade	No.2
Strong Axis Length, L1	11 FT
Weak Axis Length, L2	3.666666667 FT
Narrow Width, d2	4 IN
Wide Width, d1	12 IN
LoadType	Wind Load



STEP 1:
date: column size, length, support condition, material properties
required: maximum load capacity in compression(Pmax)

STEP 2:
Find adjustment factors for column using NDS supplement

STEP 3:
calculate slenderness ratio
*check in both directions
*consider MAX for the design
*slenderness ration must be < 50

STEP 4:
calculate Cp

STEP 5:
determine F'c based on Fc and adjustment factors

STEP 6:
Structural stress=allowable stress
fc=F'c

STEP 7:
Find the MAX allowable load
Pmax= F'c*A

Maximum load capacity

- Dimensioned lumber column
- 1/3 point weak axis bracing
- Moisture content= 15%
- Ct=Ci=1
- Assume pinned end condition(K=1)
- Wood species: redwood
- Wood grade: NO.2
- Strong axis length, L1= 11ft
- Weak axis length, L2= 3.666666667 ft
- Narrow width, d2= 4 in
- Wide width, d2=12 in
- Load type: wind load

GIVEN INFORMATION OF THE PROBLEM

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 K_F	Resistance Factor ϕ	Time Effect Factor
$F_b' = F_b$	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_i	-	-	-	-	-	-	-
$E_{min}' = E_{min}$	x	-	C_M	C_t	-	-	-	C_i	-	-	C_T	-	1.76	0.85	-

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	
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		

Table 2.3.2 Frequently Used Load Duration Factors, C_D[1]

Load Duration	C_D	Typical Design Loads
Permanent	0.9	Dead Load
Ten years	1.0	Occupancy Live Load
Two months	1.15	Snow Load
Seven days	1.25	Construction Load
Ten minutes	1.6	Wind/Earthquake Load
Impact[2]	2.0	Impact Load

Size Factors, C_F

Grades	Width (depth)	F_b Thickness (breadth) 2" & 3"	F_b Thickness (breadth) 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
	14" & wider	0.9	1.0	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 (for surfaced dry Dense Structural 86, Dense Structural 72, and Dense Structural 65 use tabulated surfaced green design values for wet service conditions without further adjustment):

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

Calculate buckling stiffness factor (CT)

- Le< 96”
- Le> 96” → Le=96”
- In columns CT=1

4.4.2 Wood Trusses

4.4.2.1 Increased chord stiffness relative to axial loads where a 2" x 4" or smaller sawn lumber truss compression chord is subjected to combined flexure and axial compression under dry service condition and has 3/8" or thicker wood structural panel sheathing nailed to the narrow face of the chord in accordance with code required roof sheathing fastener schedules (see References 32, 33, and 34), shall be permitted to be accounted for by multiplying the reference modulus of elasticity design value for beam and column stability, E_{min}, by the buckling stiffness factor, C_T, in column stability calculations (see 3.7 and Appendix H). When $\ell_e < 96"$, C_T shall be calculated as follows:

$$C_T = 1 + \frac{K_M \ell_e}{K_T E} \qquad (4.4\text{-}1)$$

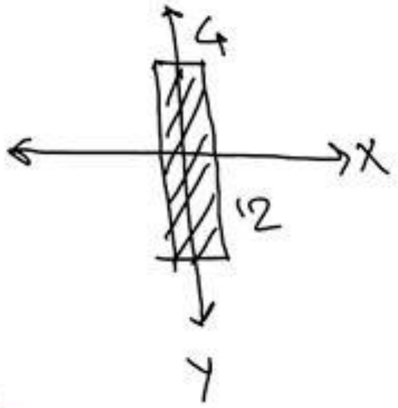
Calculate slenderness ratio in both directions

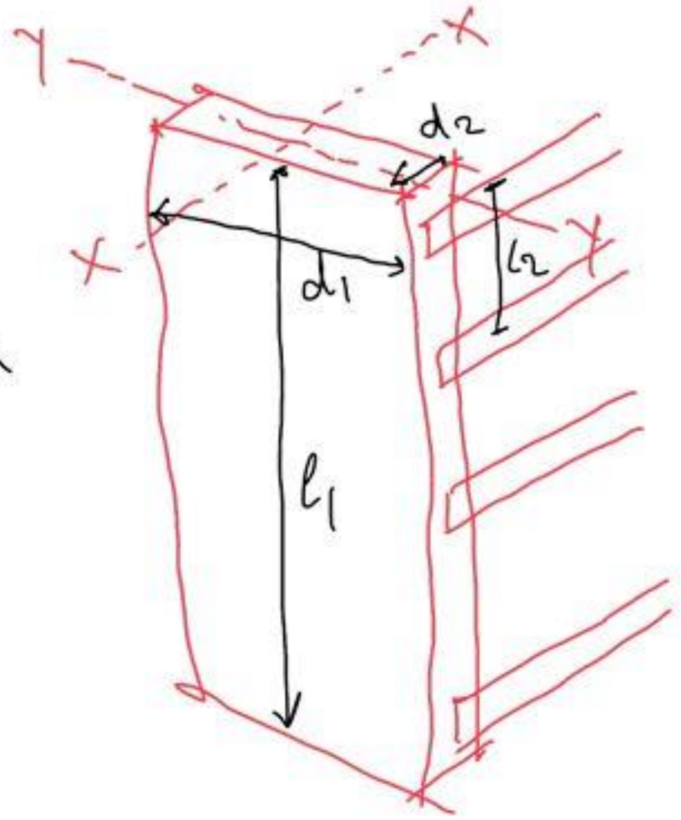
$l_1 = 11$ ft

$l_2 = 3.666666667$ ft

$d_2 = 4$ in

$d_1 = 12$ in





X–X

$l_{ex} = 11 \times 12 = 132$

$\frac{l_{ex}}{d} = \frac{132}{11,5} = 11,47 < 50$ ✓

Y–Y → $l_{ey} = 3,666666667 \times 12 = 44$

$\frac{l_{ey}}{d} = \frac{44}{3,5} = \boxed{12,57} < 50$ ✓

max

E'min=Ct . Cm . CT . Ci . Emin

= 1* 1*1*1* 370000= 370000

$$E'_{min} = C_t \cdot C_M \cdot C_T \cdot C_i \cdot E_{min}$$
$$= 1 \times 1 \times 1 \times 1 \times 370000 = 370000$$

$$F_{cE} = \frac{0{,}822 \times 370000}{(12{,}57)^2} = \frac{304140}{158{,}0049} = 1924{,}877$$

$$F^*_c = C_D \cdot C_M \cdot C_t \cdot C_F \cdot C_i \cdot F_c$$
$$= 1.6 \times 1 \times 1 \times 0.9 \times 1 \times 700 = 1008 \text{ PSI}$$

$$C_p = \frac{1 + \frac{1924{,}877}{1008}}{2(0.8)} - \sqrt{\left[\frac{1 + \frac{1924{,}877}{1008}}{2(0.8)}\right]^2 - \frac{\frac{1924{,}877}{1008}}{0.8}}$$

$$\longrightarrow C_p = 0.86$$

$$C_p = \frac{1 + (F_{cE}/F_c^*)}{2c} - \sqrt{\left[\frac{1 + (F_{cE}/F_c^*)}{2c}\right]^2 - \frac{F_{cE}/F_c^*}{c}} \quad (3.7\text{-}1)$$

where:

F_c^* = reference compression design value parallel to grain multiplied by all applicable adjustment factors except C_P (see 2.3), psi

$$F_{cE} = \frac{0.822\, E_{min}'}{(\ell_e/d)^2}$$

c = 0.8 for sawn lumber

c = 0.85 for round timber poles and piles

c = 0.9 for structural glued laminated timber, structural composite lumber, and cross-laminated timber

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/ft³	30 lbs/ft³	35 lbs/ft³	40 lbs/ft³	45 lbs/ft³	50 lbs/ft³
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

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

$$1.6 \times 1 \times 1 \times 0.9 \times 1 \times 0.86 \times 700 = 866{,}88$$

Area from Table 1B: 39,38

$$P_{max} = F'_c \cdot A = (866{,}88)(39{,}38) = 34137{,}7344 \text{ LBS}$$

- Thanks for your attention ☺