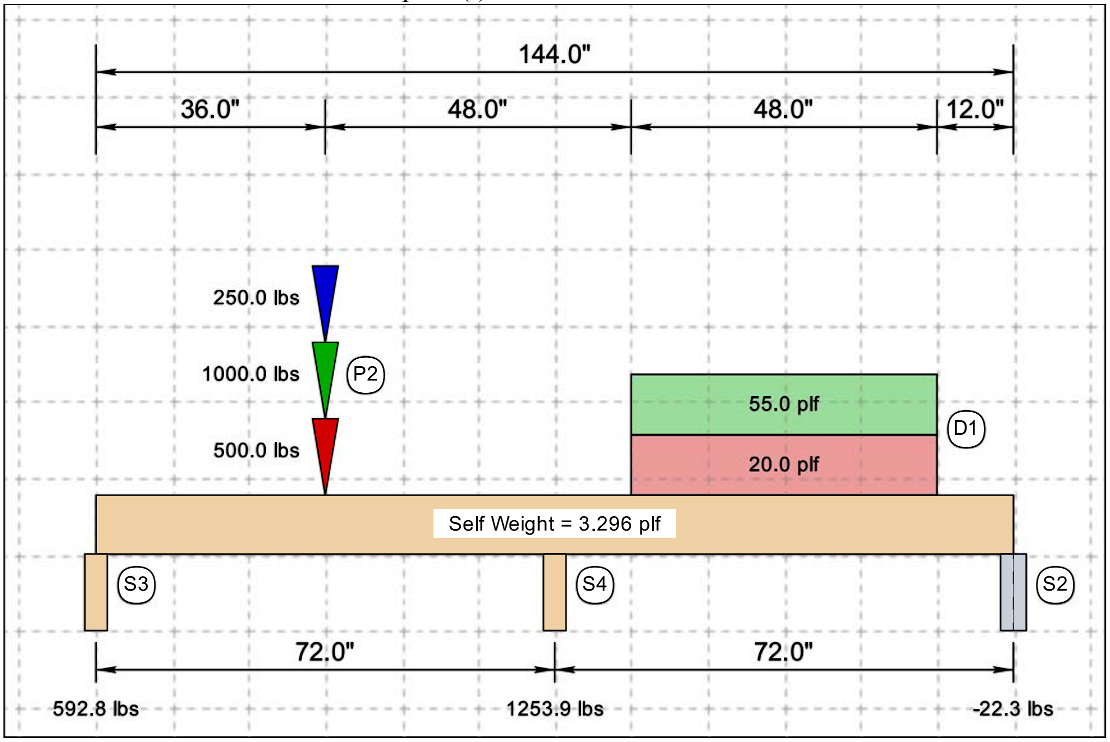
FAILED

Beam Design

1 piece(s) 1.5" x 9.25" DF No. 1



Design Results	Location	Actual	Allowed	Result	C_D	Load Combination
Member Reaction (lbs)	S4	1253.9	3281.3	**38%**	-	D + L
Shear (lbs)	73"	926.9	1665.0	**56%**	1.0	D + L
Neg. Moment (ft-lbs)	72"	1002	1692	**59%**	1.0	D + L
Pos. Moment (ft-lbs)	36"	1764	1692	**104%**	1.0	D + L
LL Deflection (in)	34"	0.0309	0.2	**L/2329**	-	D + L
TL Deflection (in)	34"	0.0469	0.3	**L/1534**	-	D + L

Supports	Bearing	Dead	Live (F)	Live (R)	Snow	Wind	Seismic	Factored
S3 - Column - DF	3.5"	204.2	388.7	-	101.6	-	-	592.8/204.2
S4 - Column - DF	3.5"	421.2	832.6	-	171.9	-	-	1253.9/421.2
S2 - Column - STL	4.0"	-5.8	-1.3	-	-23.4	-	-	-5.8/-22.3

Loads	Location	Dead	Live (F)	Live (R)	Snow	Wind	Seismic	Comments
D0 - Uniform (plf)	0.0" - 144.0"	3.3	-	-	-	-	-	Self Weight
D1 - Uniform (plf)	84.0" - 132.0"	20.0	55.0	-	-	-	-	
P2 - Point (lbs)	36.0"	500	1000	-	250	-	-	

Subject	Customer	Location	Job. No.
Beam Design	John Smith	123 S 234 W Provo, UT 84604	2025-002

Engr. Nathaniel Wilkerson

Date 08/05/2025

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Rev. -

1. Beam Data

Beam Type:	Sawn Lumber
Species:	Douglas Fir-Larch
Grade:	DF No. 1
Size:	1.5 x 9.25 in.
Beam Length:	12.0 ft.
Beam Ply (N):	1
Beam Weight:	39.5 lbs
Code Standards:	ASCE7-22, NDS 2024
Design Method:	ASD / Euler-Bernoulli
Notes:	This is a test.

2. Design Options

Lateral Support (B):	unbraced
Lateral Support (T):	unbraced
Defl. Limits:	360|240
Load Duration (V):	1.0
Load Duration (M):	1.0/1.0
Exposure:	dry
Temperature:	T <= 100°F
Orientation:	Vertical
Incised:	No
Rep. Members:	No

3. Beam Calculations

Determine reference design values, sectional properties and self weight of beam:

$$A = b \times d = 1.5 \times 9.25 = 13.875 \text{ in.}^2$$

$$S_x = \frac{bd^2}{6} = (1.5)(9.25)^2/6 = 21.391 \text{ in.}^3, \quad S_y = \frac{b^2 d}{6} = (1.5)^2(9.25)/6 = 3.469 \text{ in.}^3$$

$$I_x = \frac{bd^3}{12} = (1.5)(9.25)^3/12 = 98.932 \text{ in.}^4, \quad I_y = \frac{b^3 d}{12} = (1.5)^3(9.25)/12 = 2.602 \text{ in.}^4$$

Reference Design Values from Table 4A NDS Supplement (Reference Design Values for Visually Graded Dimension Lumber, 2" - 4" thick).

Species & Grade	F_b	F_t	F_v	$F_{c\perp}$	F_c	E	E_{min}	SG
DF No.1	1000	675	180	625	1500	1700000	620000	0.5

4. Adjustment Factors

Factor	Description	F_b	F_t	F_v	F_c	$F_{c\perp}$	E/E_{min}
C_D	Load Duration Factor	1.0/1.0	-	1.0	-	-	-
C_M	Wet Service Factor	1.0[b]	1.0	1.0	1.0[c]	1.0	1.0
C_t	Temperature Factor	1.0	1.0	1.0	1.0	1.0	1.0
C_L	Beam Stability Factor	0.86/0.86	-	-	-	-	-
C_F	Size Factor	1.1	1.1	-	1.0	-	-
C_{fu}	Flat Use Factor	1.2[d]	-	-	-	-	-
C_i	Incising Factor	1.0	1.0	1.0	1.0	1.0	1.0
C_r	Rep. Member Factor	1.0	-	-	-	-	-

a) Adjustment factors per AWC NDS 2024 and NDS 2024 Supplement.

b) When $(F_b)(C_F) \leq 1{,}150$ psi, $C_M = 1.0$.

c) When $(F_c)(C_F) \leq 750$ psi, $C_M = 1.0$.

d) Only applies when sawn lumber or glulam beams are loaded in bending about the y-y axis.

5. Self Weight

The following formula shall be used to determine the density of wood (lbs/ft^3). *(NDS Supplement Sec. 3.1.3)*

$$\rho_w = 62.4\left[\frac{SG}{1+SG(0.009)(m.c)}\right]\left[1+\frac{m.c.}{100}\right] = 62.4\left[\frac{0.5}{1+0.5(0.009)(19)}\right]\left[1+\frac{19}{100}\right] = 34.2 \text{ lbs/ft}^3$$

where:

ρ_w = Density of wood (lbs/ft^3)
SG = 0.5 Specific gravity of wood (dimensionless)
m.c. = 19 % (Max. moisture content at dry service conditions)

$$\text{Volume}_{beam} = N[A \times L] = 1 \times [13.875 \times 144.0] \div (12 \text{ in./ft.})^3 = 1.16 \text{ ft}^3$$

$$\text{Self Weight } (W_S) = \rho_w \times \text{Volume}_{beam} = 34.2 \times 1.16 = 39.55 \text{ lbs}$$

$$\text{Distributed Self Weight } (w_s) = \frac{W_S}{L} = \frac{39.55}{12.0} = 3.296 \text{ plf}$$

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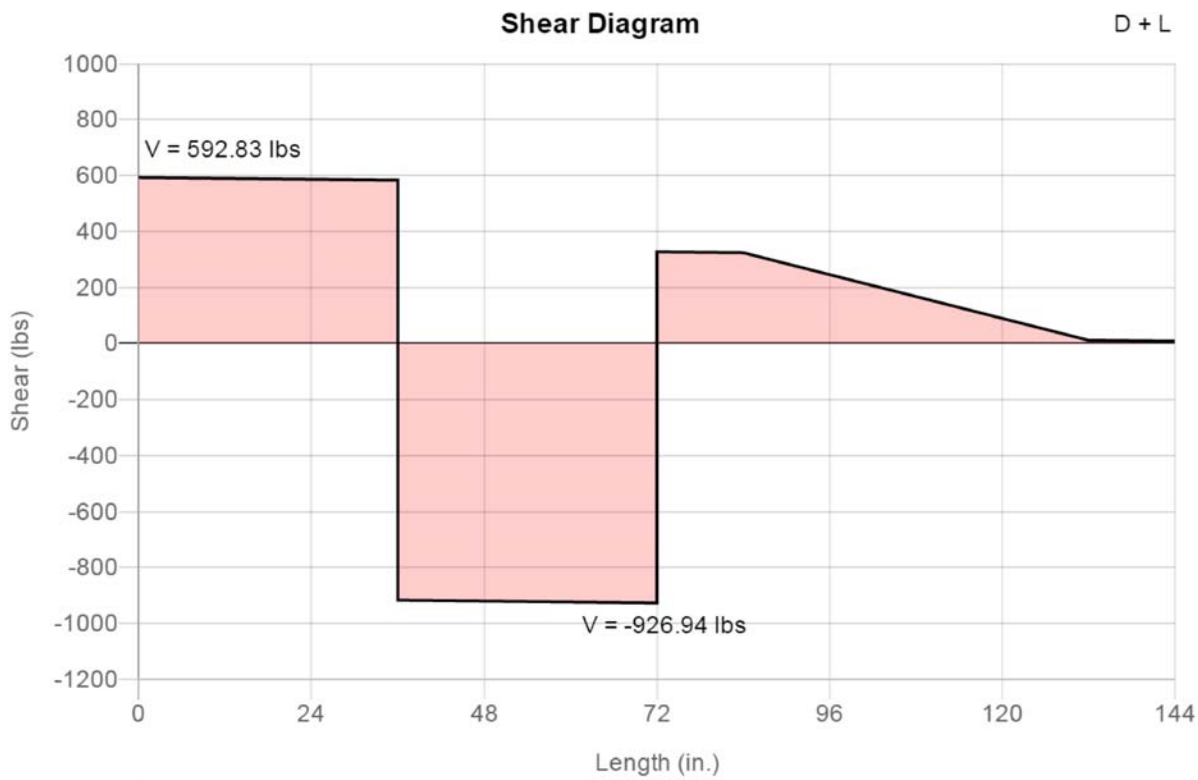
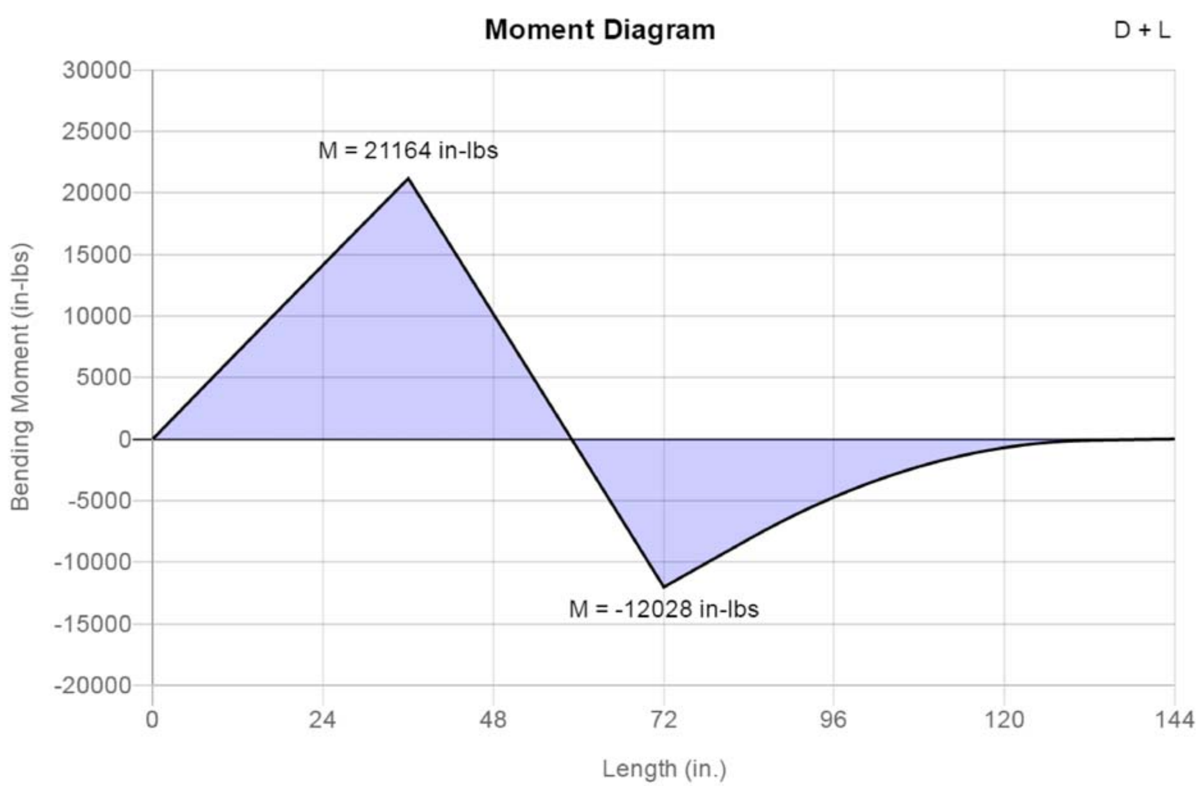
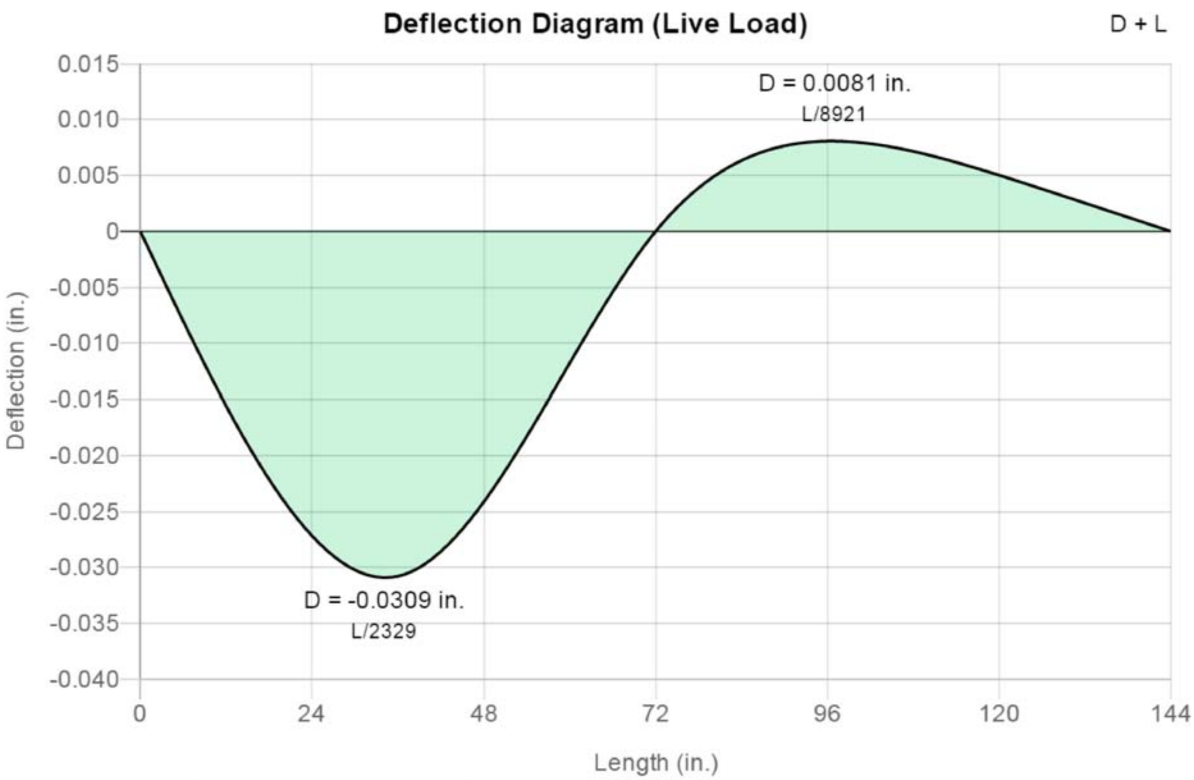


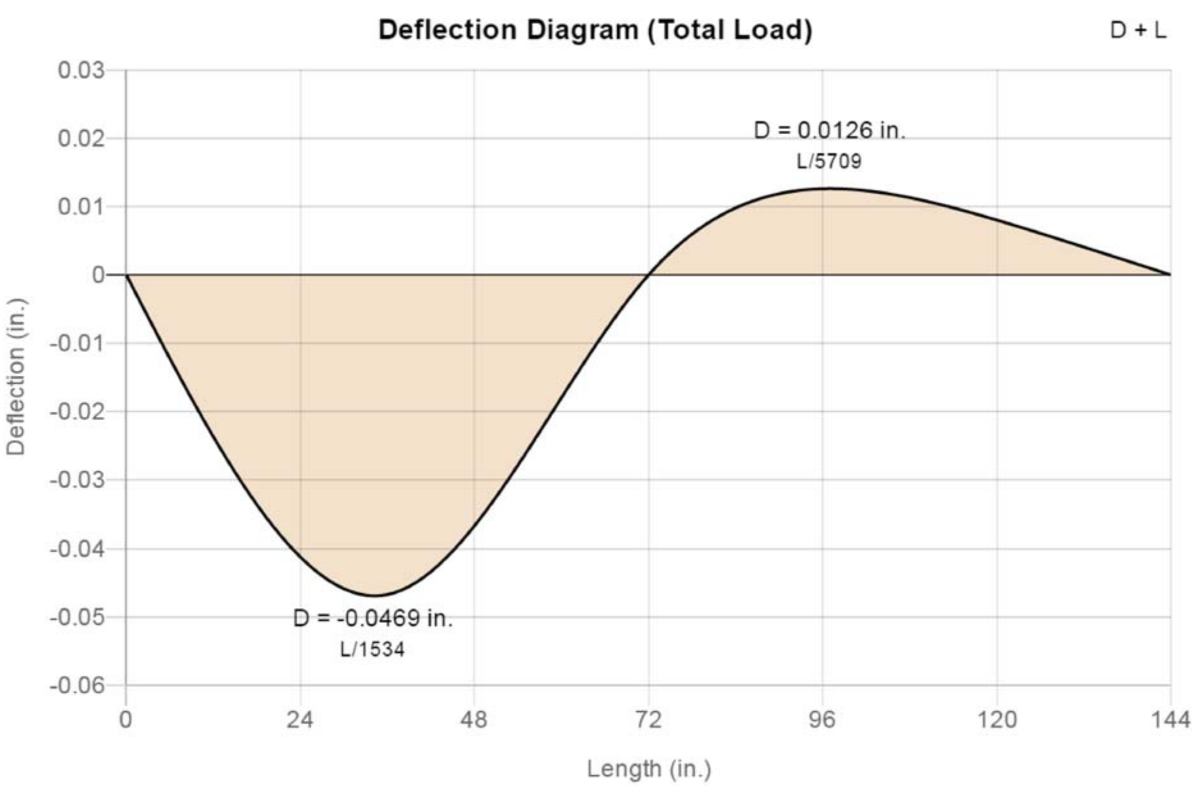
Shear Load Case: D + L ▼



Moment Load Case: D + L ▼



Deflection Load Case: D + L ▼



Deflection Load Case: D + L ▼

1.) Shear:

Members subject to shear stresses shall be proportioned so that the actual shear stress parallel to grain or shear force at any cross section of the bending member shall not exceed the adjusted shear design value:

$f_v \leq F_v'$ *(NDS Sec. 3.4.1)*

where:

$f_v = \frac{3V}{2A}$

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

$F_{vx}' = (180)(1.0)(1.0)(1.0) = 180.00$ psi

$f_v = \frac{3V}{2(N \times A)} = \frac{3(926.94)}{2(1 \times 13.875)} = 100.21$ psi

$f_v = 100.21$ psi $< F_{vx}' = 180.00$ psi (CSI = 0.56) ➜ **OK**

Calculations shown for load combination "D + L" at location x = 73 in.

2.) Deflection:

Bending deflections calculated per standard method of engineering mechanics for live load and total load:

LL Allowable: L/360
TL Allowable: L/240

$E_x' = E_x(C_M)(C_t)(C_i) = 1700000(1.0)(1.0)(1.0) = 1700000$ psi

$\Delta_{LL} = -0.0309$ in.

$(L/d)_{LL} = 72.0 / 0.0309 = 2329$

$\Delta_{LL} = -0.0309$ in = L/2329 < L/360 ➜ **OK**

Calculations shown for load combination "D + L" at location x = 34 in.

$\Delta_{TL} = -0.0469$ in.

$(L/d)_{TL} = 72.0 / 0.0469 = 1534$

$\Delta_{TL} = -0.0469$ in = L/1534 < L/240 ➜ **OK**

Calculations shown for load combination "D + L" at location x = 34 in.

3.) Bending:

Members subject to bending stresses shall be proportioned so that the actual bending stress or moment shall not exceed the adjusted bending design value:

$f_b \le F_b'$ *(NDS Sec. 3.3.1)*

where:

$f_b = M / S$

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

Negative Bending: Beam is unbraced along its compression (bottom) edge, lateral stability is considered below:

Slenderness Ratio for bending member R_B:

l_u = Unbraced Length = 72.0 in.

$l_u/d = \frac{72.0}{9.25} = 7.78$

$l_e = 1.63 l_u + 3d = 1.63(72.0) + 3(9.25) = 145.11$ in. *(NDS Table 3.3.3)*

$$R_b = \sqrt{\frac{l_e d}{b^2}} = \sqrt{\frac{145.11(9.25)}{(1 \times 1.5)^2}} = 24.42$$

$R_b = 24.42 < 50$ → **OK**

Euler-based ASD critical buckling value for bending members:

$E_{miny}' = E_{miny}(C_M)(C_t)(C_i) = 620000(1.0)(1.0)(1.0) = 620000$ psi

$$F_{bE} = \frac{1.2E'_{miny}}{(R_b)^2} = \frac{1.2(620000)}{(24.42)^2} = 1247.14 \text{ psi}$$

$F_{bx}^* = F_{bx}(C_D)(C_M)(C_t)(C_F)(C_i)(C_r) = (1000)(1.0)(1.0)(1.0)(1.1)(1.0)(1.0) = 1100.0$ psi

Beam stability factor:

$$C_L = \frac{1+F_{be}/F_{bx}^*}{1.9} - \sqrt{\left(\frac{1+F_{be}/F_{bx}^*}{1.9}\right)^2 - \frac{F_{be}/F_{bx}^*}{0.95}} = \frac{1+1247.14/1100.0}{1.9} - \sqrt{\left(\frac{1+1247.14/1100.0}{1.9}\right)^2 - \frac{1247.14/1100.0}{0.95}} = 0.863$$

$F_b' = (1000)(1.0)(1.0)(1.0)(0.863)(1.1)(1.0)(1.0)(1.0) = 949.0$ psi

$$f_b = \frac{M}{N \times S} = \frac{12028}{1 \times 21.39} = 562.3 \text{ psi}$$

$f_b = 562.3$ psi $< F_{bx}' = 949.0$ psi (CSI = 0.59) → **OK**

Calculations shown for load combination "D + L" at location x = 72 in.

Positive Bending: Beam is unbraced along its compression (top) edge, lateral stability is considered below:

Slenderness Ratio for bending member R_B:

l_u = Unbraced Length = 72.0 in.

$l_u/d = \frac{72.0}{9.25} = 7.78$

$l_e = 1.63 l_u + 3d = 1.63(72.0) + 3(9.25) = 145.11$ in. *(NDS Table 3.3.3)*

$R_b = \sqrt{\frac{l_e d}{b^2}} = \sqrt{\frac{145.11(9.25)}{(1 \times 1.5)^2}} = 24.42$

$R_b = 24.42 < 50$ → **OK**

Euler-based ASD critical buckling value for bending members:

$E_{miny}' = E_{miny}(C_M)(C_t)(C_i) = 620000(1.0)(1.0)(1.0) = 620000$ psi

$F_{bE} = \frac{1.2E'_{miny}}{(R_b)^2} = \frac{1.2(620000)}{(24.42)^2} = 1247.14$ psi

$F_{bx}^* = F_{bx}(C_D)(C_M)(C_t)(C_F)(C_i)(C_r) = (1000)(1.0)(1.0)(1.0)(1.1)(1.0)(1.0) = 1100.0$ psi

Beam stability factor:

$$C_L = \frac{1+F_{be}/F_{bx}^*}{1.9} - \sqrt{\left(\frac{1+F_{be}/F_{bx}^*}{1.9}\right)^2 - \frac{F_{be}/F_{bx}^*}{0.95}} = \frac{1+1247.14/1100.0}{1.9} - \sqrt{\left(\frac{1+1247.14/1100.0}{1.9}\right)^2 - \frac{1247.14/1100.0}{0.95}} = 0.863$$

$F_b' = (1000)(1.0)(1.0)(1.0)(0.863)(1.1)(1.0)(1.0)(1.0) = 949.0$ psi

$f_b = \frac{M}{N \times S} = \frac{21164}{1 \times 21.39} = 989.4$ psi

$f_b = 989.4$ psi $> F_{bx}' = 949.0$ psi (CSI = 1.04) → **NG**

Calculations shown for load combination "D + L" at location x = 36 in.

4.) Bearing:

Members subject to bearing stresses perpendicular to the grain shall be proportioned so that the actual compressive stress perpendicular to grain shall be based on the net bearing area and shall not exceed the adjusted compression design value perpendicular to grain:

$f_{c\perp} \leq F_{c\perp}'$ *(NDS Sec. 3.10.2)*

where:

$F_{c\perp}' = F_{c\perp}(C_M)(C_t)(C_i)$

$F_{c\perp x}' = (625)(1.0)(1.0)(1.0) = 625.00$ psi

$f_{c\perp} = \frac{R}{A_b}$

$A_b = b \text{ x } l_b = 1.5 \text{ x } 3.5 = 5.25 \text{ in}^2$

$f_{c\perp} = \frac{R}{N \times A_b} = \frac{1253.88}{1 \times 5.25} = 238.8$ psi

$f_{c\perp} = 238.8$ psi $< F_{c\perp x}' = 625.00$ psi (CSI = 0.38) ➜ **OK**

Calculations shown for load combination "D + L" at support S4.

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