

Architecture 324: Structures II

Wood Joist Design

Problem 2: Floor Joist Design — Eastern Softwoods

Task: Design a 2x dimensioned lumber floor joist to carry the given dead + live floor load (neglect joist selfweight). Assume conditions of 4.4.1 ($C_L = 1.0$), CD, Ct, CL Cf and Ci each =1.0. Find the short term deflection under live load only. Check against code limit L/360.

Given Data: Species: Eastern Softwoods — Grade: Select Structural — Span: 15 ft — Spacing: 19.2 in — DL: 9 PSF — LL: 30 PSF — M.C.: 15%

Q1–Q3: Tabulated F_b , F_v , and E

1. Refer to **Table 4A** in NDS Supplement.
2. Locate **Eastern Softwoods** (Select Structural).
3. *Note: Ensure you check the specific shear value for this species group.*

$$F_b = \underline{1250} \text{ psi}, F_v = \underline{140} \text{ psi}, E = \underline{1,200,000} \text{ psi}$$

Q4 Total Applied Floor Load (PSF)

1. Add dead load and live load:
Total Load = $DL + LL = \underline{39}$ PSF

Q5 Load on Joist, w (PLF)

1. Convert the joist spacing to feet:
Spacing $S = 19.2/12 = \underline{1.6}$ ft
2. Calculate line load:
 $w = 39 \times 1.6 = \underline{62.4}$ PLF

Q6 Actual Beam Bending Moment, M

$$M = \frac{w \cdot L^2}{8}$$

1. Extract span: $L = \underline{15}$ ft
2. Calculate Moment:
 $M = \underline{1755}$ ft-lb

Q7 Actual Maximum Shear Force, V

$$V = \frac{w \cdot L}{2}$$

1. Calculate Shear:
 $V = \underline{468}$ lbs

Q8 Nominal Depth of Final Joist Used

1. convert M from ft-lb to in-lb = $M \times 12 = \underline{21060}$ in-lb
2. Estimate F_b (CF is not yet known) $\underline{1500}$ psi
3. $S_{xx} = M/F_b = \underline{14.0}$ in³
4. refer to table 1B in NDS supplement. Select a trial size (e.g., 2×8 , 2×10) and start with the smallest size that might pass stress checks. (2×8 has $S = 13.14$, but gains strength factors).
5. Enter the **Nominal Depth** :
Nominal Depth = $\underline{8}$ IN

Q9 Size Factor, C_F

Refer to NDS Supplement Table 4A (Adjustment Factors).

1. Based on the nominal depth chosen in Q8 (2×8) and the grade (Select Structural).

$$C_F = \underline{1.2}$$

Q10 Repetitive Member Factor, C_r

1. Check joist spacing. If spacing $\leq 24''$ o.c. and there are ≥ 3 members, apply C_r .
2. For dimension lumber joists, standard $C_r = 1.15$.

$$C_r = \underline{1.15}$$

Q11–Q12 Wet Service Factors, C_M

1. Check moisture content (m.c.) from data (15%).
2. If m.c. $\leq 19\%$, then $C_M = 1.0$.

$$C_{M,b} = \underline{1.0}, C_{M,v} = \underline{1.0}$$

Q13 Factored Allow. Bending Stress, F'_b

$$F'_b = F_b \cdot C_D \cdot C_M \cdot C_t \cdot C_L \cdot C_F \cdot C_r$$

1. $C_D = 1.0$ (Occupancy Live Load), $C_t = 1.0$, $C_L = 1.0$.
2. $1250 \times 1.2 \times 1.15$.

$$F'_b = \underline{1725} \text{ psi}$$

Q14 Factored Allow. Shear Stress, F'_v

$$F'_v = F_v \cdot C_D \cdot C_M$$

1. Use F_v (Q2). Note: C_F and C_r do not apply to shear.

$$F'_v = \underline{140} \text{ psi}$$

Q15 Actual Bending Stress, $f_{b,actual}$

$$f_{b,actual} = \frac{M \times 12}{S}$$

1. Find Section Modulus S (in³) for your chosen size (2×8).

$$S = \underline{13.14} \text{ in}^3$$

2. Calculate stress:

$$f_{b,actual} = \underline{1603} \text{ psi}$$

Q16 Actual Shear Stress, $f_{v,actual}$

$$f_{v,actual} = 1.5 \frac{V}{A}$$

1. Find Area A (in²) for your chosen size (2×8).

$$A = \underline{10.88} \text{ in}^2$$

2. Calculate stress:

$$f_{v,actual} = \underline{65} \text{ psi}$$

Q17 Factored Modulus of Elasticity, E'

$$E' = E \cdot C_M \cdot C_t$$

1. Use E from Q3.

$$E' = \underline{1,200,000} \text{ psi}$$

Q18 Short Term Deflection (100% LL)

$$\Delta_{LL} = \frac{5 \cdot w_{LL} \cdot L^4}{384 \cdot E' \cdot I}$$

1. Calculate Live Load portion only:
 $w_{LL} = 30$ (psf) $\times 1.6$ (ft) = $\underline{48}$ PLF
2. Convert w_{LL} to lb/in (divide by 12): $\underline{4.0}$ lb/in
3. Convert Span L to inches: $\underline{180}$ in
4. Find Moment of Inertia I (in⁴) for 2×8 : $\underline{47.63}$ in⁴
5. Calculate Δ_{LL} :

$$\text{Deflection } \Delta = \underline{0.96} \text{ IN}$$

Q19 Deflection Limit

$$\Delta_{limit} = L/360$$

1. Use Span L in inches (180).

$$\text{Limit} = \underline{0.50} \text{ IN}$$

Q20 Deflection Passing Check

1. Compare Q18 (0.96) and Q19 (0.50).
2. If $\Delta_{actual} \leq \Delta_{limit}$, enter "1". Else enter "0".

$$\text{Pass/Fail (1/0): } \underline{0}$$