

# Beam Design - Douglas Residnece

2. Design Loads

### 1. Beam Data

Uniform Dist. Load Live Load: Load Type: 274 plf Support: Simple Beam Dead Load: 137 plf Sawn Lumber Beam Type: Selfweight: 228.5 lbs Douglas Fir-Larch Dist. Selfweight: 16.03 plf Species: Grade: DF No.1 Total Weight: 232.5 lbs

Size: 2 x 12 Design Span (L): 14.25 ft. 14.00 ft. Clear Span: 14.50 ft. Total Span: Bearing (lb): 3 in. 4 Quantity (N):

## 3. Design Options

Temperature: Orientation:

Incised Lumber:

Rep. Members:

# 4. Design Assumptions and Notes

Code Standard: IBC 2015, NDS 2015 Lateral Support: braced Defl. Limits: 360|240 Bending Stress: Parallel to Grain Load Duration: Notes: 1.00 Exposure: dry

# 5. Adjustment Factors

| Factor  | Description              | Fb               | Ft   | $F_{\mathbf{v}}$ | Fc             | Fc⊥ | E/E <sub>min</sub> |
|---------|--------------------------|------------------|------|------------------|----------------|-----|--------------------|
| $C_{D}$ | Load Duration Factor     | 1.00             | 1.00 | 1.00             | 1.00           | -   | -                  |
| CM      | Wet Service Factor       | 1 <sup>b</sup>   | 1    | 1                | 1 <sup>c</sup> | 1   | 1                  |
| Ct      | Temperature Factor       | 1                | 1    | 1                | 1              | 1   | 1                  |
| $C_{L}$ | Beam Stability Factor    | 1                | -    | -                | -              | -   | -                  |
| CF      | Size Factor              | 1                | 1    | -                | 1              | -   | -                  |
| Cfu     | Flat Use Factor          | 1.2 <sup>d</sup> | _    | -                | _              | -   | -                  |
| Ci      | Incising Factor          | 1                | 1    | 1                | 1              | 1   | 1                  |
| Cr      | Repetitive Member Factor | 1                | -    | -                | -              | -   | -                  |

- a) Adjustment factors per AWC NDS 2015 and NDS 2015 Supplement.
- b) When  $(F_b)(C_F) \le 1,150 \text{ psi}$ ,  $C_M = 1.0$ .

 $T \le 100^{\circ}F$ 

Vertical

No

No

- c) When  $(F_c)(C_F) \le 750 \text{ psi}$ ,  $C_M = 1.0$ .
- d) Only applies when sawn lumber or glulam beams are loaded in bending about the y-y axis.

| Subject                     | Customer  | Location                         | Job No. |
|-----------------------------|---|----------------------------------|---------|
| Beam Design Raymond Douglas |   | 276 Tryon Street, Middletown, CT | 12413   |
| N. Wilkerson                | MEDEEK ENGINE   | written consent of               | Rev.    |
| 12/29/2021                  | 3050 State Route 109 Copa<br>ph. (425) 741-5555 www.r | alis Beach, WA 98535             | Page 1  |

### 6. Beam Calculations

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

 $A = b \times d$ 

,

,

#### where:

b = Breadth of rectangular beam in bending (in.)

d = Depth of rectangular beam in bending (in.)

A = Cross sectional area of beam (in.<sup>2</sup>)

 $S_x$  = Section modulus about the X-X axis (in.<sup>3</sup>)

 $S_y$  = Section modulus about the Y-Y axis (in.<sup>3</sup>)

 $I_X = Moment of inertia about the X-X axis (in.<sup>4</sup>)$ 

 $I_y = Moment of inertia about the Y-Y axis (in.<sup>4</sup>)$ 

b = 1.500 in.

d = 11.250 in.

$$A = 1.500 \text{ x } 11.250 = 16.88 \text{ in.}^2$$

$$S_x = (1.500)(11.250)^2/6 = 31.64 \text{ in.}^3$$

$$S_V = (1.500)^2 (11.250)/6 = 4.22 \text{ in.}^3$$

$$I_x = (1.500)(11.250)^3/12 = 177.98 \text{ in.}^4$$

$$I_v = (1.500)^3 (11.250)/12 = 3.16 \text{ in.}^4$$

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

| Species & Grade | Fb   | Ft  | $F_{\mathbf{v}}$ | Fc⊥ | Fc   | Е       | Emin   | G   |
|-----------------|------|-----|------------------|-----|------|---------|--------|-----|
| DF No.1         | 1000 | 675 | 180              | 625 | 1500 | 1700000 | 620000 | 0.5 |

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

#### where:

 $\rho_{\rm W}$  = Density of wood (lbs/ft<sup>3</sup>

G = Specific gravity of wood (dimensionless)

m.c. = Moisture content of wood (percentile)

G = 0.5

m.c. = 19 % (Max. moisture content at dry service conditions)

| Beam Design  | Raymond Douglas Location 276 Tryon Street, Middletown, CT |   | <sub>Јор No.</sub><br>12413   |        |
|--------------|---|---|---|--------|
| N. Wilkerson | MEDEEK ENGINE   |   | This report may not be<br>copied, reproduced or<br>distributed without the<br>written consent of<br>Medeek Engineering Inc. | Rev.   |
| 12/29/2021   | 3050 State Route 109 Copa<br>ph. (425) 741-5555 www.r     | • | Medeek Engineering Inc.  Copyright © 2014   | Page 2 |

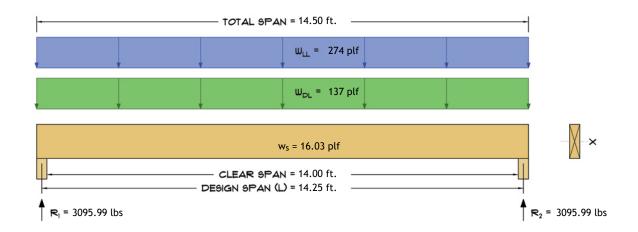
$$= 34.20 \text{ lbs/ft}^3$$

$$\begin{aligned} & \text{Volume}_{total} = \text{N[A x (L + l_b)]} = 4 \text{ x [16.88 x (171.00 + 3)] x (12 in./ft.)}^3 = 6.80 \text{ ft}^3 \\ & \text{Volume}_{span} = \text{N[A x L]} = 4 \text{ x [16.88 x 171.00] x (12 in./ft.)}^3 = 6.68 \text{ ft}^3 \end{aligned}$$

Total Weight (W<sub>T</sub>) = 
$$\rho_W$$
 x Volume<sub>total</sub> = 34.20 x 6.80 = 232.5 lbs Self Weight (W<sub>S</sub>) =  $\rho_W$  x Volume<sub>span</sub> = 34.20 x 6.68 = 228.5 lbs

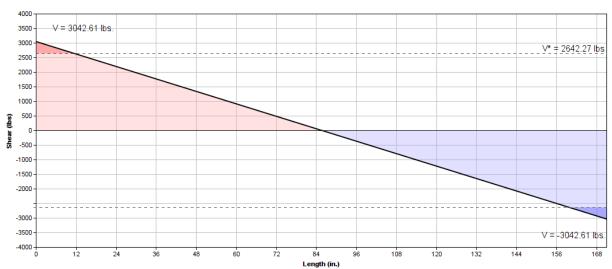
Distributed Self Weight ( $w_s$ ) = = 16.03 plf

#### Load, Shear and Moment Diagrams:



Beam - Shear Diagram

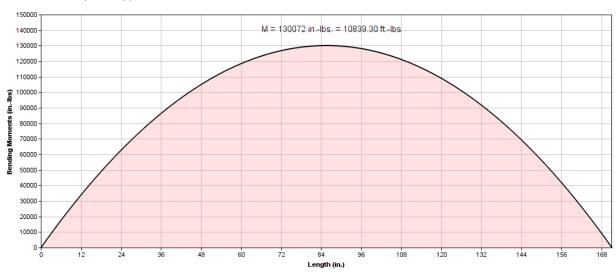
Shear Equation: V(x) = -35.59x + 3042.6



| Subject Beam Design | Customer Raymond Douglas                              | 276 Tryon Street, Middletown, CT | Job No. 12413 |
|---------------------|---|----------------------------------|---------------|
|                     | Raymond Douglas                                       | 270 Hyon Street, Wildaletown, C1 | 12713         |
| N. Wilkerson        | MEDEEK ENGINE   | written consent of               | Rev.          |
| 12/29/2021          | 3050 State Route 109 Copa<br>ph. (425) 741-5555 www.n |                                  | Page 3        |

#### Beam - Moment Diagram

Moment Equation:  $M(x) = -17.79x^2 + 3042.6x$ 



#### 1.) 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:

$$f_b \leq F_{b} \text{'} \ \textit{(NDS Sec. 3.3.1)}$$

where:

$$f_b = M / S$$

$$F_b' = F_b(C_D)(C_M)(C_t)(C_L)(C_F)(C_i)(C_r)$$

Beam is braced laterally along its compression edge. Laterial stability is not a consideration:

 $C_L$  = Beam Stability Factor = 1.0

$$F_{bx}' = (1000)(1.00)(1)(1)(1)(1)(1)(1) = 1000.0 \text{ psi}$$

$$f_b = = 1027.7 \ psi$$

$$f_b = 1027.7 \text{ psi} > F_{bx'} = 1000.0 \text{ psi (CSI} = 1.03)$$
 ? **NG**

| Beam Design     | Raymond Douglas                                       | 276 Tryo | on Street, Middletown, Cl | Γ   | 12413  |
|-----------------|---|----------|---------------------------|---|--------|
| N. Wilkerson    | MEDEEK ENGINE   |          |                           | This report may not be copied, reproduced or distributed without the written consent of Medeek Engineering Inc. | Rev.   |
| Date 12/29/2021 | 3050 State Route 109 Copa<br>ph. (425) 741-5555 www.r | ,        |                           | Copyright © 2014  | Page 4 |

#### 2.) 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:

$$f_v \le F_{v'}$$
 (NDS Sec. 3.4.1)

where:

$$f_v =$$

$$F_{v'} = F_{v}(C_{D})(C_{M})(C_{t})(C_{i})$$

$$F_{vx'} = (180)(1.00)(1)(1)(1) = 180.00 \text{ psi}$$

Shear Reduction: For beams supported by full bearing on one surface and loads applied to the opposite surface, uniformly distributed loads within a distance, d, from supports equal to the depth of the bending member shall be pemitted to be ignored. For beams supported by full bearing on one surface and loads applied to the opposite surface, concentrated loads within a distance equal to the depth of the bending member from supports shall be permitted to be multiplied by x/d where x is the distance from the beam support face to the load. See NDS 2015, Figure 3C.

$$f_{v}* = 58.72 \text{ psi}$$

$$f_v^* = 58.72 \text{ psi} < F_{vx'} = 180.00 \text{ psi} \text{ (CSI} = 0.33) ? OK$$

No Reduction in Shear (conservative):

$$f_v = = 67.61 \text{ psi}$$

$$f_v = 67.61 \text{ psi} < F_{vx'} = 180.00 \text{ psi} \text{ (CSI} = 0.38)$$
 ? **OK**

#### 3.) Deflection:

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

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

$$E_{x'} = E_{x}(C_{M})(C_{t})(C_{i}) = 1700000(1)(1)(1) = 1700000 \text{ psi}$$

| Subject         | Customer  | Location           | Job No. |  |
|-----------------|---|--------------------|---------|--|
| Beam Design     | Raymond Douglas 276 Tryon Street, Middletown, CT      |                    |         |  |
| N. Wilkerson    | MEDEEK ENGINE   | written consent of | Rev.    |  |
| Date 12/29/2021 | 3050 State Route 109 Copa<br>ph. (425) 741-5555 www.r |                    | Page 5  |  |

$$\Delta_{LL} = = 0.21$$
 in.

$$(L/d)_{LL} = 171.00 / 0.21 = 814$$

$$\Delta_{LL} = 0.21 \text{ in} = L/814 < L/360 ? OK$$

$$\Delta_{TL} = = 0.33$$
 in.

$$(L/d)_{TL} = 171.00 / 0.33 = 522$$

$$\Delta_{TL} = 0.33 \text{ in} = L/522 < L/240$$
 ? **OK**

#### 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:

$$f_{c\perp} =$$

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

$$F_{c \perp x}' = (625)(1)(1)(1) = 625.00 \text{ psi}$$

$$A_b = b \times l_b = 1.5 \times 3 = 4.50 \text{ in}^2$$

$$f_{c\perp}$$
 = = 172.0 psi

$$f_{c\perp} = 172.0 \text{ psi} < F_{c\perp x'} = 625.00 \text{ psi} \text{ (CSI} = 0.28)$$
 ? **OK**

\*Disclaimer: The calculations produced herein are for initial design and estimating purposes only. The calculations and drawings presented do not constitute a fully engineered design. All of the potential load cases required to fully design an actual structure may not be provided by this calculator. For the design of an actual structure, a registered and licensed professional should be consulted as per IRC 2012 Sec. R802.10.2 and designed according to the minimum requirements of ASCE 7-10. The beam calculations provided by this online tool are for educational and illustrative purposes only. Medeek Design assumes no liability or loss for any designs presented and does not guarantee fitness for use.

| Beam Design  | Raymond Douglas 276 Tryon Street, Middletown, CT      |                                    | 12413   |        |
|--------------|---|------------------------------------|---|--------|
| N. Wilkerson | MEDEEK ENGINE   |                                    | This report may not be copied, reproduced or distributed without the written consent of Medeek Engineering Inc. | Rev.   |
| 12/29/2021   | 3050 State Route 109 Copa<br>ph. (425) 741-5555 www.r | ilis Beach, WA 98535<br>medeek.com | Copyright © 2014  | Page 6 |