STRUCTURAL CALCULATION REPORT

DESIGN CALCULATIONS FOR SKYLIGHT FRAME

Contents

1. Executive Summary

This document provides the design calculations of the skylight frame.

2. Design Codes & Standards

Design of structural engineering systems for the project is carried out in accordance with the regulations of below mentioned codes. The listed issue or edition of the design code or standard documents is applicable unless otherwise noted. The following codes and standards have been identified as applicable, in whole or in part, to structural engineering design and construction of this project:

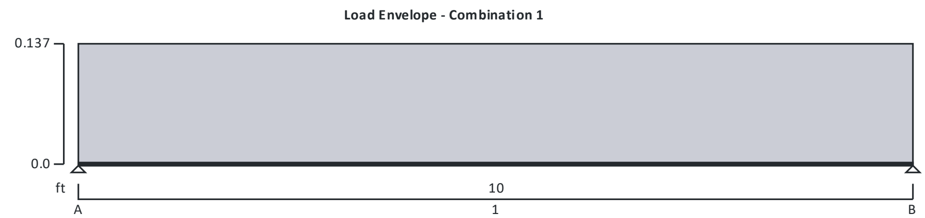
a) AISC 360-16: Specification for Structural Steel Buildings
b) IBC 2021: International Building Code with NJ provisions
c) NDS 2018: National Design Specification (NDS) for Wood Construction
d) ASCE 7-16: Minimum Design Loads for buildings and other structures

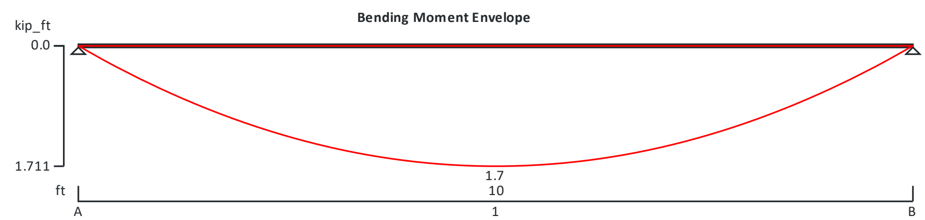
3. 4X8 rafters

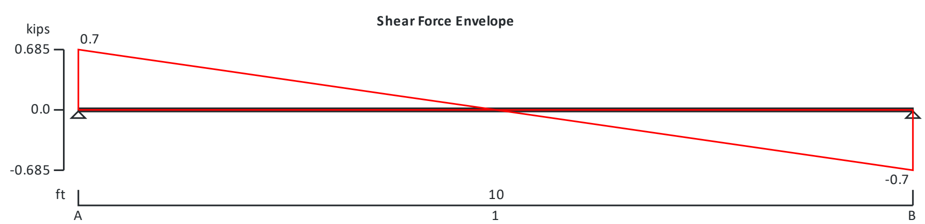
STRUCTURAL WOOD MEMBER ANALYSIS & DESIGN (NDS)

In accordance with the ANSI/AF&PA NDS-2018 using the ASD method

Tedds calculation version 1.7.10







Applied loading

Beam loads

Dead self weight of beam × 1

Dead full UDL 88 lb/ft

Live full UDL 42 lb/ft

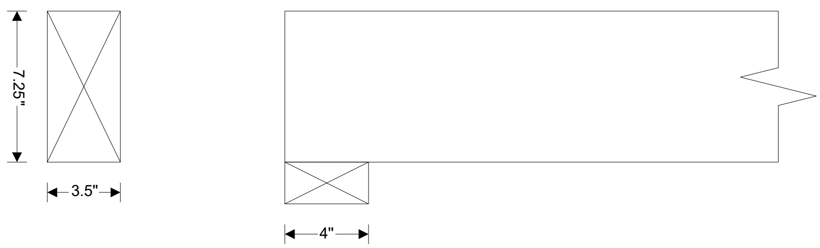
Load combinations

Load combination 1	Support A	Dead × 1.00
		Live × 1.00
		Snow × 1.00
	Span 1	Dead × 1.00
		Live × 1.00
		Snow × 1.00
	Support B	Dead × 1.00
		Live × 1.00

Snow $\times$ 1.00

Analysis results

Maximum moment	M_{max} = **1711** lb_ft	M_{min} = **0** lb_ft
Design moment	M = max(abs(M_{max}),abs(M_{min})) = **1711** lb_ft	
Maximum shear	F_{max} = **685** lb	F_{min} = **-685** lb
Design shear	F = max(abs(F_{max}),abs(F_{min})) = **685** lb	
Total load on member	W_{tot} = **1369** lb	
Reaction at support A	R_{A_max} = **685** lb	R_{A_min} = **685** lb
Unfactored dead load reaction at support A	R_{A_Dead} = **475** lb	
Unfactored live load reaction at support A	R_{A_Live} = **210** lb	
Reaction at support B	R_{B_max} = **685** lb	R_{B_min} = **685** lb
Unfactored dead load reaction at support B	R_{B_Dead} = **475** lb	
Unfactored live load reaction at support B	R_{B_Live} = **210** lb	



Sawn lumber section details

Nominal breadth of sections	b_{nom} = **4** in
Dressed breadth of sections	b = **3.5** in
Nominal depth of sections	d_{nom} = **8** in
Dressed depth of sections	d = **7.25** in
Number of sections in member	N = **1**
Overall breadth of member	b_b = N $\times$ b = **3.5** in
Species, grade and size classification	Douglas Fir-Larch, No.2 grade, 2" & wider
Bending parallel to grain	F_b = **900** lb/in^2
Tension parallel to grain	F_t = **575** lb/in^2
Compression parallel to grain	F_c = **1350** lb/in^2
Compression perpendicular to grain	F_{c_perp} = **625** lb/in^2
Shear parallel to grain	F_v = **180** lb/in^2
Modulus of elasticity	E = **1600000** lb/in^2
Modulus of elasticity, stability calculations	E_{min} = **580000** lb/in^2
Mean shear modulus	G_{def} = E / 16 = **100000** lb/in^2

Member details

Service condition	**Dry**
Length of span	L_{s1} = **10** ft
Length of bearing	L_b = **4** in
Load duration	**Two months**

Section properties

Cross sectional area of member	A = N $\times$ b $\times$ d = **25.37** in^2

Section modulus $S_x = N \times b \times d^2 / 6 = \mathbf{30.66}\ in^3$

$S_y = d \times (N \times b)^2 / 6 = \mathbf{14.80}\ in^3$

Second moment of area $I_x = N \times b \times d^3 / 12 = \mathbf{111.15}\ in^4$

$I_y = d \times (N \times b)^3 / 12 = \mathbf{25.90}\ in^4$

Adjustment factors

Load duration factor - Table 2.3.2 $C_D = \mathbf{1.15}$

Temperature factor - Table 2.3.3 $C_t = \mathbf{1.00}$

Size factor for bending - Table 4A $C_{Fb} = \mathbf{1.30}$

Size factor for tension - Table 4A $C_{Ft} = \mathbf{1.20}$

Size factor for compression - Table 4A $C_{Fc} = \mathbf{1.05}$

Flat use factor - Table 4A $C_{fu} = \mathbf{1.05}$

Incising factor for modulus of elasticity - Table 4.3.8

$C_{iE} = \mathbf{1.00}$

Incising factor for bending, shear, tension & compression - Table 4.3.8

$C_i = \mathbf{1.00}$

Incising factor for perpendicular compression - Table 4.3.8

$C_{ic\_perp} = \mathbf{1.00}$

Repetitive member factor - cl.4.3.9 $C_r = \mathbf{1.00}$

Bearing area factor - cl.3.10.4 $C_b = \mathbf{1.00}$

Depth-to-breadth ratio $d_{nom} / (N \times b_{nom}) = \mathbf{2.00}$

- Beam is fully restrained

Beam stability factor - cl.3.3.3 $C_L = \mathbf{1.00}$

Bearing perpendicular to grain - cl.3.10.2

Design compression perpendicular to grain $F_{c\_perp}' = F_{c\_perp} \times C_t \times C_{ic\_perp} \times C_b = \mathbf{625}\ lb/in^2$

Applied compression stress perpendicular to grain $f_{c\_perp} = R_{B\_max} / (N \times b \times L_b) = \mathbf{49}\ lb/in^2$

$f_{c\_perp} / F_{c\_perp}' = \mathbf{0.078}$

PASS - Design compressive stress exceeds applied compressive stress at bearing

Strength in bending - cl.3.3.1

Design bending stress $F_b' = F_b \times C_D \times C_t \times C_L \times C_{Fb} \times C_i \times C_r = \mathbf{1346}\ lb/in^2$

Actual bending stress $f_b = M / S_x = \mathbf{670}\ lb/in^2$

$f_b / F_b' = \mathbf{0.498}$

PASS - Design bending stress exceeds actual bending stress

Strength in shear parallel to grain - cl.3.4.1

Design shear stress $F_v' = F_v \times C_D \times C_t \times C_i = \mathbf{207}\ lb/in^2$

Actual shear stress - eq.3.4-2 $f_v = 3 \times F / (2 \times A) = \mathbf{40}\ lb/in^2$

$f_v / F_v' = \mathbf{0.195}$

PASS - Design shear stress exceeds actual shear stress

Deflection - cl.3.5.1

Modulus of elasticity for deflection $E' = E \times C_{ME} \times C_t \times C_{iE} = \mathbf{1600000}\ lb/in^2$

Design deflection $\delta_{adm} = 0.003 \times L_{s1} = \mathbf{0.360}\ in$

Total deflection $\delta_{b\_s1} = \mathbf{0.173}\ in$

$\delta_{b\_s1} / \delta_{adm} = \mathbf{0.481}$

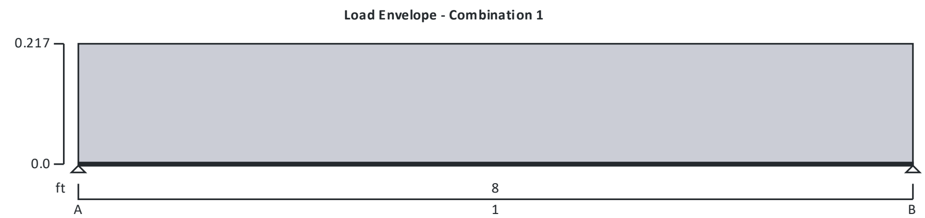
PASS - Total deflection is less than design deflection

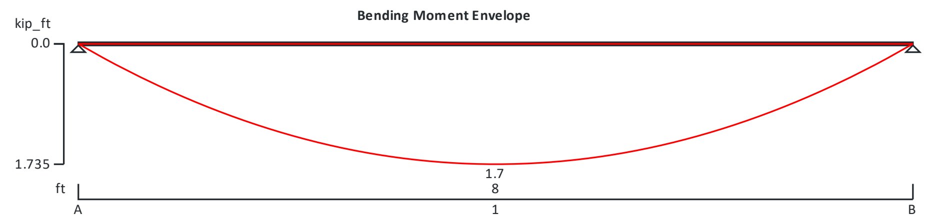
4. B 10X12

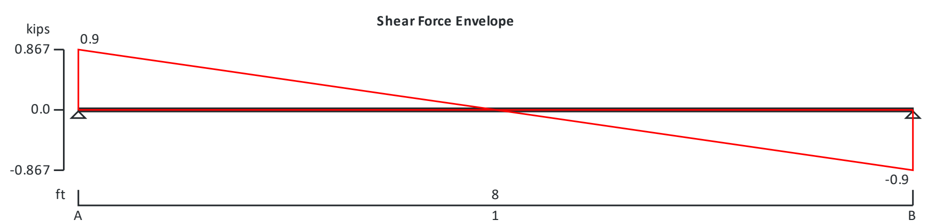
STRUCTURAL WOOD MEMBER ANALYSIS & DESIGN (NDS)

In accordance with the ANSI/AF&PA NDS-2018 using the ASD method

Tedds calculation version 1.7.10







Applied loading

Beam loads

Dead self weight of beam × 1

Dead full UDL 125 lb/ft

Live full UDL 60 lb/ft

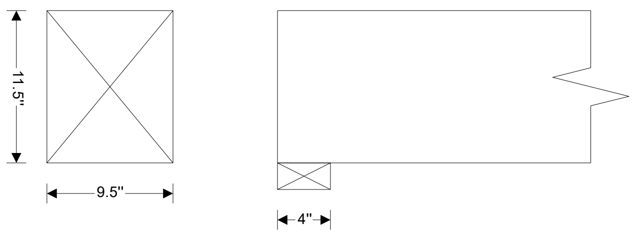
Load combinations

Load combination 1	Support A	Dead × 1.00
		Live × 1.00
		Snow × 1.00
	Span 1	Dead × 1.00
		Live × 1.00
		Snow × 1.00
	Support B	Dead × 1.00
		Live × 1.00

Snow × 1.00

Analysis results

Maximum moment	M_{max} = **1735** lb_ft	M_{min} = **0** lb_ft
Design moment	M = max(abs(M_{max}),abs(M_{min})) = **1735** lb_ft	
Maximum shear	F_{max} = **867** lb	F_{min} = **-867** lb
Design shear	F = max(abs(F_{max}),abs(F_{min})) = **867** lb	
Total load on member	W_{tot} = **1735** lb	
Reaction at support A	R_{A_max} = **867** lb	R_{A_min} = **867** lb
Unfactored dead load reaction at support A	R_{A_Dead} = **627** lb	
Unfactored live load reaction at support A	R_{A_Live} = **240** lb	
Reaction at support B	R_{B_max} = **867** lb	R_{B_min} = **867** lb
Unfactored dead load reaction at support B	R_{B_Dead} = **627** lb	
Unfactored live load reaction at support B	R_{B_Live} = **240** lb	



Sawn lumber section details

Nominal breadth of sections	b_{nom} = **10** in
Dressed breadth of sections	b = **9.5** in
Nominal depth of sections	d_{nom} = **12** in
Dressed depth of sections	d = **11.5** in
Number of sections in member	N = **1**
Overall breadth of member	b_b = N × b = **9.5** in
Species, grade and size classification	Douglas Fir-Larch, No.2 grade, Posts and timbers
Bending parallel to grain	F_b = **750** lb/in^2
Tension parallel to grain	F_t = **475** lb/in^2
Compression parallel to grain	F_c = **700** lb/in^2
Compression perpendicular to grain	F_{c_perp} = **625** lb/in^2
Shear parallel to grain	F_v = **170** lb/in^2
Modulus of elasticity	E = **1300000** lb/in^2
Modulus of elasticity, stability calculations	E_{min} = **470000** lb/in^2
Mean shear modulus	G_{def} = E / 16 = **81250** lb/in^2

Member details

Service condition	**Dry**
Length of span	L_{s1} = **8** ft
Length of bearing	L_b = **4** in
Load duration	**Two months**

Section properties

Cross sectional area of member	A = N × b × d = **109.25** in^2

Section modulus $S_x = N \times b \times d^2 / 6 = \mathbf{209.40}$ in^3

$S_y = d \times (N \times b)^2 / 6 = \mathbf{172.98}$ in^3

Second moment of area $I_x = N \times b \times d^3 / 12 = \mathbf{1204.03}$ in^4

$I_y = d \times (N \times b)^3 / 12 = \mathbf{821.65}$ in^4

Adjustment factors

Load duration factor - Table 2.3.2 $C_D = \mathbf{1.15}$

Temperature factor - Table 2.3.3 $C_t = \mathbf{1.00}$

Size factor for bending - Table 4D $C_{Fb} = \mathbf{1.00}$

Size factor for tension - Table 4D $C_{Ft} = \mathbf{1.00}$

Size factor for compression - Table 4D $C_{Fc} = \mathbf{1.00}$

Flat use factor - Table 4D $C_{fu} = \mathbf{1.00}$

Incising factor for modulus of elasticity - Table 4.3.8

$C_{iE} = \mathbf{1.00}$

Incising factor for bending, shear, tension & compression - Table 4.3.8

$C_i = \mathbf{1.00}$

Incising factor for perpendicular compression - Table 4.3.8

$C_{ic\_perp} = \mathbf{1.00}$

Repetitive member factor - cl.4.3.9 $C_r = \mathbf{1.00}$

Bearing area factor - cl.3.10.4 $C_b = \mathbf{1.00}$

Depth-to-breadth ratio $d_{nom} / (N \times b_{nom}) = \mathbf{1.20}$

- Beam is fully restrained

Beam stability factor - cl.3.3.3 $C_L = \mathbf{1.00}$

Bearing perpendicular to grain - cl.3.10.2

Design compression perpendicular to grain $F_{c\_perp}' = F_{c\_perp} \times C_t \times C_{ic\_perp} \times C_b = \mathbf{625}$ lb/in^2

Applied compression stress perpendicular to grain $f_{c\_perp} = R_{A\_max} / (N \times b \times L_b) = \mathbf{23}$ lb/in^2

$f_{c\_perp} / F_{c\_perp}' = \mathbf{0.037}$

PASS - Design compressive stress exceeds applied compressive stress at bearing

Strength in bending - cl.3.3.1

Design bending stress $F_b' = F_b \times C_D \times C_t \times C_L \times C_{Fb} \times C_i \times C_r = \mathbf{863}$ lb/in^2

Actual bending stress $f_b = M / S_x = \mathbf{99}$ lb/in^2

$f_b / F_b' = \mathbf{0.115}$

PASS - Design bending stress exceeds actual bending stress

Strength in shear parallel to grain - cl.3.4.1

Design shear stress $F_v' = F_v \times C_D \times C_t \times C_i = \mathbf{196}$ lb/in^2

Actual shear stress - eq.3.4-2 $f_v = 3 \times F / (2 \times A) = \mathbf{12}$ lb/in^2

$f_v / F_v' = \mathbf{0.061}$

PASS - Design shear stress exceeds actual shear stress

Deflection - cl.3.5.1

Modulus of elasticity for deflection $E' = E \times C_{ME} \times C_t \times C_{iE} = \mathbf{1300000}$ lb/in^2

Design deflection $\delta_{adm} = 0.003 \times L_{s1} = \mathbf{0.288}$ in

Total deflection $\delta_{b\_s1} = \mathbf{0.013}$ in

$\delta_{b\_s1} / \delta_{adm} = \mathbf{0.044}$

PASS - Total deflection is less than design deflection

5. Post 10x10

WOOD MEMBER DESIGN (NDS 2018)

In accordance with the ANSI/AF&PA NDS 2018 using the ASD method

Tedds calculation version 2.2.22

Design summary

Overall design utilisation 0.024

Overall design status PASS

Design section s1 results summary	Unit	Capacity	Maximum	Utilization	Result
Compressive stress	lb/in^2	918	22	0.024	PASS

Design section 1

User note: Check column at base

Member details

Service condition Dry

Load duration - Table 2.3.2 Ten years

Sawn lumber section details

Number of sections in member $N = \mathbf{1}$

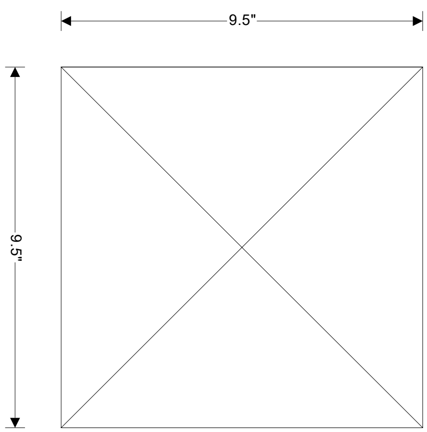
Nominal breadth of sections $b_{nom} = \mathbf{10}$ in

Breadth of sections $b = \mathbf{9.5}$ in

Nominal depth of sections $d_{nom} = \mathbf{10}$ in

Depth of sections $d = \mathbf{9.5}$ in

Material **Douglas Fir-Larch, Posts and timbers, No.1 grade**



10"x10" sawn lumber section
Cross-sectional area, A, 90.25 in^2
Section modulus, S_x, 142.9 in^3
Section modulus, S_y, 142.9 in^3
Second moment of area, I_x, 678.8 in^4
Second moment of area, I_y, 678.8 in^4
Radius of gyration, r_x, 2.742 in
Radius of gyration, r_y, 2.742 in
Douglas Fir-Larch, Posts and timbers, No.1 grade
Bending, F_b, 1200 psi
Shear parallel to grain, F_v, 170 psi
Compression parallel to grain, F_c, 1000 psi
Compression perpendicular to grain, F_{c_perp}, 625 psi
Tension parallel to grain, F_t, 825 psi
Modulus of elasticity, E, 1600000 psi
Minimum modulus of elasticity, E_{min}, 580000 psi
Density, ρ, 34.204 lbm/ft^3
Specific gravity, G, 0.5

Span details

Unbraced length - Major axis $L_x = \mathbf{10}$ ft

Effective bending length - Major axis $L_{e,x} = 1.63 \times L_x + 3 \times b = \mathbf{18.675}$ ft

Column buckling length - Major axis $L_{b,x} = L_x = \mathbf{10}$ ft

Unbraced length - Minor axis $L_y = \mathbf{10}$ ft

Effective bending length - Minor axis $L_{e,y} = 1.63 \times L_y + 3 \times d = \mathbf{18.675}$ ft

Column buckling length - Minor axis $L_{b,y} = L_y = \mathbf{10}$ ft

Analysis results

Design axial compression force $P = \mathbf{2000}$ lb

Adjustment factors - Table 4.3.1

Load duration factor - Table 2.3.2 $C_D = \mathbf{1}$

Reference compression design value $F_c^* = F_c \times C_D = \mathbf{1000}$ lb/in^2

Adjusted modulus of elasticity $E_{min}' = E_{min} = \mathbf{580000}$ lb/in^2

Critical buckling design value $F_{cE} = 0.822 \times E_{min}' / (L_{b,y} / b)^2 = \mathbf{2988}$ lb/in^2

Column stability factor - eq.3.7-1

$$C_P = (1 + (F_{cE} / F_c^*)) / 1.6 - \sqrt{((1 + (F_{cE} / F_c^*)) / 1.6)^2 - (F_{cE} / F_c^*) / 0.8} = \mathbf{0.918}$$

Compression members - General - cl.3.6

Design axial compression force $P = \mathbf{2000}$ lb

Design compression parallel to grain - Table 4.3.1 $F_c' = F_c \times C_D \times C_P = \mathbf{918}$ lb/in^2

Actual compression parallel to grain $f_c = P / (b \times d) = \mathbf{22}$ lb/in^2

$f_c / F_c' = \mathbf{0.024}$

PASS - Design compression stress exceeds actual compression stress