Plants Spaced Every 4" for 20' → 60 plants per side

Plants Climb 8' each → 8' x 60 plants = 480 LF / side

Assume Ivy = 15.5 g/LF → 480 LF x 15.5 g/LF = 7440 g = 16.4 lb/side

≈ 0.1 psf for Ivy ∫ 0.8 lb/ft for 20' side

Black Powder Coated Galvanized Aircraft Cable

3/16", 33 lbs – 500', break strength = 4200 lbs → 0.066 lb/LF

480 LF/side x 0.066 lb/LF = 31.68 lb/side ∫ 1.6 lb/ft for 20' side

≈ 0.2 psf for cable

SIDE VINES & CABLE = (0.1 + 0.2)(8' x 20') = 48#

TOP VINES & CABLE = ½ [(0.1+0.2)(8' x 20')] = 24#

→ 72#

4x6 w/ ρ = 50 lb/ft³ → 6.684 lb/LF

20' Beam = 133.68#

8' Beam = 53.47#

From Fig 1608.2 in Design of Wood Structures

Snow Load = 20 psf

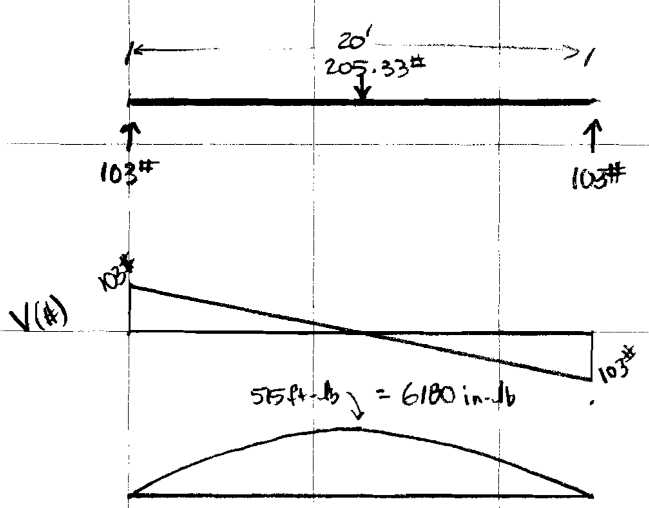
$\left(\frac{4"}{12"}\right)(20')(20\text{ psf}) = 133.33\#$

= 6.7 lb/ft

DL = (Vines & Cable) + Snow

= 72# + 133.33#

= 205.33#



4x6 properties from NDS Supplement Table 1B.

$f_b = \frac{M}{S} = \frac{6180 \text{ in-lb}}{17.65 \text{ in}^3} = 350 \text{ psi}$

$C_D = 1.15$ for (D+S)

$C_r = 1.0$

$C_L = 1.0$

$C_F = 1.3$ (NDS Table 4A)

$C_M = 1.0$ (NDS Table 4A)

$F_b (C_F) = (350 \text{psi})(1.3) = 455 \text{ psi}$

$\therefore C_m = 1.0$

$C_i = 0.8$ Assuming incised lumber would be needed.

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

$= 350 (1.15)(1.0)(1.0)(1.0)(1.3)(1.0)(0.8)$

$= 419 \text{ psi} > 350 \text{ psi} \therefore$ OK ← BENDING

SHEAR

$f_v = \frac{1.5 V}{A} = \frac{1.5(103)}{19.25} = 8.03 \text{ psi}$

$F'_v = F_v (C_D)(C_m)(C_t)$

$= 6180 (1.15)(0.97)(1.0)$

$= 6894 \text{ psi} > 8.03 \text{ psi} \therefore$ OK ← Shear

Deflection

Will look at No.1 : Hem Fir → E = 1600000 , E' = 1440000

Western Cedar → E = 1000000 , E' = 900 000

Northern White Cedar → E = 700 000 , E' = 630 000

$E' = E(C_m)(C_t)(C_i) = 1600000 (0.9)(1)(1) = 1440000$

Hem-Fir

$\Delta S = \frac{5wL^4}{384E'I} = \frac{5(6.7\ lb/ft)(20)^4(1728)}{384(1440000)(48.53)}$

$w = D + S = (0.8+1.6)+6.7 = 9.1\ lb/ft$

$w_s = 6.7$

$= \frac{497012.16}{1440000} = 0.35\ in$

Allow $\Delta_s = \frac{L}{360} = \frac{20\times12}{360} = 0.67\ in \therefore > 0.35$ OK

$\Delta T_L = \left(\frac{9.1}{6.7}\right)0.35 = 0.48$ $\Delta T_L = \frac{L}{240} = \frac{20\times12}{240} = 1.0\ in \therefore > 0.48$ OK

4x6 No.1 Incised HEM-FIR BEAM IS OK

Western Cedar

$\Delta S = \frac{5wL^4}{384E'I} = 0.55\ in$

Allow $\Delta_s = \frac{L}{360} = \frac{20\times12}{360} = 0.67 \therefore .55 < .67$ OK

$\Delta T_L = \left(\frac{9.1}{6.7}\right)(0.55) = 0.75$, $\Delta T_L = \frac{L}{240} = 1.0\ in \therefore 1.0\ in > 0.75\ in$ OK

4x6 No.1 Incised Western Cedar BEAM IS OK

Northern White Cedar

$\Delta S = \frac{5wL^4}{384E'I} = 0.79\ in$

Allow $\Delta_s = L/360 = \frac{20\times12}{360} = 0.67$

∴ White Cedar Fails Snow Load Deflection CANNOT BE USED.

Green Canopy

* Seismic calcs for 4x6 columns

* Using USGS Seismic Calculator

Lat - 47°18'16.48" N

Long - 122°14' 54.85" W

* assuming site class D

$F_a = 1.013$ $F_v = 1.587$

$S_s = 1.217$ $S_{ms} = 1.232$ $S_{DS} = 0.822$

$S_1 = 0.413$ $S_{m1} = 0.655$ $S_{D1} = 0.437$

Base shear

$V = C_s W$

W = effective seismic weight

for 4x6's, $w_{linear} = 6.684$ lb/ft

total length = 2(8 ft) + 2(20 ft) + 4(8 ft) = 88 ft

$W_{wood} = 6.684$ lb/ft (88 ft) = 588.2 lb

for ivy, w_{ivy} = 15.5 g/1ft (approximately)

for top ⇒ (15.5 g/1ft)(8 ft)$\left(\frac{20 ft \times 12 in/ft}{4 in o.c.}\right)$

= 7440 g

sides ≈ top

∴ total ivy weight = 7440 g (3)

= 22320 g

in pounds,

22320 g × $\frac{1 lb}{453.6 g}$ = 49.2 lb

the AUBURN project

WSU Integrated Design Experience 2011

PROJECT Green Canopy

DATE

DESIGNER KR

SHEET 1

So,

Total effective seismic weight

$= 588\ lb + 50\ lb = \underline{\underline{638\ lb}}$

$$C_s = \frac{S_{DS}}{\left(\frac{R}{I}\right)}$$

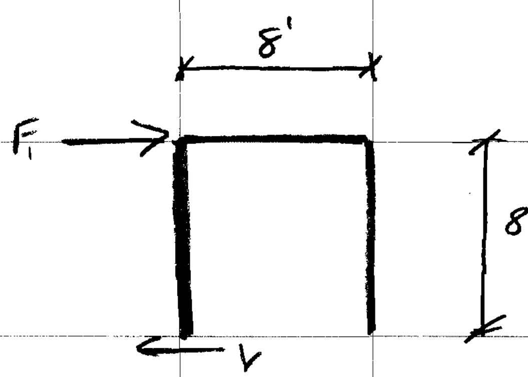
*assume similar to inverted pendulum type structure

$\therefore\ R \neq 2$

*assume $I = 1.0$ since importance is low

$$C_s = \frac{0.822}{\left(\frac{2}{1}\right)} = 0.411$$

$\therefore\ V = C_s W = 0.411(638\ lb) = 262.2\ lb$



$V = F_1 = 262.2\ lb$

* Design columns for bending

- to be conservative, check if one column can resist a 262 lb Seismic load in bending

Bending design

- Also use ASD combinations w/ no reduction factors to be conservative

$f_b \le F_b'$

$f_b = \frac{M}{S}$

$M = 262 \text{ lb} \times 8 \text{ ft} = 2096 \text{ lb}\cdot\text{ft}$

$S = \frac{bd^2}{6} = \frac{3.5(5.5)^2}{6} = 17.65 \text{ in}^3$

$f_b = \frac{M}{S} = \frac{(2096 \text{ lb}\cdot\text{ft} \times 12 \text{ in/ft})}{17.65 \text{ in}^3} = 1425 \text{ psi}$

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

Using Hem-Fir No.1 & better

$F_b = 1100$ psi

$C_D = 1.6$ (Earthquake load)

$C_M = 1.0$

$C_t = 1.0$

$C_F = 1.3$

$C_i = 0.80$ (assuming incised)

$C_r = 1.0$

- $C_L = ?$

$l_e = 1.87 l_u = 1.87(8 \text{ ft}) = 14.96 \approx 15.0 \text{ ft} = 180 \text{ in}$

$R_B = \sqrt{\frac{(180'')(4'')}{(6'')^2}} = 4.5 \le 50$ (ok) for slenderness ratio

$F_b^* = F_b C_D C_M C_t C_F C_i C_r = 1100(1.6)(1.3)(0.8) = 1830$

$F_{bE} = \frac{1.20 E_{min}'}{R_B^2} = \frac{1.20(550000)}{(4.5)^2} = 32593$

$$C_L = \frac{1 + (F_{bE}/F_b^*)}{1.9} - \sqrt{\left[\frac{1 + (F_{bE}/F_b^*)}{1.9}\right]^2 - \frac{F_{bE}/F_b^*}{0.95}}$$

$\therefore C_L \approx 1.0$

$C_{Fu} = 1.0$

$C_i = 0.8$

$C_r = 1.0$

$F_b' = (1100\,psi)(1.6)(1.3)(0.80)$

$F_b' = 1830.4\,psi$

$(f_b = 1425\,psi) < (F_b' = 1830.4\,psi)$ OK

Even when being conservative on multiple levels, using 4x6's to resist lateral load is sufficient.