Structural Analysis Due to Wind and Water Pressure

Tributary Areas

$h_1 := 25ft$

$h_2 := 5ft$

Line Loads

Diaphragm

$$line\_load_{ground} := h_2 \cdot Pressure + \left[\frac{h_2}{2}\left[water\_pressure + \rho \cdot g \cdot \left(water\_height - h_2\right)\right]\right]$$

$$water\_line := \begin{bmatrix} \left(water\_height_{0,0} - h_2\right)^2 & \left(water\_height_{0,1} - h_2\right)^2 \\ \left(water\_height_{1,0} - h_2\right)^2 & \left(water\_height_{1,1} - h_2\right)^2 \\ \left(water\_height_{2,0} - h_2\right)^2 & \left(water\_height_{2,1} - h_2\right)^2 \\ \left(water\_height_{3,0} - h_2\right)^2 & \left(water\_height_{3,1} - h_2\right)^2 \\ \left(water\_height_{4,0} - h_2\right)^2 & \left(water\_height_{4,1} - h_2\right)^2 \end{bmatrix} \qquad water\_line = \begin{pmatrix} 1 & 0 \\ 1 & 9 \\ 16 & 49 \\ 64 & 169 \\ 196 & 25 \end{pmatrix} ft^2$$

$$line\_load_{ceiling} := h_1 \cdot Pressure + \rho \cdot g \cdot (water\_line) \cdot \frac{1}{2}$$

$$line\_load_{ground} = \begin{pmatrix} 515.176 & 855.705 \\ 1169.439 & 1794.562 \\ 2108.123 & 3073.982 \\ 3387.799 & 4992.629 \\ 5306.768 & -780.35 \end{pmatrix} \frac{lbf}{ft} \qquad line\_load_{ceiling} = \begin{pmatrix} 266.047 & 376.776 \\ 415.964 & 669.893 \\ 895.495 & 2072.753 \\ 2549.352 & 6047.47 \\ 6900.245 & 780.35 \end{pmatrix} \frac{lbf}{ft}$$

Reaction at Shear Wall

$$reaction_{ground} := \frac{width}{2} \cdot line\_load_{ground} \qquad reaction_{ceiling} := \frac{width}{2} \cdot line\_load_{ceiling}$$

$$reaction_{ground} = \begin{pmatrix} 17.208 & 28.583 \\ 39.063 & 59.943 \\ 70.417 & 102.68 \\ 113.162 & 166.768 \\ 177.261 & -26.066 \end{pmatrix} kip \qquad reaction_{ceiling} = \begin{pmatrix} 8.887 & 12.585 \\ 13.894 & 22.376 \\ 29.912 & 69.236 \\ 85.155 & 202.002 \\ 230.487 & 26.066 \end{pmatrix} kip$$

$length = 36\,ft$

$unit_{shear\_ground} := 2\,\frac{reaction_{ground}}{length}$ $unit_{shear\_ceiling} := 2\cdot\frac{reaction_{ceiling}}{length}$

$$unit_{shear\_ground} = \begin{pmatrix} 956.018 & 1587.94 \\ 2170.14 & 3330.187 \\ 3912.065 & 5704.418 \\ 6286.773 & 9264.87 \\ 9847.821 & -1448.102 \end{pmatrix} \frac{lbf}{ft} \qquad unit_{shear\_ceiling} = \begin{pmatrix} 493.706 & 699.187 \\ 771.909 & 1243.126 \\ 1661.778 & 3846.427 \\ 4730.858 & 11222.351 \\ 12804.853 & 1448.102 \end{pmatrix} \frac{lbf}{ft}$$

Select Sheathing and determine nailing schedule for the Diaphragms

The unit shear ground will be controlling for all categories except the max category 4 hurricanes and above

Category 1

Use Structural I sheathing with 8d nails; 1-3/8 in minimum fastener penetration. Minimum panel thickness of 3/8 in and a minimum nominal framing width of 2 in. The nail spacing at panel edges is at 3 in.

Category 2

Use Structural I sheathing with 10d nails; 1-1/2 in minimum fastener penetration. Minimum panel thickness of 15/32 in and a minimum nominal framing width of 3 in. The nail spacing at panel edges is at 3 in.

note this sheathing and nailing schedule only applies to the lower bound of Category 2 hurricanes, their is no sheathing available to protect against the upper bound

Category 3 and above

There is no sheathing or nailing schedule available that will resist the loads calculated above

Design of Tension Chord

Wood is Southern Pine, Select Structural

Material properties

$F_t := 1600psi$

$F_c := 2100psi$

Adjustment Factors

$C_D := 1.6$ Load Duration Factor

$C_M := 1$ Wet Service Factor

$C_t := 1$ Temperature Factor

$C_F := 1$ Size Factor

$C_i := 1$ Incising Factor

Calculate the axial force in the chord

$force\_axial_{ground} := line\_load_{ground} \cdot \frac{width^2}{8 \cdot length}$ $force\_axial_{ceiling} := line\_load_{ceiling} \cdot \frac{width^2}{8 \cdot length}$

$$force\_axial_{ground} = \begin{pmatrix} 7.983 & 13.26 \\ 18.122 & 27.809 \\ 32.668 & 47.636 \\ 52.499 & 77.368 \\ 82.236 & -12.093 \end{pmatrix} kip \qquad force\_axial_{ceiling} = \begin{pmatrix} 4.123 & 5.839 \\ 6.446 & 10.381 \\ 13.877 & 32.12 \\ 39.506 & 93.714 \\ 106.929 & 12.093 \end{pmatrix} kip$$

Calculate Tensile Capacity

$F_{t\_prime} := F_t \cdot C_D \cdot C_M \cdot C_t \cdot C_F \cdot C_i$

$F_{t\_prime} = 2560\,psi$

Determine Required area of the chord

$area\_reqd_{ground} := \frac{force\_axial_{ground}}{F_{t\_prime}}$ $area\_reqd_{ceiling} := \frac{force\_axial_{ceiling}}{F_{t\_prime}}$

$$area\_reqd_{ground} = \begin{pmatrix} 3.119 & 5.18 \\ 7.079 & 10.863 \\ 12.761 & 18.608 \\ 20.507 & 30.222 \\ 32.123 & -4.724 \end{pmatrix} in^2 \qquad area\_reqd_{ceiling} = \begin{pmatrix} 1.61 & 2.281 \\ 2.518 & 4.055 \\ 5.421 & 12.547 \\ 15.432 & 36.607 \\ 41.769 & 4.724 \end{pmatrix} in^2$$

$Minimum_{area} := 2 \cdot 1.5in \cdot 3.5in$ $Minimum_{area} = 10.5\,in^2$

The chord force is not going to limit the design

Determine Shear sheathing and nailing pattern

$window\_length := 9ft$

$wall\_length := length - window\_length$ $wall\_length = 27\,ft$

$Unit\_shear_{ground} := 2\frac{reaction_{ground}}{wall\_length}$ $Unit\_shear_{ceiling} := 2\frac{reaction_{ceiling}}{wall\_length}$

$$Unit\_shear_{ground} = \begin{pmatrix} 1274.69 & 2117.253 \\ 2893.52 & 4440.249 \\ 5216.086 & 7605.891 \\ 8382.364 & 12353.16 \\ 13130.429 & -1930.803 \end{pmatrix} \frac{lbf}{ft} \qquad Unit\_shear_{ceiling} = \begin{pmatrix} 658.274 & 932.25 \\ 1029.212 & 1657.502 \\ 2215.704 & 5128.57 \\ 6307.811 & 14963.134 \\ 17073.138 & 1930.803 \end{pmatrix} \frac{lbf}{ft}$$

Values from the NDS Wind and Seismic Provisions

Max Shear Resistance

The unit shear ground controls up until the lower bound on Category 4. Forces greater than the upper bound on Category 4 hurricanes and above, the unit shear ceiling controls

Category 1

Use of Wood Structural Panels- Structural Sheathing with a nominal panel thickness of 15/32 in. A 10d common nail is used with a minimum penetration of 1-1/2 in and a panel edge spacing of 2 in.

Category 2 and above

There is no sheathing or nailing schedule available that will resist the loads calculated above