Sample calculation of failure wind pressure for vertical load path components

Limit State equation:

$$z = R - W + D$$

R: Resistance of fastener type, calculated according to CSA O86-14 (nailed connections at RTWC and wall baseplate), cited from manufacturers' specifications(truss screws and hurricane ties), or from experimental capacity results (toe-nailed RTWCs) (Morrison & Kopp, 2011).

W: Wind load effect (uplift or lateral load) calculated using the Static Procedure for the MWFRS, specified in NBCC Part 4.1.7.3. Tributary area loads are applied to each RTWC, and wall loads are calculated as net loads (N/m) considering positive and negative pressures. This approach assumes that adjacent wall panels are securely fastened to one another.

D: Dead load due to weight of structure, cladding, and insulation.

Withdrawal Resistance of Toe-Nailed RTWC:

$$P_{rw} = \phi Y_w L_p n_F J_A J_B$$

$$Y_w = y_w \times (K_{SF} K_T)$$

$$K_{SF} = service\ condition\ factor = 1.0\ for\ dry\ service$$

$$K_T = treatment\ factor = 1.0\ for\ untreated/unincised\ lumber$$

$$y_w = 16.4 \times d_F^{0.82} G^{2.2}$$

$$d_F = d_{min} = 3.66\ mm\ (NBCC\ Part\ 9.23\ requirement)$$

$$G = specific\ gravity\ of\ Douglar\ Fir\ Lumber = 0.49$$

$$y_w = 16.4 \times (3.66^{0.82}) \times (0.49^{2.2}) = 9.893\ [N/mm]$$

$$Y_w = 9.893 \times 1 \times 1$$

$$\phi = 0.6$$

$$L_p = length\ of\ penetration\ not\ specified\ in\ NBCC, assume\ 0.5\ of\ length\ of\ nail\ penetrates$$

$$L_p = \frac{82}{2} = 41\ [mm]$$

$$n_F = number\ of\ fasteners = 3$$

$$J_A = toe - nailing\ factor = 0.67$$

$$J_B = nail\ clinching\ factor = 1$$

$$P_{rw} = 0.6 \times 9.893 \times 41 \times 3 \times 0.67 \times 1 = \mathbf{490}\ [\boldsymbol{N}]$$

Wind Uplift on RTWCs:

Solve for internal and external wind uplift in term of design wind pressure, q

$$p = I_w q C_e C_t C_g C_p$$

$$p_i = I_w q C_{ei} C_t C_{gi} C_{pi}$$

$$I_w = 1.0$$

House Dimensions:

Eaves height = 8.0 m
Plan dimensions = 9.0 x 8.9 m
Overhangs = 0.61 m
Roof slope = 4:12
Roof mid-height = 8 + (4/12)(4.45+0.61)/2 = 8.84 m
Top of roof height = 9.69 m
Reference height, h = 8.84 m
End zone width, y = 6 m (9 truss spacings)

$$C_e = \left(\frac{h}{10}\right)^{0.2} \geq 0.9 = \left(\frac{8.84}{10}\right)^{0.2} = 0.97\ (Roof\ height -\ Open\ Terrain)$$

$$C_t = 1.0$$

Internal pressure coefficient and gust factor:

$$C_{e_i} = 0.9$$

$$C_{g_i} = 2.0$$

$$C_{pi} = -0.45, +0.3$$

External pressure coefficient and gust factor taken from Figure 4.1.7.6-A:

Roof Slope	Roof Surfaces			
	CgCp			
Load Case A	2	2E	3	3E
18° (interpolated)	**-1.30**	**-2.00**	**-0.87**	**-1.26**
Load Case B				
0° to 90°	-1.30	-2.00	-0.70	-1.00

Uplift on end zone RTWCs:

External pressure:

$$p = I_w q C_e C_t C_g C_p = 1.0 \times q \times 0.97 \times 1.0 \times C_g C_p = q\ 0.97\ (C_g C_p)\ [kPa]$$

Vertical component of external suction = $0.95(C_g C_p)$:

Zone 2E:

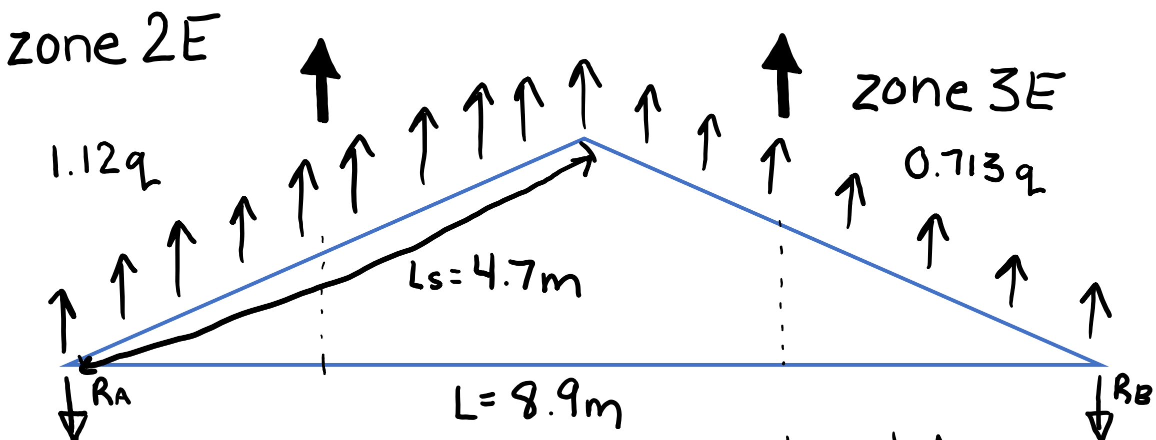
$$p_v = 0.95\,(q \times 0.97 \times -2.0) = 1.84\,q\ [kPa]$$

$$u_v = 0.61 \times 1.84\,q = 1.12\,q\ [kN/m]$$

Zone 3E:

$$p_v = 0.95\,(q \times 0.97 \times -1.26) = 1.16\,q\ [kPa]$$

$$u_v = 0.61 \times 1.17\,q = 0.713\,q\ [kN/m]$$



moment arm to A

$$M_A = 0 = R_B(8.9) - \left(1.12q \times 4.7 \times \frac{8.9}{4}\right) - \left(0.713q \times 4.7 \times \frac{3(8.9)}{4}\right)$$

$$R_B = 3.8\,q\ [kN]$$

$$R_B + R_A = (1.12q \times 4.7) + (0.713q \times 4.7)$$

$$R_A = 4.8\,q\ [kN]$$

Internal Pressure:

$$p_i = I_w q C_{ei} C_t C_{gi} C_{pi} = 1.0 \times q \times 0.9 \times 1.0 \times 2.0 \times 0.3 = 0.54q\ [kPa]$$

$$R_i = 0.54\,q \times 0.61 \times \frac{8.9}{2} = 1.4\,q\ [kN]$$

End zone RTWC uplift:

$$4.8\,q + 1.4\,q = \mathbf{6.2\,q\ [kN]}$$

Dead Load per RTWC:

$D_{RTWC} = W_{truss} + W_{roofing} + W_{ceiling}$

$$D_{RTWC} = \frac{truss\ weight}{2} + \left(roof\ trib.area \times \left(w_{shingles} + w_{sheathing}\right)\right)$$

$$+\left(ceiling\ trib.area \times w_{ceiling\ drywall}\right) =$$

$$D_{RTWC} = \frac{640}{2} + \left(3.25 \times \left(120 + 5(11)\right)\right) + (2.72 \times 100) = \mathbf{1.16}\ [\boldsymbol{kN}]$$

Balancing the Limit States Equation

With load factors:

NBCC load combination where wind is the primary load effect:

$$net\ uplift = 1.4W + 0.9D$$

$$0 = R - 1.4W + 0.9D$$

$$0 = 0.49\ kN\ - 1.4(6.2q) + 0.9(1.16)$$

Solve for failure wind pressure, q:

$$q = \frac{0.49 + 0.9(1.16)}{1.4(6.2)} = \mathbf{0.18}\ [\boldsymbol{kPa}]$$

Nominal failure wind pressure, q:

$$0 = \frac{R}{\phi} - W + D = \frac{R}{0.6} - W + D$$

$$0 = \frac{0.49}{0.6} - 6.2q + 1.16 = 0.817 - 6.2q + 1.16$$

$$q = \frac{0.817 + 1.16}{6.2} = \mathbf{0.32}\ [\boldsymbol{kPa}]$$

Results as shown in Table 3 for failure wind pressure of toe-nailed RTWCs designed per CSA O86.