Calculate Wind Pressure due to Hurricanes

ASCE 7-05 Method 2

Importance Factor ASCE 7-05 Sectoin 6.5.5

Residential building are Category I

When V > 100 mph

$I = 0.77$

When V < 100 mph

$I = 1.0$

Gust Effect Factor ASCE 7-05 Section 6.5.8

$$G = 0.925 \cdot \left(\frac{1 + 1.7 g_Q \cdot I_z \cdot Q}{1 + 1.7 \cdot g_v \cdot I_z} \right)$$

$$I_z = c \cdot \left(\frac{33}{z} \right)^{\frac{1}{6}}$$

Iz is the turbulence at height z

$z = 0.6 \cdot h$

$z_{min} = 15ft$

for building with h < or equal to z min, z shall be taken as z min

$c = 0.20$

$g_Q = 3.4$

$g_v = 3.4$

$$Q = \sqrt{\frac{1}{1 + 0.63 \cdot \left(\frac{B + h}{L_z} \right)^{0.63}}}$$

B = the horizontal dimension of building measure normal to wind direction, in ft

h = mean roof height of a building or height of other structure, except that eave height shall be used for the roof angle θ of less than or equal to 10 deg, in ft

$$L_z = l \cdot \left(\frac{z}{33} \right)^{\varepsilon}$$

$l = 500ft$

$\varepsilon = \frac{1}{5.0}$

Exposure Category, Kz or Kh, ASCE 7-05 Section 6.5.6

From Table 6-3

$K_h :=$

	0	1
0	"0-15"	0.85
1	20	0.9
2	25	0.94
3	30	0.98

Column 0 is for height above ground level, z

Column 1 is for Exposure C, cases 1 & 2

$K_{z\_15} = 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}}$ For 15 ft < z < z.g

$K_{z\_} = 2.01 \cdot \left(\frac{15}{z_g}\right)^{\frac{2}{\alpha}}$ For z < 15 ft

$z_g = 900\text{ft}$

$\alpha = 9.5$

Topographic Factor, Kzt, ASCE 7-05 Section 6.5.7

$K_{zt} = \left(1 + K_1 \cdot K_2 \cdot K_3\right)^2$

$K_{zt} = 1$ Assuming no hills or escarpment

Enclosure Classification, ASCE 7-05 Section 6.5.9

$q_z = 0.00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V^2 \cdot I$

Wind Directionality Factor, Kd, ASCE 7-05 Section 6.5.4.4

$K_d = 0.85$ Used when using ASD or LRFD for building Design

Internal pressure Coefficients GCpi, ASCE 7-05 Section 6.5.11.1

$GC_{pi} = 0.18$

$GC_{pi} = -0.18$ Assuming an Enclosed Building

Two cases shall be considered to determine the critical load

External Pressure Coefficients Cp, GCpf or Force Coefficients Cf, ASCE 7-05 Section 6.5.11.2 or 6.5.11.3

$GC_{pf} = 0.69$

This value is the most conservative value and corresponds with the building face that will experience a pressure acting on that face

Low-Rise Building, ASCE 7-05 Section 6.5.12.2.2

$p = q_h \cdot [(GC_{pf}) - (GC_{pi})]$

qh is the velocity pressure at the roof height

It is assumed for buildings under 30 ft that the wind load will act uniformly over the lenght of the structure

Calculations

Hurricane Categories

Changeable Values

$h := 30ft$ h includes the roof height

$home\_size := 2405ft^2$

$length := 36ft$

$width := \frac{home\_size}{length}$

$B := width$ $B = 66.806\,ft$

$roof\_angle := atan\left(\frac{h - 10ft}{0.5 \cdot length}\right)$ $roof\_angle = 48.013\,deg$

Changeable Parameters based on Assumptions noted Above

$c := 0.20$ $K_h := 0.98$

$\varepsilon := \frac{1}{5}$ $K_{zt} := 1$

$l := 500ft$ $K_d := 0.85$

$g_Q := 3.4$ $GC_{p1} := 0.18$

$g_v := 3.4$ $GC_{p2} := -0.18$

$z_g := 900ft$ $GC_{pf} := 0.69$

$\alpha := 9.5$

Hurricane Parameters

$V_{1\_min} := 75mph$ $V_{4\_min} := 131mph$

$V_{1\_max} := 95mph$ $V_{4\_max} := 155mph$

$V_{2\_min} := 96mph$ $V_{5\_min} := 156mph$

$V_{2\_max} := 110mph$

$V_{3\_min} := 111mph$

$V_{3\_max} := 130mph$

Values based on Changeable Parameters

$z := 0.6 \cdot h$

$z_{min} := 15ft$

$z_{control} := \max(z, z_{min})$ $z_{control} = 18\,ft$

$z := \frac{z_{control}}{ft}$

$I_z := c \cdot \left(\frac{33}{z}\right)^{\frac{1}{6}}$ $I_z = 0.221$

$L_z := l \cdot \left(\frac{z}{33}\right)^{\varepsilon}$ $L_z = 442.916\,ft$

$Q := \sqrt{\frac{1}{1 + 0.63 \cdot \left(\frac{B + h}{L_z}\right)^{0.63}}}$ $Q = 0.897$

$G := 0.925 \cdot \left(\frac{1 + 1.7 g_Q \cdot I_z \cdot Q}{1 + 1.7 \cdot g_v \cdot I_z}\right)$ $G = 0.872$

$$f(z) := \begin{cases} 2.01 \cdot \left(\frac{z \cdot ft}{z_g}\right)^{\frac{2}{\alpha}} & \text{if } z > 15 \\ 2.01 \cdot \left(\frac{15ft}{z_g}\right)^{\frac{2}{\alpha}} & \text{if } z \le 15 \end{cases}$$

$K_z := f(z)$

$K_z = 0.882$

Min pressure for Category 1 Hurricane

$V := V_{1\_min}$

$$f(V) := \begin{cases} 1 & \text{if } V \le 100\,\text{mph} \\ 0.77 & \text{if } V > 100\,\text{mph} \end{cases}$$

$I := f(V)$

$I = 1$

$q_{si} := 0.00256 \cdot V^2 \cdot \left(\frac{1}{\text{mph}}\right)^2$ $q_{si} = 14.4$

$q_s := q_{si} \cdot \text{psf}$ $q_s = 14.4\,\text{psf}$

$q_z := q_s \cdot K_z \cdot K_{zt} \cdot K_d \cdot I$ $q_z = 10.797\,\text{psf}$

$p_1 := q_z \cdot \left(GC_{pf} - GC_{p1}\right)$

$p_2 := q_z \cdot \left(GC_{pf} - GC_{p2}\right)$

$\text{pressure}_{\text{category\_1\_min}} := \max\left(p_1, p_2\right)$

$\text{pressure}_{\text{category\_1\_min}} = 9.393\,\frac{\text{lbf}}{\text{ft}^2}$

Max pressure for Category 1 Hurricane

$V := V_{1\_max}$

$$f(V) := \begin{cases} 1 & \text{if } V \le 100\,\text{mph} \\ 0.77 & \text{if } V > 100\,\text{mph} \end{cases}$$

$I := f(V)$

$I = 1$

$q_{si} := 0.00256 \cdot V^2 \cdot \left(\frac{1}{\text{mph}}\right)^2$ $q_{si} = 23.104$

$q_s := q_{si} \cdot \text{psf}$ $q_s = 23.104\,\text{psf}$

$q_z := q_s \cdot K_z \cdot K_{zt} \cdot K_d \cdot I$ $q_z = 17.323\,\text{psf}$

$p_1 := q_z \cdot \left(GC_{pf} - GC_{p1}\right)$

$p_2 := q_z \cdot \left(GC_{pf} - GC_{p2}\right)$

$pressure_{category\_1\_max} := \max(p_1, p_2)$

$pressure_{category\_1\_max} = 15.071 \frac{lbf}{ft^2}$

Min pressure for Category 2 Hurricane

$V := V_{2\_min}$

$f(V) := \begin{cases} 1 & \text{if } V \le 100\,mph \\ 0.77 & \text{if } V > 100\,mph \end{cases}$

$I := f(V)$

$I = 1$

$q_{si} := 0.00256 \cdot V^2 \cdot \left(\frac{1}{mph}\right)^2$ $q_{si} = 23.593$

$q_s := q_{si} \cdot psf$ $q_s = 23.593\,psf$

$q_z := q_s \cdot K_z \cdot K_{zt} \cdot K_d \cdot I$ $q_z = 17.69\,psf$

$p_1 := q_z \cdot (GC_{pf} - GC_{p1})$

$p_2 := q_z \cdot (GC_{pf} - GC_{p2})$

$pressure_{category\_2\_min} := \max(p_1, p_2)$

$pressure_{category\_2\_min} = 15.39 \frac{lbf}{ft^2}$

Max pressure for Category 2 Hurricane

$V := V_{2\_max}$

$f(V) := \begin{cases} 1 & \text{if } V \le 100\,mph \\ 0.77 & \text{if } V > 100\,mph \end{cases}$

$I := f(V)$

$I = 0.77$

$q_{si} := 0.00256 \cdot V^2 \cdot \left(\frac{1}{mph}\right)^2$ $q_{si} = 30.976$

$q_s := q_{si} \cdot psf$ $q_s = 30.976\,psf$

$q_z := q_s \cdot K_z \cdot K_{zt} \cdot K_d \cdot I$ $q_z = 17.884\,psf$

$p_1 := q_z \cdot (GC_{pf} - GC_{p1})$

$p_2 := q_z \cdot (GC_{pf} - GC_{p2})$

$pressure_{category\_2\_max} := \max(p_1, p_2)$

$pressure_{category\_2\_max} = 15.559 \frac{lbf}{ft^2}$

Min pressure for Category 3 Hurricane

$V := V_{3\_min}$

$f(V) := \begin{cases} 1 & \text{if } V \le 100 mph \\ 0.77 & \text{if } V > 100 mph \end{cases}$

$I := f(V)$

$I = 0.77$

$q_{si} := 0.00256 \cdot V^2 \cdot \left(\frac{1}{mph}\right)^2$ $q_{si} = 31.542$

$q_s := q_{si} \cdot psf$ $q_s = 31.542\, psf$

$q_z := q_s \cdot K_z \cdot K_{zt} \cdot K_d \cdot I$ $q_z = 18.21\, psf$

$p_1 := q_z \cdot (GC_{pf} - GC_{p1})$

$p_2 := q_z \cdot (GC_{pf} - GC_{p2})$

$pressure_{category\_3\_min} := \max(p_1, p_2)$

$pressure_{category\_3\_min} = 15.843 \frac{lbf}{ft^2}$

Max pressure for Category 3 Hurricane

$V := V_{3\_max}$

$f(V) := \begin{cases} 1 & \text{if } V \le 100 mph \\ 0.77 & \text{if } V > 100 mph \end{cases}$

$I := f(V)$

$I = 0.77$

$q_{si} := 0.00256 \cdot V^2 \cdot \left(\frac{1}{mph}\right)^2$ $q_{si} = 43.264$

$q_s := q_{si} \cdot psf$ $q_s = 43.264\, psf$

$q_z := q_s \cdot K_z \cdot K_{zt} \cdot K_d \cdot I$ $q_z = 24.978\,psf$

$p_1 := q_z \cdot \left(GC_{pf} - GC_{p1}\right)$

$p_2 := q_z \cdot \left(GC_{pf} - GC_{p2}\right)$

$pressure_{category\_3\_max} := \max\left(p_1, p_2\right)$

$pressure_{category\_3\_max} = 21.731 \frac{lbf}{ft^2}$

Min pressure for Category 4 Hurricane

$V := V_{4\_min}$

$f(V) := \begin{cases} 1 & \text{if } V \le 100mph \\ 0.77 & \text{if } V > 100mph \end{cases}$

$I := f(V)$

$I = 0.77$

$q_{si} := 0.00256 \cdot V^2 \cdot \left(\frac{1}{mph}\right)^2$ $q_{si} = 43.932$

$q_s := q_{si} \cdot psf$ $q_s = 43.932\,psf$

$q_z := q_s \cdot K_z \cdot K_{zt} \cdot K_d \cdot I$ $q_z = 25.364\,psf$

$p_1 := q_z \cdot \left(GC_{pf} - GC_{p1}\right)$

$p_2 := q_z \cdot \left(GC_{pf} - GC_{p2}\right)$

$pressure_{category\_4\_min} := \max\left(p_1, p_2\right)$

$pressure_{category\_4\_min} = 22.066 \frac{lbf}{ft^2}$

Max pressure for Category 4 Hurricane

$V := V_{4\_max}$

$f(V) := \begin{cases} 1 & \text{if } V \le 100mph \\ 0.77 & \text{if } V > 100mph \end{cases}$

$I := f(V)$

$I = 0.77$

$q_{si} := 0.00256 \cdot V^2 \cdot \left(\frac{1}{mph}\right)^2$ $q_{si} = 61.504$

$q_s := q_{si} \cdot psf$ $q_s = 61.504\,psf$

$q_z := q_s \cdot K_z \cdot K_{zt} \cdot K_d \cdot I$ $q_z = 35.508\,psf$

$p_1 := q_z \cdot \left(GC_{pf} - GC_{p1}\right)$

$p_2 := q_z \cdot \left(GC_{pf} - GC_{p2}\right)$

$pressure_{category\_4\_max} := \max\left(p_1, p_2\right)$

$pressure_{category\_4\_max} = 30.892\,\frac{lbf}{ft^2}$

Min pressure for Category 5 Hurricane

$V := V_{5\_min}$

$f(V) := \begin{cases} 1 & \text{if } V \le 100\,mph \\ 0.77 & \text{if } V > 100\,mph \end{cases}$

$I := f(V)$

$I = 0.77$

$q_{si} := 0.00256 \cdot V^2 \cdot \left(\frac{1}{mph}\right)^2$ $q_{si} = 62.3$

$q_s := q_{si} \cdot psf$ $q_s = 62.3\,psf$

$q_z := q_s \cdot K_z \cdot K_{zt} \cdot K_d \cdot I$ $q_z = 35.968\,psf$

$p_1 := q_z \cdot \left(GC_{pf} - GC_{p1}\right)$

$p_2 := q_z \cdot \left(GC_{pf} - GC_{p2}\right)$

$pressure_{category\_5\_min} := \max\left(p_1, p_2\right)$

$pressure_{category\_5\_min} = 31.292\,\frac{lbf}{ft^2}$

Summary of Pressure Due to Hurricane Winds

$pressure_{category\_1\_min} = 9.393\,\frac{lbf}{ft^2}$ $pressure_{category\_1\_max} = 15.071\,\frac{lbf}{ft^2}$

$pressure_{category\_2\_min} = 15.39\,\frac{lbf}{ft^2}$ $pressure_{category\_2\_max} = 15.559\,\frac{lbf}{ft^2}$

$$\text{pressure}_{\text{category\_3\_min}} = 15.843 \frac{\text{lbf}}{\text{ft}^2} \qquad \text{pressure}_{\text{category\_3\_max}} = 21.731 \frac{\text{lbf}}{\text{ft}^2}$$

$$\text{pressure}_{\text{category\_4\_min}} = 22.066 \frac{\text{lbf}}{\text{ft}^2} \qquad \text{pressure}_{\text{category\_4\_max}} = 30.892 \frac{\text{lbf}}{\text{ft}^2}$$

$$\text{pressure}_{\text{category\_5\_min}} = 31.292 \frac{\text{lbf}}{\text{ft}^2}$$

$$\text{Pressure} := \begin{pmatrix} \text{pressure}_{\text{category\_1\_min}} & \text{pressure}_{\text{category\_1\_max}} \\ \text{pressure}_{\text{category\_2\_min}} & \text{pressure}_{\text{category\_2\_max}} \\ \text{pressure}_{\text{category\_3\_min}} & \text{pressure}_{\text{category\_3\_max}} \\ \text{pressure}_{\text{category\_4\_min}} & \text{pressure}_{\text{category\_4\_max}} \\ \text{pressure}_{\text{category\_5\_min}} & 0 \cdot \text{psf} \end{pmatrix} \qquad \text{Pressure} = \begin{pmatrix} 9.393 & 15.071 \\ 15.39 & 15.559 \\ 15.843 & 21.731 \\ 22.066 & 30.892 \\ 31.292 & 0 \end{pmatrix} \text{psf}$$