Wind Design:
ASCE 7-98, 7-02, 7-05, 7-10, 7-16, 7-22;
IBC 2000, 2003, 2006, 2009, 2012, 2015, 2018, 2021;
CBC-2010, CBC-2013, 2016, 2019, 2022

Notes on Reference to ASCE 7

IBC 2000 defers to the use of ASCE 7 for wind design in paragraph 1609.1.1 on page 305. IBC 2000 Chapter 35 references ASCE 7-98.

IBC 2003 defers to the use of ASCE 7 for wind design in paragraph 1609.1.1 on page 305. IBC 2003 Chapter 35 references ASCE 7-02.

IBC 2006 defers to the use of ASCE 7 for wind design in paragraph 1609.1.1 on page 292. IBC 2009 defers to the use of ASCE 7 for wind design in paragraph 1609.1.1 on page 16-47 of Volume II. CBC 2010 defers to ASCE 7 for wind design in paragraph 1609.1.1 on page 20 of Volume II. IBC 2006 and 2009 and CBC 2010 Chapter 35 references ASCE 7-05.

IBC 2012 defers to the use of ASCE 7 for wind design in paragraph 1609.1.1 on page 348. CBC 2013 defers to the use of ASCE 7 for wind design in paragraph 1609.1.1 on page 18 of Volume II. IBC 2015 defers to the use of ASCE 7 for wind design in paragraph 1609.1.1 on page 366. CBC 2016 defers to the use of ASCE 7 for wind design in paragraph 1609.1.1 on page 16 of Volume II. IBC 2012 and CBC 2013 and IBC 2015 and CBC 2016 Chapter 35 references ASCE 7-10.

IBC 2018 defers to the use of ASCE 7 for wind design in paragraph 1609.1.1 on page 401. CBC 2019 defers to the use of ASCE 7 for wind design in paragraph 1609.1.1 on page 17 of Volume II. IBC 2021 defers to the use of ASCE 7 for wind design in paragraph 1609.1.1 on page 431. CBC 2022 defers to the use of ASCE 7 for wind design in paragraph 16091.1 on page 59 of Volume II. IBC 2018 and CBC 2019 and IBC 2021 and CBC 2022 Chapter 35 references ASCE 7-16.

Inputs

1. Determine the worst exposure category for the vessel, considering each direction.[a b c d e]
    a. Category A is only an option for ASCE 7-98 and IBC 2000.

2. Determine the basic wind speed, V , for the vessel:
    a. Use Figures 6-1 through 6-1c. for ASCE 7-98 and Figure 1609 for IBC 2000. [f]
    b. Use Figures 6-1 through 6-1c. for ASCE 7-02 and Figure 1609 for IBC 2003. [g]
    c. Use Figures 6-1 through 6-1c. for ASCE 7-05, Figure 1609 for IBC 2006 and IBC 2009 and CBC 2010. [h]
    d. Use Figures 26.5-1A – 26.5-1C for ASCE 7-10, Figure 1609 for IBC 2012 and CBC 2013 and IBC 2015, Figure 1609 for CBC 2016. [i]
    e. Use Figures 26.5-1A – 26.5-2D for ASCE 7-16, Figures 1609.3(1) through 1609.3(8) for IBC 2018, Figures 1609.3(1) through 1609.3(12) for IBC 2021, Figures 1609.3(1) through 1609.3(8) for CBC 2019, Figures 1609.3(1) through 1609.3(12) for CBC 2022. [j]
    f. Use Figures 26.5-1A – 26.5-1D for ASCE 7-22 [k]

3. Determine the worst topographic factor, K_{zt} , for the vessel, considering each direction:
    a. This value is typically greater than or equal to 1.
    b. Use ASCE 7-98 Fig. 6-2 for ASCE 7-98 and IBC 2000. [l]
    c. Use ASCE 7-02 Fig. 6-4 for ASCE 7-02 and IBC 2003. [m]
    d. Use ASCE 7-05 Fig. 6-4 for ASCE 7-05, IBC 2006, IBC 2009 and CBC 2010. [n]
    e. Use ASCE 7-10 Fig. 26.8-1 for ASCE 7-10, IBC 2012, IBC 2015, CBC 2013, and CBC 2016. [o]
    f. Use ASCE 7-16 Fig. 26.8-1 for ASCE 7-16, IBC 2018, IBC 2021, CBC 2019, and CBC 2022. [p]
    g. Use ASCE 7-22 Fig. 26.8-1 for ASCE 7-22 [q]

4. Determine the worst wind directionality factor, K_d, for the vessel:
    a. This value typically ranges from 0.85 to 1.
    b. Use ASCE 7-98 Table 6-6 for ASCE 7-98 and IBC 2000. [r]
    c. Use ASCE 7-02 Table 6-4 for ASCE 7-02 and IBC 2003. [s]
    d. Use ASCE 7-05 Table 6-4 for ASCE 7-05, IBC 2006, IBC 2009 and CBC 2010. [t]
    e. Use ASCE 7-10 Table 26.6-1 for ASCE 7-10, IBC 2012, IBC 2015, CBC 2013, and CBC 2016. [u]
    f. Use ASCE 7-16 Table 26.6-1 for ASCE 7-16, IBC 2018, IBC 2021, CBC 2019, and CBC 2022. [v]
    g. Use ASCE 7-22 Table 26.6-1 for ASCE 7-22 [w]

5. Determine the worst net force coefficient, C_f, for the vessel, considering each direction:
    a. This value typically ranges from 0.5 to 2.
    b. Use ASCE 7-98 Table 6-10 for ASCE 7-98 and IBC 2000. [x]
    c. Use ASCE 7-02 Figure 6-19 for ASCE 7-02 and IBC 2003. [y]
    d. Use ASCE 7-05 Figure 6-21 for ASCE 7-05, IBC 2006, IBC 2009 and CBC 2010. [z]
    e. Use ASCE 7-10 Figure 29.5-1 for ASCE 7-10, IBC 2012, IBC 2015, CBC 2013, and CBC 2016. [aa]
    f. Use ASCE 7-16 Figure 29.4-1 for ASCE 7-16, IBC 2018, IBC 2021, CBC 2019, and CBC 2022. [bb]
    g. Use ASCE 7-22 Figure 29.4-1 for ASCE 7-22 [cc]

6. Determine the importance factor, *I*, for the vessel:
    a. This value typically ranges from 0.77 to 1.15.
    b. Use ASCE 7-98 Table 6-1 for ASCE 7-98 and IBC 2000. [dd]
    c. Use ASCE 7-02 Table 6-1 for ASCE 7-02 and IBC 2003. [ee]
    d. Use ASCE 7-05 Table 6-1 for ASCE 7-05, IBC 2006, IBC 2009 and CBC 2010. [ff]
    e. This is not used for ASCE 7-10, -16, -22, IBC 2012, 2015, 2018, 2021, CBC 2013, 2016, 2019, 2022 as these codes instead use wind speed maps that account for this concept.

7. Determine the ground elevation factor, K_e, for the vessel:
    a. The value typically ranges from 0.8 to 1.
    b. This value is not used for ASCE 7-98, -02, -05, -10, IBC 2000, 2003, 2006, 2009 2012, 2015, CBC 2010, 2013, or 2016.
    c. Use ASCE 7-16 Table 26.9-1 for ASCE 7-16, IBC 2018, 2021, CBC 2019, 2022. [gg]
    d. Use ASCE 7-22 Table 26.9-1 for ASCE 7-22 [hh]

8. Determine the gust effect factor, *G*, for vessels not supported on skirts:
    a. This value is typically 0.85 or greater.
    b. This value is calculated by DesignCalcs for skirt supported vessels per condition (e.g. Operating, Empty).

9. Determine the dampening coefficient, β, for vessels supported on skirts.

Math

1. Determine a and z_g for all vessels. Determine the additional values for skirt supported vessels only. **Note that â and b̂ are not currently used.**

ASCE 7-98, -02, -05, -10, 16, IBC 2000, 2003, 2006, 2009, 2012, 2015, 2018, 2021, CBC 2010, 2013, 2016, 2019, 2022

Exposure	α	z_g ft (m)	â	b hat	a bar	b bar	c	ℓ ft (m)	Ebar	z_{min} ft (m)
A	5.0	1500 (457.2)	1/5	0.64	1/3.0	0.30	0.45	180 (54.864)	1/2.0	60 (18.288)
B	7.0	1200 (365.76)	1/7	0.84	1/4.0	0.45	0.30	320 (97.54)	1/3.0	30 (9.14)
C	9.5	900 (274.32)	1/9.5	1.00	1/6.5	0.65	0.20	500 (152.4)	1/5.0	15 (4.57)
D	11.5	700 (213.36)	1/11.5	1.07	1/9.0	0.80	0.15	650 (198.12)	1/8.0	7 (2.13)

Table 1a: Terrain Exposure Constants [ii jj kk ll mm]

ASCE 7-22

Exposure	α	z_g ft (m)	â	b hat	a bar	b bar	c	ℓ ft (m)	Ebar	z_{min} ft (m)
A	7.5	3280 (1,000)	1/7.5	0.84	1/4.5	0.47	0.30	320 (97.54)	1/3.0	30 (9.14)
B	7.5	3280 (1,000)	1/7.5	0.84	1/4.5	0.47	0.30	320 (97.54)	1/3.0	30 (9.14)
C	9.8	2,460 (750)	1/9.8	1.00	1/6.4	0.66	0.20	500 (152.40)	1/5.0	15 (4.57)
D	11.5	1,935 (590)	1/11.5	1.09	1/8.0	0.78	0.15	650 (198.12)	1/8.0	7 (2.13)

Table 1b: Terrain Exposure Constants [nn]

2. Determine Z. Z is the wind center of gravity for Lug/Leg/Support Ring supported vessels. Z is the vessel centerline height for saddle supported vessels. For Skirt supported vessels, Z is determined for each of the vessel segments in the Tower Analysis report and it is the top elevation of the segment.

3. Determine $Z_{min\text{-}Kz}$: [oo pp qq rr ss tt]

$$z_{min-K_z} = 15\ ft\ (4.6\ m)$$

4. Determine K_z: [uu vv ww xx yy zz]

For ASCE 7-98, -02, -05, -10, -16, IBC 2000, 2003, 2006, 2009, 2012, 2015, 2018, 2021, CBC 2010, 2013, 2016, 2019, 2022 use:

$$K_z = 2.01\left(\frac{max\left(Z_{min-K_z}, Z\right)}{z_g}\right)^{\frac{2}{\alpha}}$$

For ASCE 7-22 and z <= z_g use:

$$K_z = 2.41\left(\frac{max\left(Z_{min-K_z}, Z\right)}{z_g}\right)^{\frac{2}{\alpha}}$$

For ASCE 7-22 and z_g <= z <= 3,280 ft (1,000 m) use:

$$K_z = 2.41$$

5. Determine C_{qz}: aaa bbb ccc ddd eee fff

C_{qz} = 0.00256 for Customary

C_{qz} = 0.613 for Metric

6. Determine q_z: ggg hhh iii jjj kkk lll

$$q_z = C_{qz}K_zK_{zt}K_dV^2I \text{ for ASCE 7-98, -02, -05}$$

$$q_z = C_{qz}K_zK_{zt}K_dV^2 \text{ for ASCE 7-10}$$

$$q_z = C_{qz}K_zK_{zt}K_dK_eV^2 \text{ for ASCE 7-16, -22}$$

7. Determine the First Natural Period of Vibration, *T*, for skirt supported vessels. This is done by DesignCalcs for each loading condition (e.g. operating and empty).

8. Determine the natural frequency, n_1, for skirt supported vessels for each loading condition.

$$n_1 = \frac{1}{T}$$

9. Determine *G* (for skirt supported vessels this is done for each loading condition).

a. Use the user input value for support types other than skirts.

b. For skirt supported vessels for each condition with n_1 >= 1, $G = 0.85$. mmm nnn ooo ppp qqq rrr

c. For skirt supported vessels for each condition with n_1 < 1: sss ttt uuu vvv www xxx

h = height at top of vessel

B = L = smallest diameter segment on vessel

$$\bar{z} = max(0.6h, z_{min})$$

$$g_Q = 3.4$$

$$g_v = 3.4$$

$$x_0 = 33ft\ (10\ m)$$

$$I_{\bar{z}} = c\left(\frac{x_o}{\bar{z}}\right)^{1/6}$$

$$L_{\bar{z}} = \ell\left(\frac{\bar{z}}{x_0}\right)^{\bar{\epsilon}}$$

$$x_1 = \frac{88}{60}(Customary) = 1(Metric)$$

$$Q = \sqrt{\frac{1}{1 + 0.63\left(\frac{B+h}{L_{\bar{z}}}\right)^{0.63}}}$$

$$\bar{V}_{\bar{z}} = \bar{b}\left(\frac{\bar{z}}{x_0}\right)^{\bar{a}} x_1 V$$

$$N_1 = \frac{n_1 L_{\bar{z}}}{\bar{V}_{\bar{z}}}$$

$$R_n = \frac{7.47N_1}{(1 + 10.3N_1)^{5/3}}$$

$$n_h = \frac{4.6n_1 h}{\bar{V}_{\bar{z}}}$$

$$n_B = \frac{4.6n_1 B}{\bar{V}_{\bar{z}}}$$

$$n_L = \frac{15.4n_1 L}{\bar{V}_{\bar{z}}}$$

$$R_h = \frac{1}{n_h} - \frac{1}{2{n_h}^2}(1 - e^{-2n_h})\ for\ n_h > 0\ and\ R_h = 1\ for\ n_h = 0$$

$$R_B = \frac{1}{n_B} - \frac{1}{2{n_B}^2}(1 - e^{-2n_B})\ for\ n_B > 0\ and\ R_B = 1\ for\ n_B = 0$$

$$R_L = \frac{1}{n_L} - \frac{1}{2{n_L}^2}(1 - e^{-2n_L})\ for\ n_L > 0\ and\ R_L = 1\ for\ n_L = 0$$

$$R = \sqrt{\frac{1}{\beta} R_n R_h R_B (0.53 + 0.47R_L)}$$

$$g_R = \sqrt{2\ln(3600n_1)} + \frac{0.577}{\sqrt{2\ln(3600n_1)}}$$

$$G = 0.925\left(\frac{1 + 1.7I_{\bar{z}}\sqrt{g_Q^2 Q^2 + g_R^2 R^2}}{1 + 1.7g_v I_{\bar{z}}}\right)$$

10. Determine the minimum wind pressure: yyy zzz aaaa bbbb cccc dddd

P_{min} = 10 lbf/ft^2 (480 N/m^2) for ASCE 7-98, -02, -05

P_{min} = 16 lbf/f^{t2} (770 N/m^2) for ASCE 7-10, -16, -22

11. Determine the wind pressure: eeee ffff gggg hhhh iiii jjjj

$P_W = \max(q_z G C_f, P_{min})$ lbf/ft^2 (N/m^2)

12. Determine the wind load case multiplier: kkkk llll mmmm nnnn oooo pppp

C_{wi} = 1 for ASCE 7-98 and IBC 2000 for load cases 3 and 4

C_{wi} = 1 for ASCE 7-02, -05 and IBC 2003, 2006, 2009, CBC 2010 for load cases 5 and 7

C_{wi} = 0.75 for ASCE 7-02, -05 and IBC 2003, 2006, 2009, CBC 2010 for load case 6

C_{wi} = 0.6 for ASCE 7-10, -16, -22 and IBC 2012, 2015 and CBC 2013 for load cases 5 and 7

C_{wi} = 0.45 for ASCE 7-10, -16, -22 and IBC 2012, 2015 and CBC 2013 for load case 6

13. Determine the projected area affected by wind, A_f. For skirt supported vessels, this is done per segment in the tower analysis. For saddle supported vessels, this is done for both the longitudinal and transverse directions.

14. Determine the wind force, F_W. For skirt supported vessels, this is done per segment in the tower analysis. For saddle supported vessels, this is done for both the longitudinal and transverse directions.

$$F_W = P_W A_f C_{wi}$$

a. ASCE 7-98, Par. 6.5.6.1, pg. 28; IBC 2000, Par. 1609.4, pg. 311
b. ASCE 7-02, Par. 6.5.6.3, pg. 29; IBC 2003, Par. 1609.4, pg. 290
c. ASCE 7-05, Par. 6.5.6.3, pgs. 25-26; IBC 2006, Par. 1609.4.3, pg. 293; IBC 2009, Par. 1609.4.3, pg. 325; CBC 2010 Vol. II, Par. 1609.4.3, pg. 27
d. ASCE 7-10, Par. 26.7.3, pg. 251; IBC 2012, Par. 1609.4.3, pg. 353; CBC 2013, Par. 1609.4.3, pg. 23; IBC 2015, Par. 1609.4.3, pgs. 373 – 374; CBC 2016 Vol. II, Par. 1609.4.3, pg. 5
e. ASCE 7-16, Par. 26.7.3, pg. 266; IBC 2018, Par. 1609.4.3, pg. 378; CBC 2019, Par. 1609.4.3, pg. 25; IBC 2021, Par. 1609.4.3, pg. 447; CBC 2022, Par. 1609.4.3, pg. 63
f. ASCE 7-98, pgs. 34-38; IBC 2000, pgs. 314-318
g. ASCE 7-02, pgs. 36-40; IBC 2003, pgs. 284-288
h. ASCE 7-05, pgs. 32-36; IBC 2006, pgs. 294-298; IBC 2009, pgs. 320 - 324; CBC 2010 Vol. II, pgs. 22-26
i. ASCE 7-10, Figures 26.5-1A – 26.5-1C, pgs. 247a-249b; IBC 2012, pgs. 350-352; CBC 2013, pgs. 20-22; IBC 2015, pgs. 370-372; CBC 2016, pgs. 20-22
j. ASCE 7-16, Figures 26.5-1A – 26.5-2D, pgs. 250 – 265; IBC 2018, Figures 1609.3(1)-(8), pgs. 379-390; CBC 2019, Figures 1609.3(1) – (4), pgs. 20-23; IBC 2021, Figures 1609.3(1)-(12), pgs. 435-446; CBC 2022, Figures 1609.3(1)-(4), pgs. 64-67
k. ASCE 7-22, Figures 26.5-1A – 26.5-1D, pgs. 266 - 271
l. ASCE 7-98, Figure 6-2, pgs. 39-40
m. ASCE 7-02, Figure 6-4, pgs. 47-48
n. ASCE 7-05, Figure 6-4, pgs. 45-46
o. ASCE 7-10, Figure 26.8-1, pgs. 252-253
p. ASCE 7-16, Figure 26.8-1, pg. 267
q. ASCE 7-22, Figure 26.8-1, pg. 276
r. ASCE 7-98, Table 6-6, pg. 61
s. ASCE 7-02, Table 6-4, pg. 76
t. ASCE 7-05, Table 6-4, pg. 80
u. ASCE 7-10, Table 26.6-1, pg. 250
v. ASCE 7-16, Table 26.6-1, pg. 256
w. ASCE 7-22, Table 26.6-1, pg. 274
x. ASCE 7-98, Table 6-10, pg. 65
y. ASCE 7-02, Figure 6-19, pg. 69
z. ASCE 7-05, Figure 6-21, pg. 74
aa. ASCE 7-10, Figure 29.5-1, pg. 312
bb. ASCE 7-16, Figure 29.4-1, pg. 325
cc. ASCE 7-16, Figure 29.4-1, pg. 303
dd. ASCE 7-98, Table 6-1, pg. 55
ee. ASCE 7-02, Table 6-1, pg. 73
ff. ASCE 7-05, Table 6-1, pg. 77
gg. ASCE 7-16, Table 26.9-1, pg. 268
hh. ASCE 7-22, Table 26.9-1, pg. 275
ii. ASCE 7-98, Table 6-4 pg. 59
jj. ASCE 7-02, Table 6-2, pg. 74
kk. ASCE 7-05, Table 6-2, pg. 78
ll. ASCE 7-10, Table 26.9-1, pg. 256

mm. ASCE 7-16, Table 26.11-1, pg. 269
nn. ASCE 7-22, Table 26.11-1, pg. 278
oo. ASCE 7-98, Table 6-5 pg. 60
pp. ASCE 7-02, Table 6-3, pg. 75
qq. ASCE 7-05, Table 6-3, pg. 79
rr. ASCE 7-10, Table 27.3-1, pg. 261
ss. ASCE 7-16, Table 26.10-1, pg. 268
tt. ASCE 7-22, Table 26.10-1, pg. 277
uu. ASCE 7-98, Table 6-5 pg. 60
vv. ASCE 7-02, Table 6-3, pg. 75
ww. ASCE 7-05, Table 6-3, pg. 79
xx. ASCE 7-10, Table 27.3-1, pg. 261
yy. ASCE 7-16, Table 26.10-1, pg. 268
zz. ASCE 7-22. Table 26.10-1, pg. 277
aaa. ASCE 7-98, Par. 6.5.10, pg. 30
bbb. ASCE 7-02, Par. 6.5.10, pg. 31
ccc. ASCE 7-05, Par. 6.5.10, pg. 27
ddd. ASCE 7-10, Par. 29.3.2, pg. 261
eee. ASCE 7-16, Par. 26.10.2, pg. 268
fff. ASC 7-22, Par. 26.10.2, pg. 277
ggg. ASCE 7-98, Par. 6.5.10, pg. 30
hhh. ASCE 7-02, Par. 6.5.10, pg. 31
iii. ASCE 7-05, Par. 6.5.10, pg. 27
jjj. ASCE 7-10, Par. 29.3.2, pg. 261
kkk. ASCE 7-16, Par. 26.10.2, pg. 268
lll. ASCE 7-22, Par. 26.10.2, pg. 277
mmm. ASCE 7-98, Par. 6.5.8.1, pg. 29
nnn. ASCE 7-02, Par. 6.5.8.1, pg. 30
ooo. ASCE 7-05, Par. 6.5.8.1, pg. 26
ppp. ASCE 7-10, Par. 29.3.4, pg. 254
qqq. ASCE 7-16, Par. 26.11.4, pg. 269
rrr. ASCE 7-22, Par. 26.11.4, pg. 278
sss. ASCE 7-98, Par. 6.5.8.2, pgs. 29 – 30
ttt. ASCE 7-02, Par. 6.5.8.2, pg. 30
uuu. ASCE 7-05, Par. 6.5.8.2, pgs. 26 – 27
vvv. ASCE 7-10, Par. 29.3.5, pg. 255
www. ASCE 7-16, Par. 26.11.5, pg. 270
xxx. ASCE 7-22, Par. 26.11.5, pg. 278-279
yyy. ASCE 7-98, Par. 6.1.4.1, pg. 23
zzz. ASCE 7-02, Par. 6.1.4.1, pg. 23
aaaa. ASCE 7-05, Par. 6.1.4.1, pg. 21
bbbb. ASCE 7-10, Par. 29.8, pg. 309
cccc. ASCE 7-16, Par. 29.7, pg. 332
dddd. ASCE 7-22, Par. 29.7, pg. 311
eeee. ASCE 7-98, Par. 6.5.13, pg. 33
ffff. ASCE 7-02, Par. 6.5.13, pg. 34

gggg. ASCE 7-05, Par. 6.5.15, pg. 29
hhhh. ASCE 7-10, Par. 29.5, Eq. 29.5-1, pg. 308
iiii. ASCE 7-16, Par. 29.4-1, Eq. 29.4-1, pg. 322
jjjj. ASCE 7-22, Par. 29.4-1, Eq. 29.4-1, pg. 300
kkkk. ASCE 7-98, Par. 2.4.1, pg. 5
llll. ASCE 7-02, Par. 2.4.1, pg. 6
mmmm. ASCE 7-05, Par. 2.4.1, pg. 5
nnnn. ASCE 7-10, Par. 2.4.1, pg. 8
oooo.ASCE 7-16, Par. 2.4.1, pg. 8
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