Appendix A Example 1: Wind Loads

This appendix covers the topic of wind loads. It uses three different methods to calculate wind loads, including Caltrans standard specifications, ASCE 7-16, and an AASHTO method. The results of the methods are then tabulated and compared.

Given Information

- Containment structure 42 feet high and 15 feet wide starting at grade
- Supported at top and base
- Located adjacent to traffic
- Ground elevation = 1000 ft

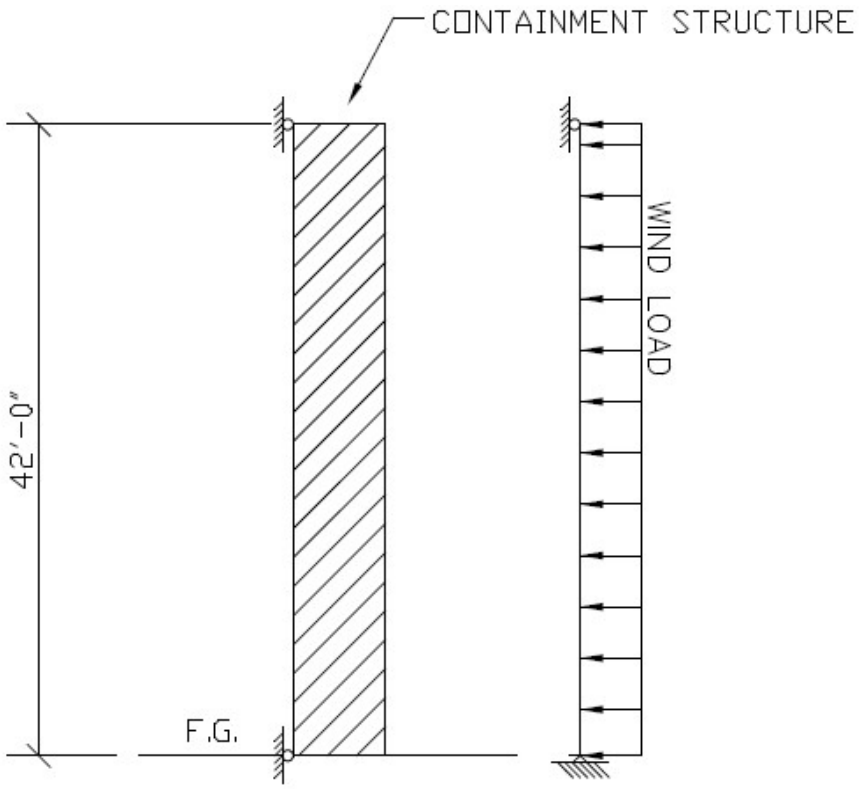

Figure A-1-1. Containment Structure Section

Required

1. Determine wind pressure using the wind pressure tables in *Contract Specifications* Section 48-2.02B(2), *Temporary Structures – Falsework – Materials – Design Criteria – Loads.*
2. Determine the wind pressure using ASCE 7-16.
3. Determine the wind pressure using AASHTO *Guide Design Specification for Bridge Temporary Works* (GSBTW).
4. Compare the results of the three methods above.
5. Determine the total force for each method above at top and bottom support.

1 - Wind Pressure Table Method (Contract Spec. 48-2)

Height zone, H (feet above ground)	Wind pressure value	
	Shores or columns adjacent to traffic (psf)	At other locations (psf)
H≤30	20	15
30<H≤50	25	20
50<H≤100	30	25
H>100	35	30

Figure A-1-2. Wind Pressure Table from Section 48-2.02B(2)

Height zone 0 to 30 feet pressure = 20 psf(15')(30') = 9000 lbs
Height zone 30 to 42 feet pressure = 25 psf(15')(12') = 4500 lbs
Total force = 13500 lbs

Total force on top support ($\mathbf{F_t}$):

$$F_t = \frac{9000(15) + 4500(36)}{42} = 7071 \text{ lbs} \quad \text{(A-1-1)}$$

Total force on bottom support ($\mathbf{F_b}$):

$$F_b = 13500 - 7071 = 6429 \text{ lbs} \quad \text{(A-1-2)}$$

2 - ASCE 7-16 Method

Determine the basic wind pressure using the procedures in ASCE 7-16, Chapter 26, *Wind Loads: General Requirements* and Chapter 29, *Wind Loads on Building Appurtenances and Other Structures* (this and other resources may be obtained from the Transportation Library[1]).

Given

Basic wind speed from Figure A-1-3 below (assume Risk Category II)

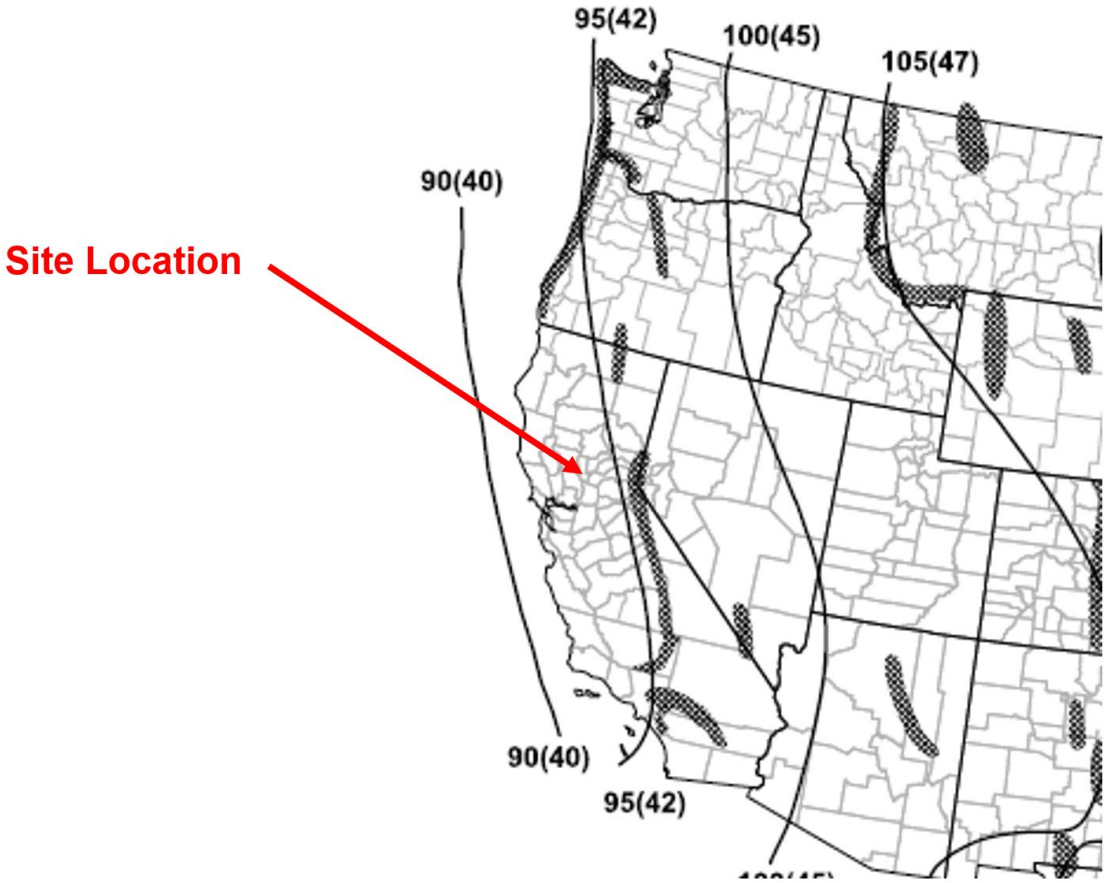

Figure A-1-3. Basic wind speeds for Risk Category II Buildings and Other Structures (ASCE 7-16 Figure 26.5-1B)

Basic wind speed (V) = 93 mph (interpolated based on site location)

The surface roughness and exposure are site specific

[1] Caltrans internal use only

Surface Roughness category = B (ASCE 26.7.2)

Exposure category = B (ASCE 26.7.3)

Topographic effects over hills, ridges, escarpments are determined using the topographic factor (**K_{zt}**) found in ASCE 26.8.2. For this example, there are no topographic effects which results in **K_{zt}** =1.0.

The ground level for this example is 1000 feet. From ASCE 7-16 Table 26.9-1, the ground elevation factor (**K_e**) = 0.96

Velocity pressure exposure coefficient from ASCE 7-16 Table 26.10-1 (shown below):

K_z for height above ground (**z**) 42 feet = 0.77 interpolated value (ASCE Table 26.10-1)

The wind directionality factor (**K_d**) = 0.85 (ASCE Table 26.6-1)

The velocity pressure (ASCE equation 26.10-1) at height **z** is shown below:

$$q_z = 0.00256\,(K_z)(K_{zt})(K_d)(K_e)(V^2) \qquad \text{(A-1-3)}$$

Therefore, **q_z** for height 42 feet is:

$$q_z = 0.00256(0.77)(1.0)(0.85)(0.96)(93)^2 = 13.9\ \text{psf} \qquad \text{(A-1-4)}$$

Using ASCE 7-16 Chapter 29, *Wind Loads on Building Appurtenances and Other Structures*- from section 29.3 *Design Wind Loads: Solid Freestanding Walls and Solid Signs*:

Design wind force (**F**)	=	$q_h G C_f A_s$ (ASCE Eq 29.3-1)
q_h = **q_z**	=	13.9 psf
Gust factor (**G**)	=	0.85 (ASCE 26.11.1)
s/h = 42/42	=	1 (ASCE Figure 29.3-1)
B/s = 15/42	=	0.36 (ASCE Figure 29.3-1)
Force coefficient (**C_f**)	=	1.60 (interpolated from ASCE Figure 29.3-1)
Projected area (**As**)	=	630 sqft

$$F = 13.9(0.85)(1.60)(630) = 11910 \text{ lbs} \quad \text{(A-1-5)}$$

Force applied at $\frac{42}{2} + 0.05(42) = 23.10$ ft (common practice to apply at 55 % height) (A-1-6)

Design forces calculated above are strength design. For allowable stress design the design force is multiplied by 0.6 per ASCE 2.4 *Load Combinations for Allowable Stress Design.* Loads specified by the designer are service loads and are not reduced by the 0.6 factor. A wind load specified by the designer for removal of the containment system is an example of a service load that is not reduced.
Total force on top (**F_t**) support:

$$F_t = 0.6\left(\frac{23.10}{42}\right)(11910) = 3930 \text{ lbs} \quad \text{(A-1-7)}$$

Total force on bottom (**F_b**) support:

$$F_b = 0.6\,(11910) - 3930 = 3216 \text{ lbs} \quad \text{(A-1-8)}$$

Verify conformance with minimum loading (16 psf) of ASCE 29.7:

$$F_{min} = \frac{0.6(16)(15)(42)}{2} = 3024 \text{ lbs} < 3216 \text{ lbs} \quad \text{(A-1-9)}$$

3 - AASHTO GSBTW Method

Determine the wind pressure using AASHTO *Guide Design Specification for Bridge Temporary Works* (GSBTW)

Given

Basic wind speed from AASHTO Bridge Design Specification (BDS) is shown in Figure A-1-4 below:

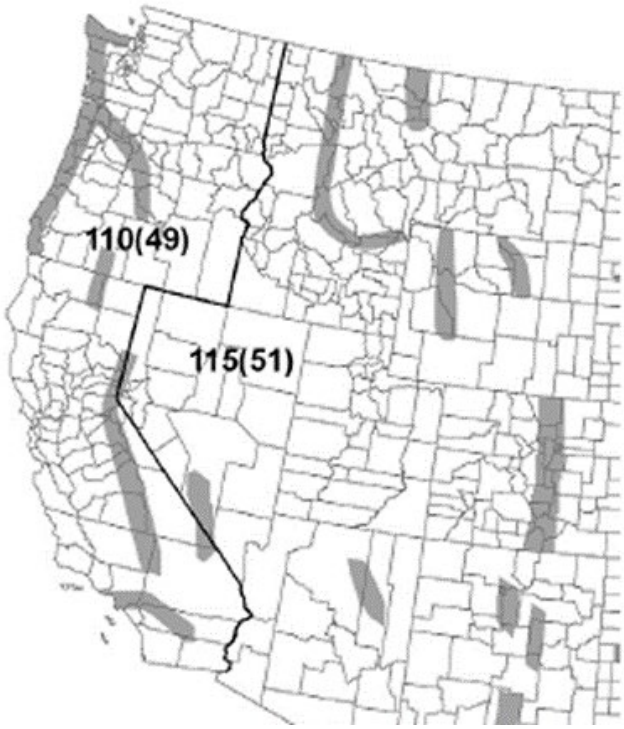

Figure A-1-4. Basic wind speed from AASHTO Bridge Design Specification (Figure 3.8.1.1.2-1)

Figure 3.8.1.1.2-1 is based on ASCE 7-10 with values corresponding to 3-second gust wind speeds at 33 feet above ground for Exposure C. Future revisions of the BDS will use wind maps found in the latest version of ASCE 7.

Basic wind speed (**V**) = 110 mph

Wind exposure category = **B** (used in previous example)

Pressure exposure coefficient at **h**= 42 feet ($\mathbf{K_z}$) = 0.76 (AASHTO BDS Table C3.8.1.2.1-1)

Gust coefficient (**G**) = 0.85 (GSBTW 2.3.5.2.3b)

Drag coefficient ($\mathbf{C_D}$) for solid surface = 2.0 (GSBTW Table 2.3.5.2.3b-2)

Wind directionality factor ($\mathbf{K_d}$) = 0.95 (GSBTW 2.3.5.2.3b)

Design wind pressure $\mathbf{P_z} = 0.00256(K_z)(G)(C_d)(K_d)(V^2)$

$\mathbf{P_z}$ for height 42 feet = $0.00256(0.76)(0.85)(2.0)(0.95)(110^2) = 38.02$ psf

Increase $\mathbf{P_z}$ by 5 psf for members over or adjacent to traffic per GSBTW 2.3.5.2.3b

$\mathbf{P_z}$ = 43.02 psf

$F= P_z(A)$

A = Area projected on vertical plane

Design forces calculated above are strength design. For allowable stress design the design force is multiplied by 0.6 per GSBTW Table 2.3.2.2-1 *Load Combinations and Load Factors.*

Total force **F**:

$$\mathrm{F} = 0.6\,(43.02)(15)(42) = 16262 \text{ lbs} \quad \text{(A-1-10)}$$

Total force on top ($\mathbf{F_t}$) and bottom ($\mathbf{F_b}$) support Case 1 (GSBTW 2.3.5.2.3d)

$$\mathrm{F_t} = \mathrm{F_b} = \frac{16262}{2} = 8131 \text{ lbs} \quad \text{(force applied at centroid)} \quad \text{(A-1-11)}$$

Total force on top ($\mathbf{F_t}$) support Case 2 (GSBTW 2.3.5.2.3d)

$$\mathrm{F_t} = \left(\frac{23.10}{42}\right)(16262) = 8944 \text{ lbs} \quad \text{(Total Force applied at 0.55 height of gross area)}$$

(A-1-12)

$$\mathrm{F_b} = 16262 - 8944 = 7318 \text{ lbs} \quad \text{(Total Force applied at 0.55 height of gross area)}$$

(A-1-13)

4 - Comparison of Methods

Table A-1-1. Comparison of Methods

Design Method	Total Force (lbs)	Force at Top (lbs)	Force at Bottom (lbs)
CT Pressure Table	13500	7071	6429
ASCE 7-16	7146	3930	3216
AASHTO GSBTW	16262	8944	7318

The wind pressure tables in *Contract Specifications* Section 48-2, *Loads*, are an acceptable method to determine forces on other temporary structures. If the temporary structure design is capable of resisting the wind pressure loads in Section 48-2, no further analysis is needed.

If it is determined the temporary structure cannot resist the loading using the wind pressure tables in Section 48-2, then further analysis using the wind pressure method the temporary structure designer used is required to determine if the structure can resist the calculated wind loads.