Florida Department of Transportation

CHARLIE CRIST
GOVERNOR

605 Suwannee Street
Tallahassee, FL 32399-0450

STEPHANIE C. KOPELOUSOS
SECRETARY

TEMPORARY DESIGN BULLETIN C09-07

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TO: District Directors of Production, District Design Engineers, District Structures Design Engineers, District Construction Engineers

FROM: Robert Robertson, P.E., State Structures Design Engineer

COPIES: Brian Blanchard, Lora Hollingsworth

SUBJECT: Revised Wind Loading Criteria for New Bridge Projects

This Temporary Design Bulletin (TDB) revises the Wind Load calculation criteria for both the construction period and service life for all new bridges.

REQUIREMENTS

1. Structures Manual, Volume 1: Structures Design Guidelines (SDG)

    a. Section 2.4 Wind Loads - Replace Section 2.4 with Attachment 'A.'

COMMENTARY

The following attachments may be used for the calculation of wind loading and evaluation of the effect of calculation changes:

Attachment 'A' – SDG: Section 2.4 - Wind Loads

Attachment 'B' – Example Calculations

Attachment 'C' – Comparisons of New SDG Design Wind Pressures and *AASHTO LRFD Bridge Design Specifications* Design Wind Pressures

Attachment 'D' – Comparisons of New SDG Design Wind Pressures and *AASHTO Guide Design Specifications for Bridge Temporary Works* Design Wind Pressures

BACKGROUND

The revised procedures for calculation of wind loads are based on chapter six of *ASCE 7-05, Minimum Design Loads for Buildings and Other Structures*. In addition to updated coefficients based on extensive research by ASCE, these revised calculations are also based on a three second gust design wind speed. The fastest mile wind speed, which is the measure of wind speed used in the *AASHTO LRFD Bridge Design Specifications* and the *AASHTO Guide Design Specifications for Bridge Temporary Works*, has been phased out of measurement by the National Weather Service. The three second gust wind speed is now the common unit of measure for wind speed.

These calculations provide a more accurate and uniform calculation method for wind loading, based on current wind speed maps. The revised basic wind speeds represent a mean recurrence interval of about 850 years, based on the strength limit state. The load factors for wind according to the *AASHTO LRFD Bridge Design Specifications* have been revised for some Service and Strength limit states as well as for construction loading. Although some load factors have been revised from the *AASHTO LRFD Bridge Design Specifications,* the definitions of each limit state remains equivalent.

The description of the Strength III, Strength V, Service I, and Service IV limit states according to the *AASHTO LRFD Bridge Design Specifications* are as follows:

- STRENGTH III – Load combination relating to the bridge exposed to wind velocity exceeding 55 mph.
- STRENGTH V – Load combination relating to normal vehicular use of the bridge with wind of 55 mph velocity.
- SERVICE I – Load combination relating to the normal operational use of the bridge with a 55 mph wind and all loads taken at their nominal values. Also related to deflection control in buried metal structures, tunnel liner plate, and thermoplastic pipe to control crack width in reinforced concrete structures, and for transverse analysis relating to tension in concrete segmental girders. This load combination should also be used for the investigation of slope stability.
- SERVICE IV – Load combination relating only to tension in prestressed concrete columns with the objective of crack control. (The commentary notes the 0.70 factor on wind represents an 84 mph wind with a 10 year mean recurrence interval.)

The Strength III, Strength V and Service I limit states have been revised to be based upon a three-second gust wind speed, instead of a fastest mile wind speed. A 55 mph fastest mile wind speed is about equivalent to a 70 mph three second gust wind speed, so the basic wind speed is a speed which exceeds 70 mph for the Strength III limit state and the basic wind speed is 70 mph for the Strength V and Service I limit states. Per AASHTO, the load factors for wind on structures for the Strength III and Service I limit states essentially include a load factor and a factor to reduce the wind speed from the base wind speed of 100 mph to the appropriate wind speed according the definition of the limit state. Due to the greater variance of wind speeds according to the ASCE maps for 3-second gust wind speeds, these factors for wind on structures are no longer appropriate. Instead, the basic wind speed used for wind pressure calculation is defined according to the limit state definition, and the factor for wind on structures is simply a load factor. This is further clarified in Attachment A, Section 2.4.1B. The load factor of 0.70 for the

Service IV limit state is based on a 10 year mean recurrence interval, which corresponds to an 84 mph fastest mile wind speed. The greater variety of wind speeds means it is not feasible to specify a three second gust wind speed which represents the mean recurrence interval of 10 years. However, a load factor of 0.60 represents a 10 year mean recurrence interval for a three second gust wind. Therefore, the load factor for the Service IV limit state has been revised to 0.60.

The equation for wind pressure, P_z, is similar to the wind pressure equation presented in ASCE 7-05. However, several simplifications have been made. Instead of requiring a designer to determine the wind speed according to a wind speed map, the map has been simplified into a table which specifies wind speeds according to Florida counties. ASCE 7 designates three different exposure categories based on surface roughness categories which have a diminishing effect on the wind pressure as height above grade increases. For simplicity purposes, the velocity pressure exposure coefficient is calculated based on the ASCE exposure category C, which is a conservative assumption for the calculation of wind pressures in Florida. The gust effect factor is also simplified to be taken as 0.85 for bridges within height and span constraints. This is consistent with requirements of ASCE 7, which allows the gust effect factor to be taken as 0.85 for structures which do not qualify as wind sensitive structures. It is assumed that structures within this height and span limit are not wind sensitive structures. The pressure coefficient is simplified to two values for superstructure and substructure components, with another value for construction, based on drag coefficients for the expected structure shapes. These simplifications are intended to reduce design time and ensure reproducibility of wind pressure calculations, while still providing safe and efficient designs.

The current Structures Design Guidelines require a 20% increase in the wind pressures for bridges located in Palm Beach, Broward, Dade and Monroe counties, which is appropriate for wind loads calculated per the *AASHTO LRFD Bridge Design Specifications* or *AASHTO Guide Design Specifications for Bridge Temporary Works*. This 20% increase is not appropriate when wind pressures are calculated according to this bulletin because of the increased accuracy in design wind speeds. Please note that for projects for which this bulletin is not effective, wind pressures calculated according to the *AASHTO LRFD Bridge Design Specifications* or *AASHTO Guide Design Specifications for Bridge Temporary Works* shall still be increased by 20% for bridges located in Palm Beach, Broward, Dade and Monroe counties.

IMPLEMENTATION

All requirements for wind loading contained herein are effective immediately for all projects having a design start date on or after the release date of this TDB.

This bulletin is not mandatory for projects currently under design, but Districts may elect to incorporate the requirements into ongoing design projects at their discretion.

CONTACT

Sam Fallaha, P.E.
Assistant State Structures Design Engineer
Phone: (850) 414-4296, Fax: (850) 414-4955
E-mail: Sam.Fallaha@dot.state.fl.us

Attachment A

Structures Design Guidelines: Section 2.4

2.4 Wind Loads

Section 2.4 included here is intended as a replacement for sections 3.8.1.1 and 3.8.1.2 of the *AASHTO LRFD Bridge Design Specifications*. Sections 3.8.1.3 and 3.8.2 are not meant to be replaced or modified. Wind load shall be the pressure of the wind acting horizontally on a vertical projection of the exposed area of a structure or vehicles.

2.4.1 Wind Pressure on Structures: WS

A. General

The design wind pressure shall be computed using the following equation:

$$\mathbf{P_z = 2.56x10^{-6}K_zV^2GC_p} \qquad \text{[Eq. 2 -1]}$$

Where:

P_z = Design wind pressure (ksf)
K_z = Velocity pressure exposure coefficients (2.4.1.D)
V = Basic wind speed (2.4.1.C) (mph)
G = Gust effect factor (2.4.1.E)
C_p = Pressure coefficient (2.4.1.F)

Pressures specified herein shall be assumed to be caused by a basic wind speed, *V*. Consideration should be given to the use of a higher basic wind speed if historical data for the site warrants design for a higher wind speed. For site conditions elevated considerably above the surrounding terrain, such as hills or escarpments, where the influence of ground on the wind is reduced, consideration must be given to using higher pressures at heights exceeding 33 feet.

B. Load Combinations and Load Factors

All load combinations according to Table 3.4.1-1 of the *AASHTO LRFD Bridge Design Specifications* shall be considered in design using equation 2-1 for the calculation of wind pressure on structures loads (WS). The load factor (γ_{WS}) and basic wind speed for WS shall be modified according to the following table:

Table 2.2 Load Factors		
LOAD COMBINATION LIMIT STATE	**γ_{WS}**	**BASIC WIND SPEED, V (MPH)**
STRENGTH III	1.40	Per Table 2.3
STRENGTH V	1.30	70
SERVICE I	1.0	70
SERVICE IV	0.60	Per Table 2.3

γ_{WS} during construction shall be determined from Section 2.4.3.

C. Basic Wind Speed

The basic wind speed, *V*, shall be taken as 70 MPH for the Strength V and Service I limit states. The basic wind speed for the Strength III and Service IV limit state shall be determined from the table below, which was derived from the ASCE 7-05 wind speed map.

Table 2.3 Basic Wind Speed, V

County (Dist)	**Basic Wind Speed (mph)**	**County (Dist)**	**Basic Wind Speed (mph)**	**County (Dist)**	**Basic Wind Speed (mph)**
Alachua (2)	110	Hardee (1)	110	Okeechobee (1)	130
Baker (2)	110	Hendry (1)	130	Orange (5)	130
Bay (3)	130	Hernando (7)	130	Osceola (5)	130
Bradford (2)	110	Highlands (1)	130	Palm Beach (4)	150
Brevard (5)	130	Hillsborough (7)	130	Pasco (7)	130
Broward (4)	150	Holmes (3)	130	Pinellas (7)	130
Calhoun (3)	130	Indian River (4)	150	Polk (1)	110
Charlotte (1)	130	Jackson (3)	110	Putnam (2)	110
Citrus (7)	130	Jefferson (3)	110	St. Johns (2)	130
Clay (2)	110	Lafayette (2)	110	St. Lucie (4)	150
Collier (1)	150	Lake (5)	110	Santa Rosa (3)	150
Columbia (2)	110	Lee (1)	130	Sarasota (1)	130
DeSoto (1)	130	Leon (3)	110	Seminole (5)	130
Dixie (2)	130	Levy (2)	130	Sumter (5)	110
Duval (2)	130	Liberty (3)	130	Suwannee (2)	110
Escambia (3)	150	Madison (2)	110	Taylor (2)	130
Flagler (5)	130	Manatee (1)	130	Union (2)	110
Franklin (3)	130	Marion (5)	110	Volusia (5)	130
Gadsden (3)	110	Martin (4)	150	Wakulla (3)	130
Gilchrist (2)	110	Miami-Dade (6)	150	Walton (3)	130
Glades (1)	130	Monroe (6)	150	Washington (3)	130
Gulf (3)	130	Nassau (2)	130		
Hamilton (2)	110	Okaloosa (3)	130		

D. Velocity Pressure Exposure Coefficient, K_z

The velocity pressure exposure coefficient, K_z, shall be determined using the following equation:

$$\mathbf{K_z = 2.01\,(z/900)^{(0.2105)} \geq 0.85} \qquad \text{[Eq. 2-2]}$$

Where:

z = height to centroid of exposed area (ft)

E. Gust Effect Factor, G

1.) For bridges with spans less than 250 feet and a height less than 75 feet, the gust effect factor, *G*, shall be taken as 0.85. Bridges with spans greater than 250 feet or a height greater than 75 feet shall be evaluated according to ASCE/SEI 7 Section 6.5.8.

F. Pressure Coefficient, C_p

The pressure coefficient, C_p, shall be taken as 1.1 for bridge superstructures and 1.6 for bridge substructures, except that C_p for truss bridges shall be determined per the guidelines given in ASCE/SEI 7.

G. Loads from Superstructures
The wind direction for design shall be that which produces the greatest force effect on the component under investigation. The transverse and longitudinal pressures need not be applied simultaneously.

H. Forces Applied Directly to the Substructure
The transverse and longitudinal forces to be applied directly to the substructure shall be calculated by the equation for P_z, [Eq. 2-1]. For wind directions taken skewed to the substructure, this force may be resolved into components parallel and perpendicular to the pier or bent.

2.4.2 Wind Loads on Other Structures

Wind speeds for sign, lighting, and signal structures are specified in ***Volume 9.***

2.4.3 Wind Loads During Construction

A. See also SDG 6.8 Erection Scheme and Beam/Girder Stability.
B. Wind loads during construction are to be considered in the evaluation of beam stability during construction in order to prevent damage or overturning of girders.
C. Wind loads during construction shall be calculated per the equation for design wind pressure, Pz [Eq. 2-1], with load factors per Section 3.4.2 of the *AASHTO LRFD Bridge Design Specification*, except the pressure coefficient, *Cp*, shall be taken as 2.2 for I-shaped girders and shall be taken as 1.5 for Florida U Beams. For exposure periods less than one year, the Basic Wind Speed, *V*, may be reduced by a factor of 0.60. The exposure period is defined as the time period for which temporary load cases of the superstructure exist. For example, the exposure period for a girder bridge is defined as the time period from when the girder is set until the girder is made composite with the bridge deck, and the exposure period for a segmental bridge is defined as the time period from when segments are placed until they are made continuous.

Attachment B

Example Calculations

For comparison purposes, example calculations for wind pressures on a beam bridge superstructure for both construction and the Strength III limit state are presented here based on three different codes. The example bridge is at a height of 40 feet, and is located in suburban Tallahassee. The bridge spans are between 50 feet and 250 feet. For calculation of construction wind load, the exposure period is assumed to be less than one year.

<u>Example according to AASHTO LRFD Bridge Design Specifications:</u>

From ASCE 7-88, $V = 90$ mph
From AASHTO, $V_B = 100$ mph and $P_B = 50$ psf
Based on a suburban exposure, from Table 3.8.1.1-1, $V_0 = 10.9$ and $Z_0 = 3.28$
$V_{DZ} = 2.5*V_0*(V_{30}/V_B)*\ln(Z/Z_0) = 61.34$
$P_D = P_B*(V_{DZ}/V_B)^2 = 18.81$ psf

For Strength III limit case, $\gamma_{WS} = 1.4$, so $P = 1.4*P_D = 26.34$ psf
And $\gamma_{WS} = 1.25$ for construction loading, so $P = 1.25*P_D = 23.51$ psf for construction loading

<u>Example according to AASHTO Guide Design Specifications for Temporary Works:</u>

$Q = 1 + 0.2*W = 10.6$, but the limit for the value of Q is 10, so $Q = 10$
For $V = 90$ mph, $P = 3.0*Q = 30$ psf
For loading during construction, $\gamma_{WS} = 1.0$, so $P = 1.0*P_D = 30$ psf

<u>Example according to New SDG Requirements:</u>

From Table 2.3, $V = 110$ mph
Per Eq. 2-2, $K_z = 2.01\ (40/900)^{(0.2105)} = 1.04$
Since the span is less than 250 feet, and the height is less than 50 feet, $G = 0.85$
For the superstructure, $C_p = 1.1$
$P_z = 2.56 \text{x} 10^{-6} K_z V^2 G C_p = 0.03$ ksf = 30 psf

For Strength III limit case, $\gamma_{WS} = 1.4$, so $P = 1.4*P_z = 42$ psf

Since the exposure period is less than 1 year, the basic wind speed is reduced by 0.60 for construction loading, so V = 110 mph x 0.60 = 66 mph
And $C_p = 2.2$
$P_z = 2.56 \text{x} 10^{-6} K_z V^2 G C_p = 0.022$ ksf = 22 psf

For Strength III limit case for construction, $\gamma_{WS} = 1.25$, so $P = 1.25*P_z = 27$ psf

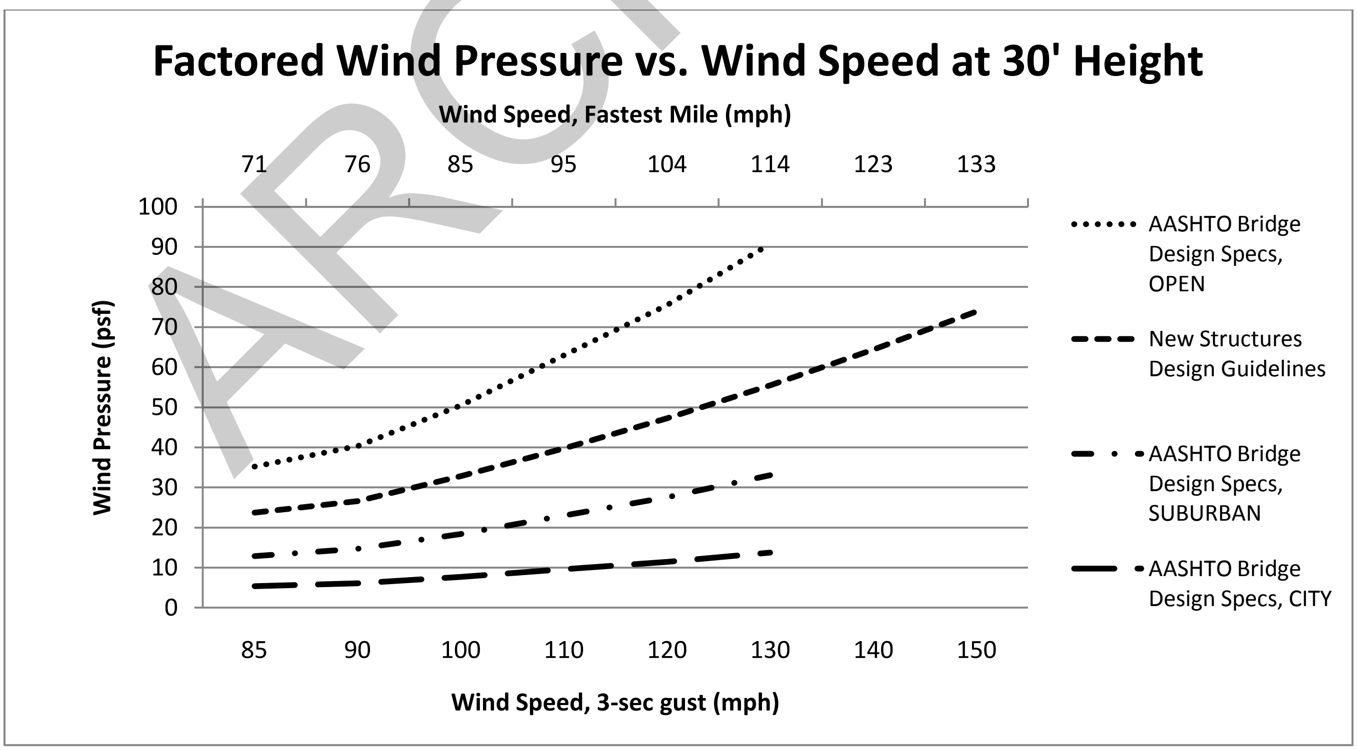
Attachment C

Comparison of Wind Pressures for New SDG Requirements & AASHTO LRFD Bridge Design Specifications

For the following charts, the coefficients used for calculation of the wind pressures for each equation are as follows:

New SDG Requirements Design Wind Pressure Equation Coefficients:
Kz = 0.98
G = 0.85
Cp = 1.1
γ_{WS} = 1.40

AASHTO LRFD Bridge Design Specifications Wind Pressure Equation Coefficients:
Vo = 12.0 for City
10.9 for Suburbs
8.2 for Open Country
Zo = 8.2 for City
3.28 for Suburbs
0.23 for Open Country
Pb = 0.050 ksf
γ_{WS} = 1.40



Attachment D

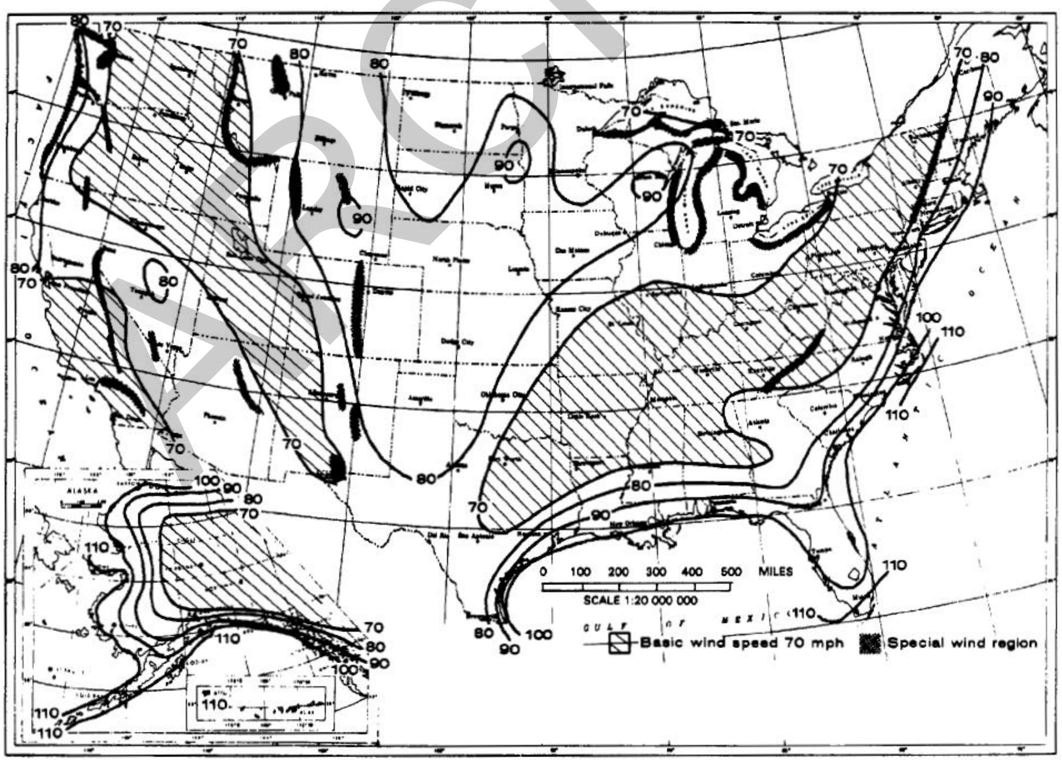
Comparison of Wind Pressures During Construction for New SDG Requirements & AASHTO Guide Design Specifications for Temporary Works

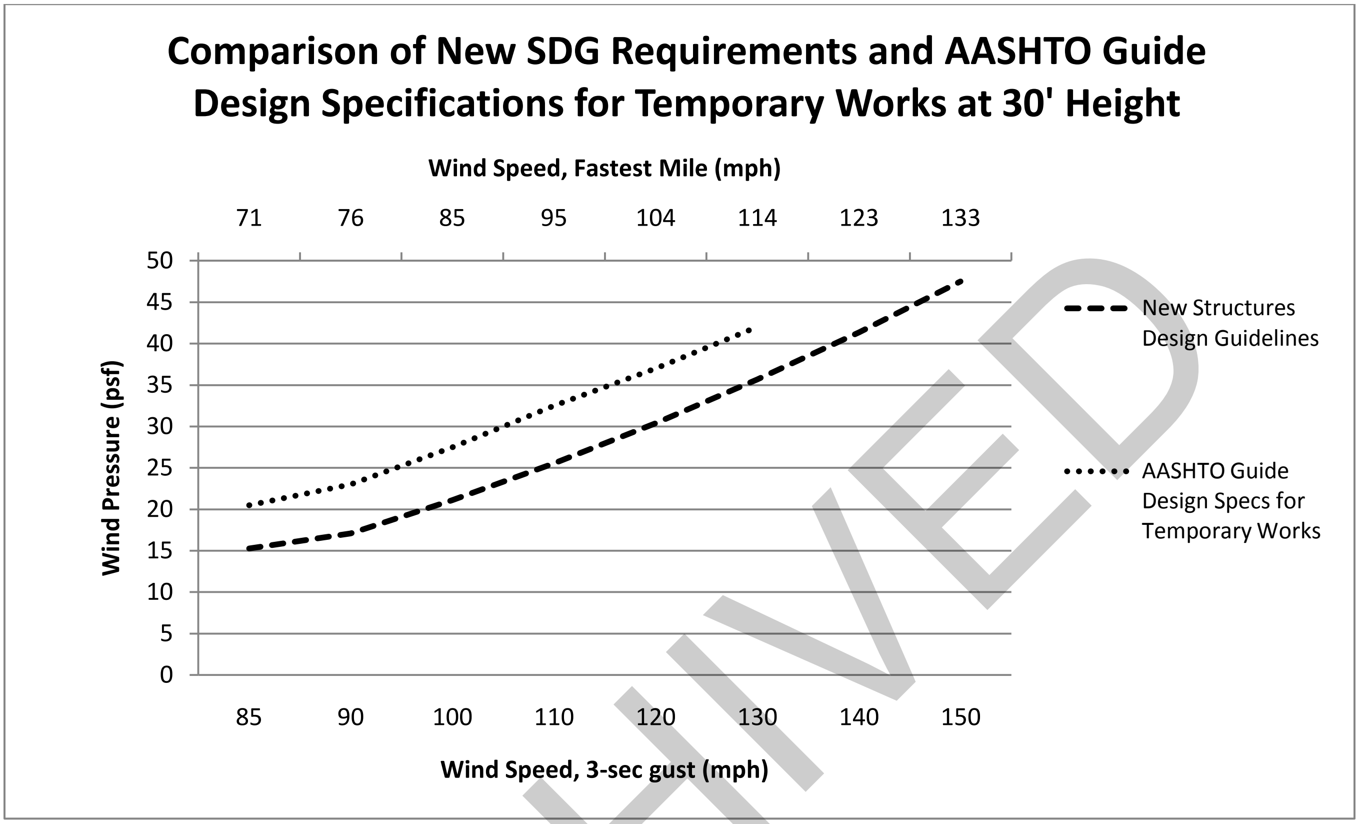
For the following charts, the coefficients used for calculation of the wind pressures for each equation are as follows:

<u>Design Wind Pressure Equation Coefficients:</u>
$K_z = 0.98$
$G = 0.85$
$C_p = 2.2$
$\gamma_{WS} = 1.25$

<u>AASHTO Guide Design Specifications for Temporary Works Wind Pressure Equation Coefficients:</u>
$Q = 10$
$\gamma_{WS} = 1.0$

Note that the wind speeds according to this Temporary Design Bulletin and the *AASHTO Guide Design for Temporary Works* are not the same for a given area in Florida. The three second gust basic wind speed for the Structures Design Guidelines design wind pressure is given in 2.4.1C in Attachment A of this Temporary Design Bulletin. The basic wind speed (fastest mile) for the *AASHTO Guide Design for Temporary Works* is shown below.




Comparison of New SDG Requirements and AASHTO Guide Design Specifications for Temporary Works at 30' Height
Wind Speed, Fastest Mile (mph)
71
76
85
95
104
114
123
133
Wind Pressure (psf)
50
45
40
35
30
25
20
15
10
5
0
85
90
100
110
120
130
140
150
Wind Speed, 3-sec gust (mph)
New Structures Design Guidelines
AASHTO Guide Design Specs for Temporary Works