T5: WAI 54
Proposed Guide Specifications for Wind Loads on Bridges during Construction

Wagdy Wassef, Ph.D., P.E.
AECOM

ASSHTO SCOBS T5 MEETING
Minneapolis, Minnesota
June 28-2016

In Memory of

Dr. Jon Raggett, Ph.D., S.E., P.E.

Presentation Outline

- Current AASHTO LRFD wind load provisions for completed bridges (balloted in 2015)
- Wind load provisions for bridges during construction and how they differ from those for completed bridges

Current AASHTO LRFD Wind Loads Provisions (1)

Design wind pressure = $P_Z = 2.56 \times 10^{-6} V^2 K_Z G C_D$

- P_Z Design wind pressure, ksf
- V Reference 3-second gust wind speed, at 33 ft. elevation, "open country setting, with 7% probability of being exceeded in 50 years (MRI = 700 years)
- K_Z Pressure exposure and elevation coefficient
- G Gust effect factor
- C_D Drag coefficient

Wind load = wind pressure * structure area in elevation

AECOM

Current AASHTO LRFD Wind Loads Provisions (2)

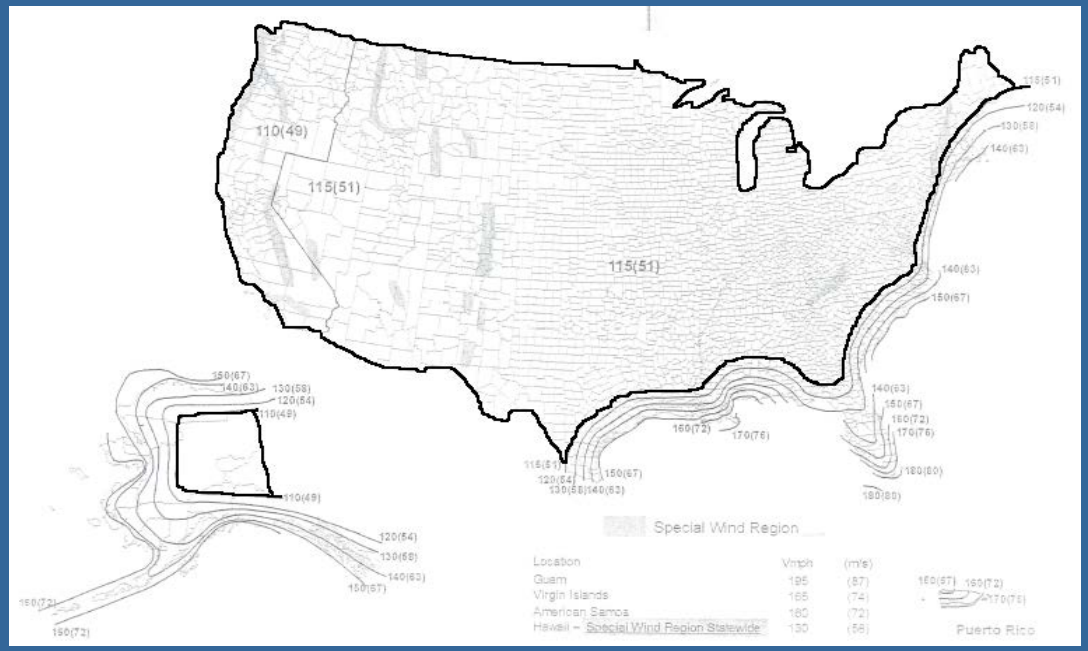
V Wind Speed

Load Combination	3-Second Gust Wind Speed (mph), V
Strength III	Wind speed taken from Figure 3.8.1.1.2-1.
Strength V	80
Service I	70
Service IV	0.75 of the speed used for the Strength III limit state

Current AASHTO LRFD Wind Loads Provisions (3)

V Reference 3-second gust wind speed, at 33 ft. elevation, "open country“ setting, with 7% probability of being exceeded in 50 years (MRI = 700 years)

For Strength III



AECOM

Current AASHTO LRFD Wind Loads Provisions (4)

- K_Z pressure exposure and elevation coefficient

Equations for K_Z are provided along with tabulated values.

Structure Height, *Z* (ft)	Wind Exposure Category B	Wind Exposure Category C	Wind Exposure Category D
≤33	0.71	1.00	1.15
40	0.75	1.05	1.20
50	0.81	1.10	1.25
60	0.85	1.14	1.29
70	0.89	1.18	1.32
80	0.92	1.21	1.35
90	0.95	1.24	1.38
100	0.98	1.27	1.41
120	1.03	1.32	1.45
140	1.07	1.36	1.49
160	1.11	1.40	1.52
180	1.15	1.43	1.55
200	1.18	1.46	1.58
250	1.24	1.52	1.63
300	1.30	1.57	1.68

Current AASHTO LRFD Wind Loads Provisions (5)

Ground Surface Roughness Categories

- Ground Surface Roughness B: Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions
- Ground Surface Roughness C: Open terrain with scattered obstructions having heights generally less than 33 ft.
- Ground Surface Roughness D: Flat, unobstructed areas and water surfaces or mud flats

Current AASHTO LRFD Wind Loads Provisions (6)

Wind Exposure Categories

- Wind Exposure Category B: Ground Surface Roughness Category B prevails in the upwind direction for a distance greater than
  - 1,500 ft. for structures with height ≤ 33 ft.
  - The greater of 2600 ft. or 20 times the height of the structure for structures with height >33 ft., respectively.
- Wind Exposure Category C: All cases where Wind Exposure Categories B or D do not apply.
- Wind Exposure Category D:
  - Ground Surface Roughness Category D prevails in the upwind direction for a distance greater than 5,000 ft. or 20 times the height of the structure, whichever is greater.
  - The structure is within a distance of 600 ft. or 20 times the height of the structure, whichever is greater, from a Ground Surface Roughness Category D condition, even if Ground Surface Roughness Category B or C exist immediately upwind of the structure.

Current AASHTO LRFD Wind Loads Provisions (7)

C_D : Drag Coefficients

Component		Drag Coef., C_D	
		Windward	Leeward
I-girder and box-girder bridge superstructures		1.3	N/A
Trusses, Columns, and Arches	Sharp Edged Member	2.0	1.0
	Round Member	1.0	0.50
Bridge Substructure		1.6	N/A
Sound Barriers		1.2	N/A

AECOM

Current AASHTO LRFD Wind Loads Provisions (8)

G : Gust Effect Factor

Structure Type	Gust Effect Factor, G
Sound Barriers	0.85
All other structures	1.0

Current AASHTO LRFD Wind Loads Provisions (9)

Skew Coefficients for Various Azimuth Angles of Attack

	Trusses, Columns and Arches		Girders	
Skew Angle (degree)	Transverse Coefficient	Longitudinal Coefficient	Transverse Coefficient	Longitudinal Coefficient
0	1.000	0.000	1.000	0.000
15	0.933	0.160	0.880	0.120
30	0.867	0.373	0.820	0.240
45	0.627	0.547	0.660	0.320
60	0.320	0.667	0.340	0.380

- For typical girder and slab bridges W/ individual span lengths <125 ft. & maximum height of 33 ft, the following wind loading combination may be used
  - 100% transverse
  - 24% longitudinal

AECOM

Current AASHTO LRFD Wind Loads Provisions (10)

Load Factors

Limit State	*Perm. loads*	*LL*	*WA*	***WS***	***WL***	*FR*	*TU*	*TG*	*SE*
Strength III	γ_p	—	1.00	**1.00**	**—**	1.00	0.50/1.20	γ_{TG}	γ_{SE}
Strength V	γ_p	1.35	1.00	**1.00**	**1.00**	1.00	0.50/1.20	γ_{TG}	γ_{SE}
Service I	1.00	1.00	1.00	**1.00**	**1.00**	1.00	1.00/1.20	γ_{TG}	γ_{SE}
Service IV	1.00	—	1.00	**1.00**	**—**	1.00	1.00/1.20	—	1.00

Proposed AASHTO LRFD Wind Loads during construction (1)

- The proposed guide specifications is a stand alone document modeled after AASHTO LRFD Section 3.8
- For bridges during construction, it replaces Section 3.8 of the design specifications
- All other sections of the design specifications apply

Proposed AASHTO LRFD Wind Loads during construction (2)

Difference between completed bridges and bridges during construction

- The absence of the deck changes the wind characteristics of the bridge
- Before the deck is cast, all girders are subjected to lateral wind load, however, the magnitude varies depending on their position from the windward exterior girder
- For the purpose of the guide specifications, bridges are considered to be “during construction” up to the time the deck is cast

Proposed AASHTO LRFD Wind Loads during construction (3)

Definitions:

- *Active Work Zone*—Work zone during the time workers are on-site and erection of the structure is in progress.
- *Inactive Work Zone*—Work zone during the time construction work is not being performed including time between work shifts and overnight and the time between the erection of the girders and the placement of the deck.

Proposed AASHTO LRFD Wind Loads during construction (4)

Design wind pressure = $P_Z = 2.56 \times 10^{-6} V^2 \underline{R^2} K_Z G \underline{C_D}$

- V 20 mph (or as specified by the owner) for active work zones and from the wind map for inactive work zone
- R wind speed reduction factor during construction of the superstructure taken as 1.0 for active work zones and from Table 4.2.1-1 for inactive work zones.

For major bridges, the minimum allowed wind speed reduction factor for inactive work zone shall be taken as 0.77. For construction duration greater than 7 years, wind speed reduction factor shall be taken as 1.0. (dim).

AECOM

Proposed AASHTO LRFD Wind Loads during construction (5)

Wind Speed Reduction Factor during Construction, *R*

Superstructure Construction Duration	Wind Speed Reduction Factor during Construction, R
0-6 weeks	0.65
6 weeks to 1 year	0.73
>1-2 years	0.75
>2-3 years	0.77
>3-7years	0.84

Proposed AASHTO LRFD Wind Loads during construction (6)

Drag coefficient for bridges during construction

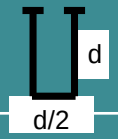
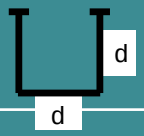
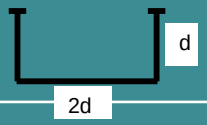
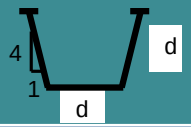
- **Base Drag Coefficient** for Bridge Superstructures During Construction

Superstructure Type	Base Drag Coefficient ($C_{D, base}$)
Steel Plate Girders	2.2
Rolled I-beams	2.2
Concrete I-Beams	2.0
Closed and Open Box-Girders	2.1
Round Members	1.0

Proposed AASHTO LRFD Wind Loads during construction (7)

Drag coefficient for bridges during construction

Measured Base Drag Coefficient for Box-Girder Bridge Superstructures During Construction

Box Geometry	Base Drag Coefficient ($C_{D,\ base}$)
	2.05
	1.66
	1.35
	1.39

AECOM

Proposed AASHTO LRFD Wind Loads during construction (8)

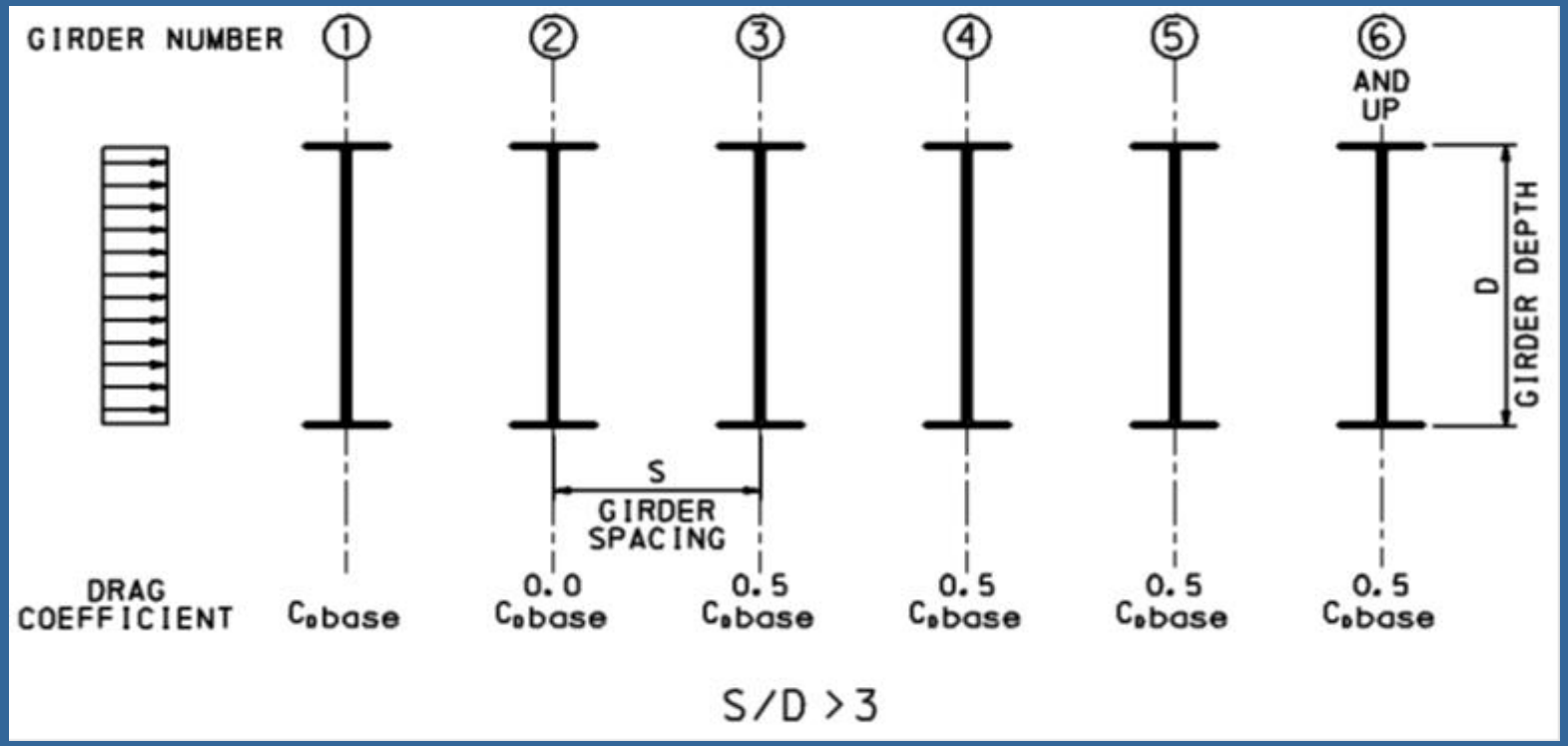
Girder		Drag Coefficient (C_D)
Windward girder in multi-girder I-girder and box-girder systems and for single box-girder systems		$C_{D,\ base}$
Second girder, windward side in multi-girder systems	In two-box-girder systems with a clear distance between the two boxes of no more than twice the girders depth	0.5 $C_{D,\ base}$
	In all other systems	0.0

Girder		(C_D)
Third, fourth and fifth girders, windward side in multi-girder systems	In multi I-girder systems with ratio of girder spacing to girder depth is not greater than 3	0.25 $C_{D,\ base}$
	In multi I-girder systems with ratio of girder spacing to girder depth is greater than 3	0.5 $C_{D,\ base}$
	In multi box-girder systems	0.5 $C_{D,\ base}$
All other girders		0.5 $C_{D,\ base}$

AECOM

Proposed AASHTO LRFD Wind Loads during construction (9)

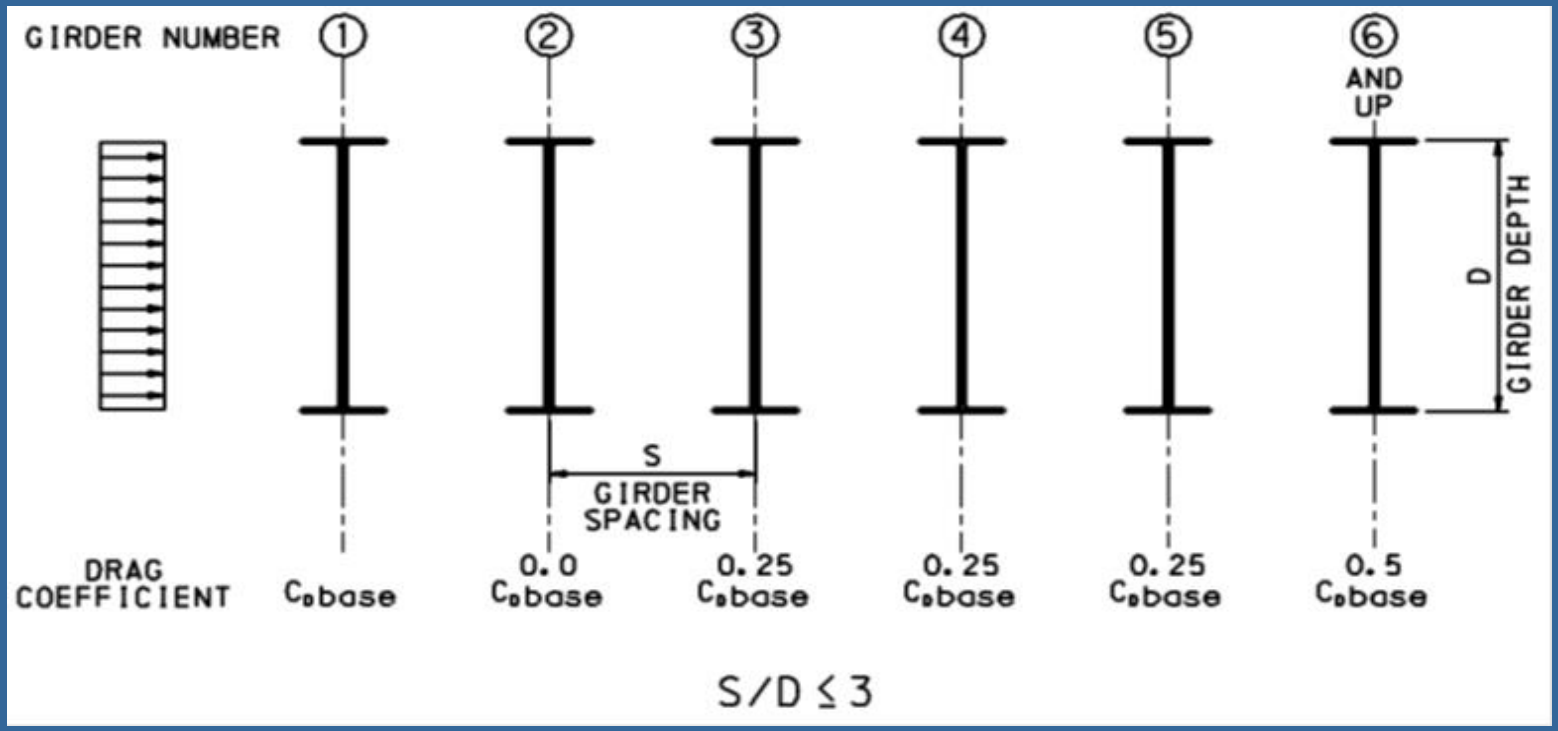
Drag Coefficient for different girders in Multi I-Girder Systems



AECOM

Proposed AASHTO LRFD Wind Loads during construction (10)

Drag Coefficient for different girders in Multi I-Girder Systems



AECOM

Proposed AASHTO LRFD Wind Loads during construction (11)

- For inactive work zones at any stage of construction, the wind load on the girders will be determined taking into consideration the position of the girder in the cross-section during the construction stage being considered.
- For total wind loads transmitted to the substructure, The C_D in the wind pressure equation becomes the sum of the CD's for all girders.

THANK YOU FOR YOUR ATTENTION

QUESTIONS?