

2017 Interim Revisions to the LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals



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2017 INTERIM REVISIONS INSTRUCTIONS AND INFORMATION

General

AASHTO has issued interim revisions to the *LRFD Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, First Edition (2015). This packet contains the revised pages. They are designed to replace the corresponding pages in the book.

Affected Articles

Underlined text indicates revisions that were approved in 2016 by the AASHTO Highways Subcommittee on Bridges and Structures. ~~Strikethrough text~~ indicates any deletions that were likewise approved by the Subcommittee. A list of affected articles is included below.

All interim pages are displayed on a pink background to make the changes stand out when inserted in the first edition binder. They also have a page header displaying the section number affected and the interim publication year. Please note that these pages may also contain nontechnical (i.e., editorial) changes made by AASHTO publications staff; any changes of this type will not be marked in any way so as not to distract the reader from the technical changes.

2017 Changed Articles

SECTION 3: LOADS

3.8.7

C3.8.7

SECTION 5: STEEL DESIGN

5.3

5.12.1

C5.12.1

SECTION 10: SERVICEABILITY REQUIREMENTS

10.4.2.1

C10.4.2.1

SECTION 11: FATIGUE DESIGN

11.5.1

11.7.2

C11.9.3

C11.9.3.1

SECTION 12: BREAKAWAY SUPPORTS

12.1

C12.1

APPENDIX B: DESIGN AIDS

B.2

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3.8.6—Gust Effect Factor G

The gust effect factor, G , shall be taken as a minimum of 1.14.

C3.8.6

G is the gust effect factor and it adjusts the effective velocity pressure for the dynamic interaction of the structure with the gust of the wind.

Information presented in ASCE/SEI 7-10 states that if the fundamental frequency of a structure is less than one Hz or if the ratio of the height to least horizontal dimension is greater than 4, the structure should be designed as a wind-sensitive structure. Thus, virtually all structures addressed by these Specifications should be classified as wind-sensitive structures based on the height to least horizontal dimension ratio. It is not appropriate to use a nonwind-sensitive gust effect factor, G , for the design of sign, luminaire, and traffic signal structures. Special procedures are presented in the commentary of ASCE/SEI 7 for the calculation of the gust effect factor for wind-sensitive structures. The ASCE/SEI 7 calculation procedure requires reasonable estimates of critical factors such as the damping ratio and fundamental frequency of the structure. These factors are site and structure dependent. Relatively small errors in the estimation of these factors result in significant variations in the calculated gust effect factor. Therefore, even though sign, luminaire, and traffic signal support structures are wind sensitive, the benefits of using the ASCE/SEI 7 gust effect factor calculation procedure do not outweigh the complexities introduced by its use.

If the designer wishes to perform a more rigorous gust effect analysis, the procedures presented in ASCE/SEI 7 may be used with permission of the Owner.

3.8.7—Drag Coefficients C_d

The wind drag coefficient, C_d , shall be determined from Table 3.8.7-1. C_v shall be taken as:

$$\begin{array}{lcl} C_v & = & 0.8 \text{ for the Extreme Limit State} \\ C_v & = & 1.0 \text{ otherwise} \end{array}$$

C3.8.7

The wind drag coefficients in Table 3.8.7-1 were established based upon the work of several research projects as noted in the footnotes. Some coefficients are a strong function of Reynold's number. The term $C_v Vd$ is a simplified form of Reynolds using units convenient for LTS design. ~~The algebraic form of these equations is somewhat different; however, the behavior is similar as illustrated in Figure C3.8.7-1 and C3.8.7-1 and C3.8.7-2 where different shapes and equations are shown.~~

The typical extreme event wind speed is 105 mph or greater. Therefore, for diameters 8-in. or greater, the C_d is associated with the turbulent case, $C_v Vd > 78$ mph-ft, and the C_d is a constant (rightmost column of Table 3.8.7-1).

For smaller members, ASCE/SEI 07-10 wind speeds will tend to lower the C_d term compared to past practice. The C_v term at the extreme limit state adjusts the wind speed to correspond to past drag coefficients used for elements subject to wind.

For the fatigue limit state, the wind speeds are on the order of 10 mph and the $C_v Vd$ will be low and the C_d will be the larger value in the leftmost column of Table 3.8.7-1. Between these extremes, the equations can ~~the be~~ used.

This observation simplifies the load application where speed varies with height, etc. The reliability calibration used these bounds in determining the load and resistance factors. See NCHRP 796 (Puckett et al, 2014).

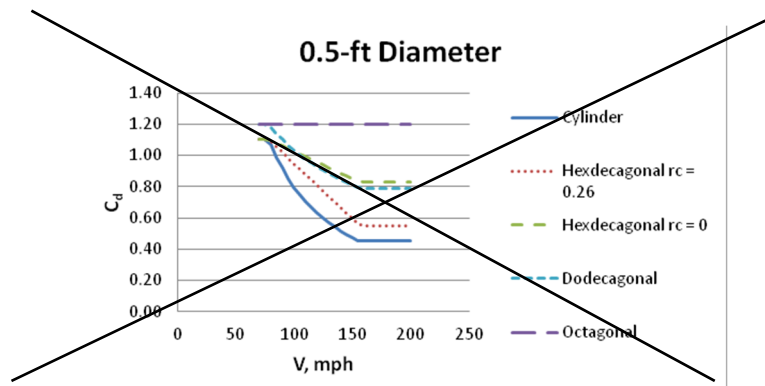
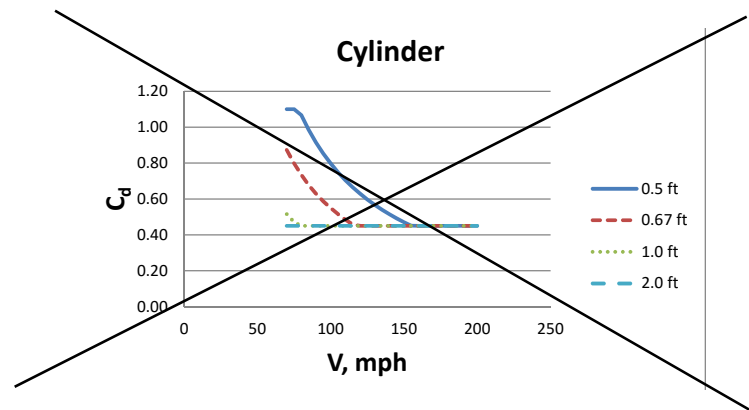
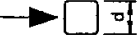
Figure C3.8.7.1 — C_d for various shapes (6in., 0.5ft)Figure C3.8.7.2 — C_d for cylinder for various diameters

Table 3.8.7-1—Wind Drag Coefficients, C_d ^a

Sign Panel $L_{\text{sign}}/W_{\text{sign}} = 1.0$ 2.0 5.0 10.0 15.0	1.12 1.19 1.20 1.23 1.30	
Traffic Signals ^b	1.20	
Luminaires (with generally rounded surfaces)	0.50	
Luminaires (with rectangular flat side shapes)	1.20	
Elliptical Member ($D/d_o \leq 2$)	<p>Broadside Facing Wind</p> $1.7 \left(\frac{D}{d_o} - 1 \right) + C_{dD} \left(2 - \frac{D}{d_o} \right)$ 	<p>Narrow Side Facing Wind</p> $C_{dd} \left[1 - 0.7 \left(\frac{D}{d_o} - 1 \right)^{\frac{1}{4}} \right]$ 
Two Members or Trusses (one in front of other) (for widely separated trusses or trusses having small solidity ratios see note c)	1.20 (cylindrical) 2.00 (flat)	
Dynamic Message Signs (CMS) ^g	1.70	
Attachments	<p>Drag coefficients for many attachments (cameras, luminaires, traffic signals, etc.) are often available from the manufacturer, and are typically provided in terms of effective projected area (EPA), which is the drag coefficient times the projected area. If the EPA is not provided, the drag coefficient shall be taken as 1.0.</p>	

Continued on next page

Table 3.8.7-1—Wind Drag Coefficients, C_d ^a—Continued

Single Member or Truss Member	$C_v Vd \leq 39$ mph-ft	$39 \text{ mph-ft} < C_v Vd < 78$ mph-ft	$C_v Vd \geq 78$ mph-ft
Cylindrical	1.10	$\frac{129}{(C_v Vd)^{1.3}}$	0.45
Flat ^d	1.70	1.70	1.70
Hexdecagonal: 16-Sides $0 \leq r_c < 0.26$	1.10	$1.37 + 1.08r_c - \frac{C_v Vd}{145} - \frac{C_v Vd r_c}{36}$	$0.83 - 1.08r_c$
Hexdecagonal: 16-Sides $r_c \geq 0.26$ ^e	1.10	$0.55 + \frac{(78.2 - C_v Vd)}{71}$	0.55
Dodecagonal ^c : 12-Sides	1.20	$\frac{10.8}{(C_v Vd)^{0.6}}$	0.79
Octagonal ^c : 8-Sides	1.20	1.20	1.20
Square 	$2.0 - 6r_s$ [for $r_s < 0.125$] 1.25 [for $r_s \geq 0.125$]		
Diamond ^f 	1.70 [for $d = 0.33$ & 0.42] 1.90 [for $d \geq 0.50$]		

Notes:

- Wind drag coefficients for members, sign panels, and other shapes not included in this table shall be established by wind tunnel tests (over an appropriate range of Reynolds numbers), in which comparative tests are made on similar shapes included in this table. Values reported in peer-reviewed publications based upon wind tunnel tests are acceptable.
Reynolds Number $Re = (9200)V_{mph}d_{ft}$
- Wind loads on free-swinging traffic signals may be modified based on experimental data or other criteria as agreed by the Owner (e.g., Marchman, 1971).
- Data show that the drag coefficients for a truss with a very small solidity ratio are merely the sum of the drags on the individual members, which are essentially independent of one another. When two elements are placed in a line with the wind, the total drag depends on the spacing of the elements. If the spacing is zero or very small, the drag is the same as on a single element; however, if the spacing is infinite, the total force would be twice as much as on a single member. When considering pairs of trusses, the solidity ratio is of importance because the distance downstream in which shielding is effective depends on the size of the individual members. The effect of shielding decreases with smaller spacing as the solidity decreases. Further documentation may be found in *Transactions* (ASCE, 1961).
- Flat members are those shapes that are essentially flat in elevation, including plates and angles.
- Valid for members having a ratio of corner radius to distance between parallel faces equal to or greater than 0.125. For multisided cross-sections with a large corner radius, a transition value for C_d can be taken as:

If $r_c \leq r_m$, then $C_d = C_{dm}$ If $r_m < r_c < r_r$, then $C_d = C_{dr} + (C_{dm} - C_{dr})[(r_r - r_c)/(r_r - r_m)]$ If $r_c \geq r_r$, then $C_d = C_{dr}$

where:

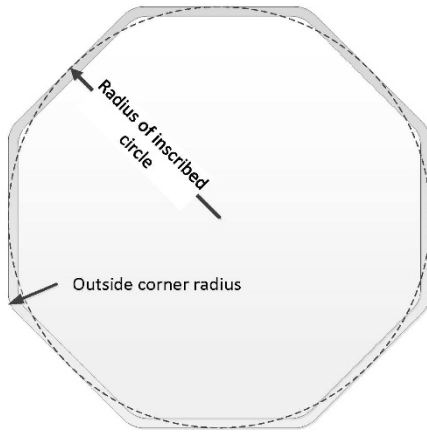
r_c = ratio of corner radius (outside) to radius of inscribed circle,

C_{dm} = drag coefficient for multisided section,

C_{dr} = drag coefficient for round section,

r_m = maximum ratio of corner radius to inscribed circle where the multisided section's drag coefficient is unchanged (see figure and table below), and

r_r = ratio of corner radius to radius of inscribed circle where multisided section is considered round (see figure and table below).



Shape	r_m	r_r
16-Sided, Hexdecagonal	0.26	0.63
12-Sided, Dodecagonal	0.50	0.75
8-Sided, Octagonal	0.75	1.00

- f. The drag coefficient applies to the diamond's maximum projected area measured perpendicular to the indicated direction of wind.
- g. A value of 1.7 is suggested for Dynamic Message Signs (DMS) until research efforts can provide accurate drag coefficients. This value may be used for both horizontal and vertical loads.

The validity of the drag coefficients (dimensionless) presented in Table 3.8.7-1 have been the subject of research (McDonald et al, 1995). Based on this work coupled with independent examinations of the information presented in Table 3.8.7-1, the drag coefficients were changed to account for 3-s gust wind speeds, except for square and diamond shapes.

Research concerning C_d values for dodecagonal shapes (12 sides) has been conducted at Iowa State University (James, 1971). The highest coefficients for the dodecagonal cylinder were measured for wind normal to a flat side. A circular cylinder was included in the testing program to allow a check on the test equipment, and boundary corrections were applied to the raw test data. All measured values for the dodecagonal cylinder with zero angle of incidence were higher than those measured for the circular cylinder. Lower shape coefficients might be justified for some velocities; however, this would require additional data for the

dodecagons at lower Reynolds numbers and review of the factors specified for round cylinders.

The equation for the C_d value for an elliptical member with the narrow side facing the wind was empirically derived to fit wind tunnel test data.

The drag coefficients for hexadecagons (16 sided) include the effects that varying ratios of corner radius to cylinder radius have on the drag coefficient. The C_d values for $C_v Vd$ greater than 78 mph-ft were selected from information from wind tunnel tests on a number of hexadecagons with different ratios of corner radius to radius of inscribed circle (James, 1985).

These minimum C_d values vary linearly from 0.83 for a ratio of zero, to a value of 0.55 for ratios equal to or over 0.26. For consistency between maximum C_d values for cylinders and hexadecagons, the maximum C_d value for hexadecagons was selected to be the maximum value given for a cylinder. For a given ratio, values of C_d for Vd values between 39 mph-ft and 78 mph-ft vary linearly from 1.10 for Vd equal to 39 mph-ft to the minimum value at Vd equal to 78 mph-ft. The wind force resulting from use of these C_d values represents the total static force acting on the member, which would be the vector sum of the actual drag force and lift or side force.

If traffic signals or signs on span-wire pole structures are restrained from swinging in the wind, the full wind load must be applied. When agreed on between Owner and Designer, reduced forces may be used for free-swinging traffic signals when substantiated by research (Marchman, 1971; Marchman and Harrison, 1971). Wind loads on signs that are not restrained from swinging in the wind may be reduced with the consent of the Owner. Wind tunnel test results (Marchman and Harrison, 1971) indicate instability problems with traffic signals with certain hood configurations when not restrained from swinging. These instability problems should be considered when designing span-wire support structures. Orientation varies according to tests, but a value of 1.20 was shown to be conservative over a wide range. Values of C_d for square tubing, with the wind direction perpendicular to the side of the tube, have been revised to reflect the influence from the ratio of the corner radius to depth of member (James and Vogel, 1996).

A transition in the values of C_d for multisided cross-sections (hexdecagonal, dodecagonal, and octagonal) that approach round was developed in NCHRP 494, *Structural Supports for Highway Signs, Luminaires, and Traffic Signals* (Fouad et al., 2003) and incorporated as note *e* to Table 3.8.7-1. The method uses a linear equation to interpolate between the drag coefficient for round poles, C_{dr} , and the drag coefficient for multisided poles, C_{dm} , with respect to the variable r_c . If r_c is unknown, the section can conservatively be treated as multisided using the lowest reasonable value of r_c for the section.

When three members are used to form a triangular truss, the wind load shall be applied to all of the members. Even though all of the members are not in the same plane of reference, they may be seen in a normal elevation.

As provided in note *b* to Table 3.8.7-1, consideration may be given to modifying the forces applied to free-

SECTION 5: STEEL DESIGN

5.1—SCOPE

C5.1

This Section specifies design provisions for steel structural supports. Fatigue-sensitive steel support structures are further addressed in Section 11. Additional design provisions not addressed in this Section shall be obtained from other references as noted.

Design provisions are provided for round and multi-sided tubular shapes, I-shaped sections, channels, plates, angles, and anchor bolts above the foundation. Anchorage requirements are specified in Section 15.

Laminated structures may be used when the fabrication process is such that adequate shear transfer between the lamina can be achieved. Their use is subject to the approval of the Owner.

5.2—DEFINITIONS

Anchor Bolt—A bolt, stud, or threaded rod used to transmit loads from the attachment into the concrete support or foundation. The end cast in concrete shall be provided with a positive anchorage device, such as forged head, nut, hooked end, or attachment to an anchor plate to resist forces on the anchor bolt.

Anchorage—The process of attaching a structural member or support to the concrete structure by means of an embedment, taking into consideration those factors that determine the load capacity of the anchorage system.

Attachment—The structural support external to the surfaces of the embedment that transmits loads to the embedment.

Compact Section—A section capable of developing the plastic moment capacity.

Ductile Anchor Connection—A connection whose resistance is controlled by the strength of the steel anchorage rather than the strength of the concrete.

Ductile Anchor Failure—A ductile failure occurs when the anchor bolts are sufficiently embedded so that failure occurs by yielding of the steel anchor bolts.

Embedment—The portion of a steel component embedded in the concrete used to transmit applied loads from the attachment to the concrete support or foundation.

Headed Anchor—A headed bolt, a headed stud, or a threaded rod with an end nut.

High-Mast Lighting Tower (HMLT)—Pole-type tower that provides lighting at heights greater than 55 ft.

Lateral-Torsional Buckling (LTB)—The buckling mode of a flexural member involving deflection normal to the plane of bending that occurs simultaneously with twist about the shear center of the cross section.

Local Flange Buckling (LFB)—Section instability due to buckling of flange or other local part of the cross section.

Multi-sided Tube—A section with generally round characteristics having eight or more sides.

Noncompact Section—A section in which the moment capacity is not permitted to exceed its yield moment.

Rectangular Tube—A square or rectangular section (four sides). Resistance checks differ from multi-sided tubes.

Retrofit Anchor Bolt—An anchor that is installed into hardened concrete.

Slender Section—A section in which the moment capacity is governed by buckling prior to reaching its yield moment.

5.3—NOTATION

A_e	= effective net area (in. ²) (5.9.2) (5.9.3)
A_{EFF}	= effective area summation (in. ²) (5.10.2.3)
A_g	= gross area (in. ²) (5.9.2) (5.9.3) (5.10.2.3) (5.11.2.1.1) (5.11.2.1.2) (5.12.1)
A_n	= net area (in. ²) (5.9.3)
A_v	= shear area (in. ²) (5.11.2) (5.11.2.1.1) (5.11.2.1.2) (5.11.2.2)
A_w	= area of the web (in. ²) (5.11.2.2)
a_w	= ratio of two times the web area in compression due to application of major axis bending moment alone to the area of the compression flange components (5.8.3.2.4)
B	= ratio (5.8.4.4) (5.12.1)
B	= moment magnification factor (5.12.1)
B_x	= moment magnification factor for second order effects (x axis) (5.12.1) (5.12.2)
B_y	= moment magnification factor for second order effects (y axis) (5.12.1) (5.12.2)
b	= element width (in.) (5.7.2) (C5.7.2) (5.7.3) (5.8.2) (5.8.3.1.2) (5.8.3.1.3) (5.10.2.3) (5.11.2.2)
b_e	= element effective width (in.) (5.10.2.3)
b_f	= flange width of rolled beam (in.) (5.7.3) (C5.9.3)
b_l	= longer leg width (in.) (5.10.2.4)
b_s	= shorter leg width (in.) (5.10.2.4)
C_b	= moment gradient coefficient (5.8.3.1.3) (5.8.3.2.4) (5.8.7.2)
C_t	= the torsional constant (5.11.3) (C5.11.3)
C_v	= shear buckling coefficient (5.11.2.2)
C_w	= warping constant (in. ⁶) (5.8.3.1.3)
c	= lateral-torsional buckling section coefficient (5.8.3.1.3)
D	= inside diameter of round cross-section (in.) (5.6.3) (5.6.6.1) (5.7.2) (C5.7.2) (5.8.2) (5.10.2.2) (5.11.2.1.1) (5.11.3.1.1)
D	= <u>outside diameter of round cross section</u> (in.) (5.6.2) (C5.6.2) (5.6.3) (5.6.6.1) (5.7.2) (C5.7.2) (5.8.2)
d	= full nominal depth for stems of tees (in.) (5.7.3) (5.8.4.3) (5.8.4.4) (5.8.7.1) (5.8.7.2) (C5.9.3) (5.11.2.2)
d	= full nominal depth for webs of rolled or formed sections (in.) (5.7.3) (5.8.4.3) (5.8.4.4) (5.8.7.1) (5.8.7.2) (C5.9.3)
E	= modulus of elasticity of steel, 29,000 (ksi) (5.7.2) (5.7.3) (5.8.2) (5.8.3.1.3) (5.8.3.2.4) (5.8.4.3) (5.8.4.4) (5.8.7.1) (5.8.7.2) (5.10.2.1) (5.10.2.2) (5.10.2.3) (5.11.2.1.1) (5.11.2.2) (5.11.3.1.1) (5.12.1)
F_{cr}	= critical buckling stress (ksi) (5.8.3.1.1) (5.8.3.2.4) (5.8.4.3) (5.8.7.2) (5.10.2.1) (5.10.2.3)
F_e	= Euler stress, calculated in the plane of bending (ksi) (5.10.2.1)
F_L	= stress defined in Table 5.7.3-1 (ksi) (5.7.3)
F_{nt}	= torsional resistance (ksi) (5.11.3) (5.11.3.1.1) (5.11.3.1.2) (5.11.3.2)
F_{nv}	= nominal shear resistance (ksi) (5.11.2) (5.11.2.1.1) (5.11.2.1.2) (5.11.2.2) (5.11.3.2)
F_u	= specified minimum fracture stress (ksi) (5.9.2)
F_y	= specified minimum yield stress (ksi) (5.7.2) (5.7.3) (5.8.2) (5.8.3.1.1) (5.8.3.1.2) (5.8.3.1.3) (C5.8.3.1.3) (5.8.3.2.1) (5.8.3.2.2) (5.8.3.2.3) (5.8.3.2.4) (5.8.4.2) (5.8.5.1) (5.8.5.2) (5.8.7.1) (5.8.7.2) (5.9.2) (5.10.2.1) (5.10.2.2) (5.11.2.1.1) (5.11.2.1.2) (5.11.2.2) (5.11.3.1.2)
f	= buckling stress (ksi) (5.10.2.3)
G	= elastic shear modulus (ksi) (5.8.4.4)
g	= transverse center-to-center spacing (gauge) between lines of fasteners (in.) (5.9.3)
H	= height of backing ring at a groove-welded tube-to-transverse-plate connection (in.) (5.6.5) (C5.6.5)
h	= clear distance between the flanges for webs of rolled or built-up sections (in.) (5.7.3) (5.11.2.2)
h_c	= twice the distance from center of gravity to inside face of compression flange (in.) (5.7.3) (5.8.3.2.4)
h_o	= distance between flange centroids (in.) (5.8.3.1.3) (5.8.3.2.4)
h_p	= twice the distance from plastic neutral axis to inside face of compression flange (in.) (5.7.3)

