LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals

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FOREWORD

The first edition of the *LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* incorporates recent work performed under the National Cooperative Highway Research Program (NCHRP), specifically NCHRP 10-80, and other research efforts including state-sponsored activities. These Specifications address:

- Division I on design,
- Division II on fabrication, construction, and
- Division III on inspection, and asset management.

Where possible, these specifications incorporate other AASHTO documents, specifically, the AASHTO *LRFD Bridge Design Specifications*, AASHTO *LRFD Bridge Construction Specifications*, AASHTO *Manual for Bridge Evaluation*, and AASHTO *Standard Specifications for Transportation Materials and Methods of Sampling and Testing.*

The design specifications are founded upon the Sixth Edition of *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* which incorporate a wealth of research, engineering practice, and long history of satisfactory performance for the vast majority of structures. Based upon NCHRP Report 796 (2014), LRFD calibration, and current research for both loads and resistances are incorporated. Resistances include several specifications associated with improved detailing for fatigue performance. Additionally, new sections on Fabrication, Construction, Inspection, and Asset Management are based upon best practices. These areas are evolving as agencies gain more experience with inspection and management of their ancillary structure inventories.

The design specifications provided in Division I are based on the LRFD methodology and are intended to address the usual structural supports. Requirements more stringent than those in the Specifications may be appropriate for atypical structural supports. The commentary is intended to provide background on some of the considerations contained in the Specifications; however, it does not provide a complete historical background or detailed discussions of the associated research studies. The Specifications and accompanying commentary do not replace sound engineering knowledge and judgment in design, fabrication, construction, inspection, or asset management.

AASHTO Highways Subcommittee on Bridges and Structures

PREFACE

The first edition of *LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* supersedes the sixth edition of the *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*. It includes changes approved by the Highways Subcommittee on Bridges and Structures in 2014.

An abbreviated table of contents follows this preface. Detailed tables of contents precede each Section and each Appendix.

AASHTO Publications Staff

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SECTION 1: INTRODUCTION

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SECTION 1:

INTRODUCTION

1.1—SCOPE

The provisions of these load and resistance factor design specifications for structural supports for highway signs, luminaires, and traffic signals, hereinafter referred to as the Specifications, are applicable to the structural design of supports for highway signs, luminaires, and traffic signals (LRFD Structural Supports). The types of supports addressed in these Specifications are discussed in Article 1.4. The Specifications are intended to serve as a standard and guide for design, fabrication, construction, inspection, and asset management.

C1.1

These Specifications are the result of National Cooperative Highway Research Program (NCHRP) Project 10-80 and the corresponding NCHRP Report 796. These Specifications are intended to replace the sixth edition, *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* (2013).

At the discretion of the Owner, proprietary solutions may be considered. These solutions may address both new structures and the repair or rehabilitation of existing structures. Testing of proprietary solutions shall model actual conditions as closely as possible, and the test methods and results shall be published.

Where appropriate, the language and intent of the Specifications is kept the same as in the *AASHTO LRFD Bridge Design Specifications* and the *AASHTO LRFD Bridge Construction Specifications*. The following definitions are used:

The term “shall” denotes a requirement for compliance with these Specifications.

The term “should” indicates a strong preference for a given criterion.

The term “may” indicates a criterion that is usable, but other local and suitably documented, verified, and approved criterion may also be used in a manner consistent with the LRFD approach to structural design.

These Specifications are not intended to supplant proper training or the exercise of judgment by the Designer. They include only the minimum requirements necessary to provide for public safety. The Owner or the Designer may require the design, quality of materials, fabrication, construction, and asset management to be higher than the minimum requirements.

The design provisions of these Specifications employ the Load and Resistance Factor Design (LRFD) methodology. The factors have been developed from the theory of reliability based on current statistical knowledge of loads and structural performance, including materials properties.

Seismic design is not included in these Specifications, and such procedures should be prescribed by the Owner.

In most cases, wind combined with other load effects controls the structural design.

The commentary references other documents that provide suggestions for meeting the requirements and intent of these Specifications. However, those documents and the commentary are not intended to be a part of these Specifications.

The commentary discusses some provisions of the Specifications with emphasis given to the explanation of new or revised provisions that may be unfamiliar to the reader. The commentary is not intended to provide a complete historical background concerning the development of this or previous Specifications, nor is it intended to provide a detailed summary of the studies and research data reviewed in developing the provisions. References to some of the research data are provided, however, for those who wish to study the background material in depth. Not all references are cited.

1.2—DEFINITIONS

AA—Aluminum Association.

AASHTO—American Association of State Highway and Transportation Officials.

ACI—American Concrete Institute.

AISC—American Institute for Steel Construction.

Arm—A cantilevered member, either horizontal or sloped, which is typically attached to a pole.

ASCE—American Society for Civil Engineers.

ASD—Allowable stress design.

AWS—American Welding Society.

Bridge Support—Also known as span-type support; a horizontal or sloped member or truss supported by at least two vertical supports.

Cantilever—A member, either horizontal or vertical, supported at one end only.

CMS—Changeable message sign, a sign that displays a variable message.

Collapse—A major change in the geometry of the structure rendering it unfit for use.

Component—Either a discrete element of the structure or a combination of elements requiring individual design consideration.

Design—Proportioning and detailing the components and connections of a structure.

Designer—The person responsible for design of the structural support.

Ductility—Property of a component or connection that allows inelastic response.

DMS—Dynamic Message Sign, see *CMS.*

Engineer—Person responsible for the design of the structure or review of design-related field submittals such as erection plans, or both.

Evaluation—Determination of load-carrying capacity or remaining life of an existing structure.

Extreme Event Limit States—Limit states relating to events such as wind, earthquakes, and vehicle collision, with return periods in excess of the design life of the structure.

Factored Load—Nominal loads multiplied by the appropriate load factors specified for the load combination under consideration.

Factored Resistance—Nominal resistance multiplied by a resistance factor.

FHWA—U.S. Federal Highway Administration.

Force Effect—A deformation, stress, or stress resultant (i.e., axial force, shear force, torsional, or flexural moment) caused by applied loads or imposed deformations.

High-Level Lighting—Also known as high-mast lighting; lighting provided at heights greater than 55 ft, typically using four to twelve luminaires.

High-Level Luminaire Support—Truss-type or pole-type tower that provides lighting at heights greater than about 55 ft, typically using four to twelve luminaires.

High-Mast Lighting Tower (HMLT)—Another description for a pole-type high-level luminaire support.

Load Effect—Same as force effect.

Limit State—A condition beyond which the structure or component ceases to satisfy the provisions for which it was designed.

Load Factor—A statistically-based multiplier applied to force effects accounting primarily for the variability of loads, the lack of accuracy in analysis, and the probability of simultaneous occurrence of different loads. Related to the statistics of the resistance through the calibration process.

Load and Resistance Factor Design (LRFD)—A reliability-based design methodology in which force effects caused by factored loads are not permitted to exceed the factored resistance of the components.

LRFD Structural Supports—highway signs, luminaires, and traffic signals.

Luminaire—A complete lighting unit consisting of a lamp or lamps together with the parts designed to provide the light, to position and protect the lamps, and to connect the lamps to an electric power supply.

Mast Arm—A member used to hold a sign, signal head, or luminaire in an approximately horizontal position.

Mean Recurrence Interval (MRI)—The expected time period for the return of a wind speed that exceeds the basic wind speed. The annual probability of exceeding the basic wind in any one-year period is the reciprocal of this value.

Member—A component that is positioned between two physical joints of a structure.

Model—An idealization of a structure for the purpose of analysis.

Monotube—A support that is composed of a single tube.

Multiple-Load-Path Structure—A structure capable of supporting the specified loads following loss of a main load-carrying component or connection.

NCHRP—National Cooperative Highway Research Program.

NDS—2012. National Design Specification for Wood Construction.

Nominal Resistance—Resistance of a component or connection to force effects, as indicated by the dimensions specified in the contract documents and by permissible stresses, deformations, or specified strength of materials.

Overhead Sign—A sign mounted over a roadway or near, and elevated with respect to, a travel way.

Owner—The person or agency having jurisdiction for the design, construction, and maintenance of the structural support.

Pole—A vertical support that is often tall, relatively slender, and generally rounded or multisided.

Pole Top—A descriptive term indicating that an attachment is mounted at the top of a structural support, usually pertaining to one luminaire or traffic signal mounted at the top of a pole.

Rehabilitation—A process in which the resistance of the structure is either restored or increased.

Resistance Factor—A statistically-based multiplier applied to nominal resistance primarily accounting for variability of material properties, structural dimensions and workmanship, and uncertainty in the prediction of resistance. Related to the statistics of the loads through the calibration process.

Roadside Sign—A sign mounted beside the roadway on a single or multiple supports.

SEI—Structural Engineering Institute (within ASCE).

Service Life—The period of time that the structure is expected to be in operation.

Service Limit States—Limit states relating to stress, deformation, and concrete cracking under regular operating conditions.

Sign—A device conveying a specific message by means of words or symbols, erected for the purpose of regulating, warning, or guiding traffic.

Span Wire—A steel cable or strand extended between two poles, commonly used as a horizontal support for signs and traffic signals.

Strength Limit States—Limit states relating to strength and stability during the design life.

Structural Support—A system of members(s) used to resist load effects associated with self weight, attached signs, luminaires, traffic signals, and any other applicable loads (notably wind)

Structure—*See* Structural Support.

Traffic Signal—An electrically operated control device by which traffic is regulated, warned, or directed to take specific actions.

TRB—Transportation Research Board.

Truss—A structural system composed of framework that is often arranged in triangles.

VMS—Variable Message Sign, see *CMS*.

1.3—APPLICABLE SPECIFICATIONS

The following specification documents may be referenced for additional information on design, materials, fabrication, construction, and asset management:

- AASHTO *Standard Specifications for Highway Bridges*,
- AASHTO *LRFD Bridge Design Specifications,*
- AASHTO *LRFD Bridge Construction Specifications*,
- AASHTO *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*,
- ASCE/SEI 7-10 *Minimum Design Loads for Building and Other Structures*,
- AASHTO *Manual for Bridge Evaluation*,
- *AISC Steel Construction Manual*,
- *ACI Building Code Requirements for Structural Concrete and Commentary*,
- ADM *Aluminum Design Manual*,
- AWS *Structural Welding Code—Stee*l,
- AWS *Structural Welding Code—Aluminum*,
- *National Design Specifications (NDS) for Wood Construction*, and
- *Book of ASTM Standards*

C1.3

Other specifications may be appropriate, such as Owner-specific specifications, which may preclude or include these Specifications.

The references listed in the Specifications may not be the most current available. The more current literature might be the same or different (applicable or not applicable) to these Specifications. Caution is advised.

1.4—TYPES OF STRUCTURAL SUPPORTS

Structural supports are categorized as follows:

- Sign support structures,
- Luminaire support structures,
- Traffic signal support structures, and
- Combinations of the above structures.

1.4.1—Sign

Structural supports for signs include both overhead and roadside structures intended to support highway traffic signs.

C1.4.1

Typical overhead and roadside sign supports are shown in Figure C1.4.1-1. Overhead sign structures are generally of the bridge or cantilever type. It is also common to support signs on existing grade separation structures that span the traffic lanes.

1.4.2—Luminaire

Structural supports for luminaires include typical poles with luminaire arms, typical poles with luminaires mounted at pole top, and high-level luminaire supports (both truss and pole type).

C1.4.2

The illumination of roadways requires the use of poles, generally tubular pole shafts that support one to two luminaires and range in height from about 30 ft to 55 ft. High-level luminaire supports normally range in heights from 55 ft to 150 ft or higher and usually support four to twelve luminaires illuminating large areas. Typical luminaire supports and high-level supports are shown in Figure C1.4.2-1.

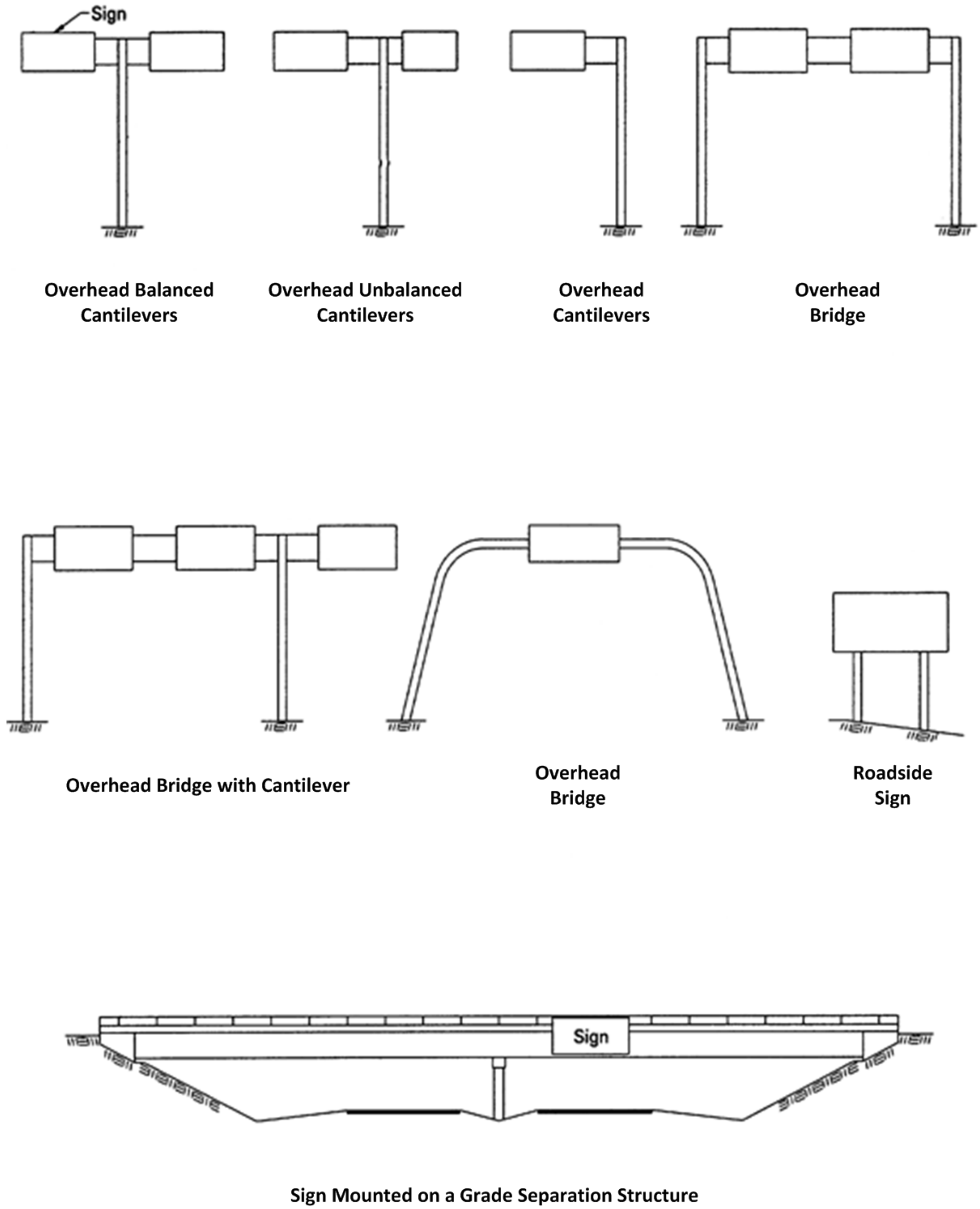

Figure C1.4.1-1—Sign Supports

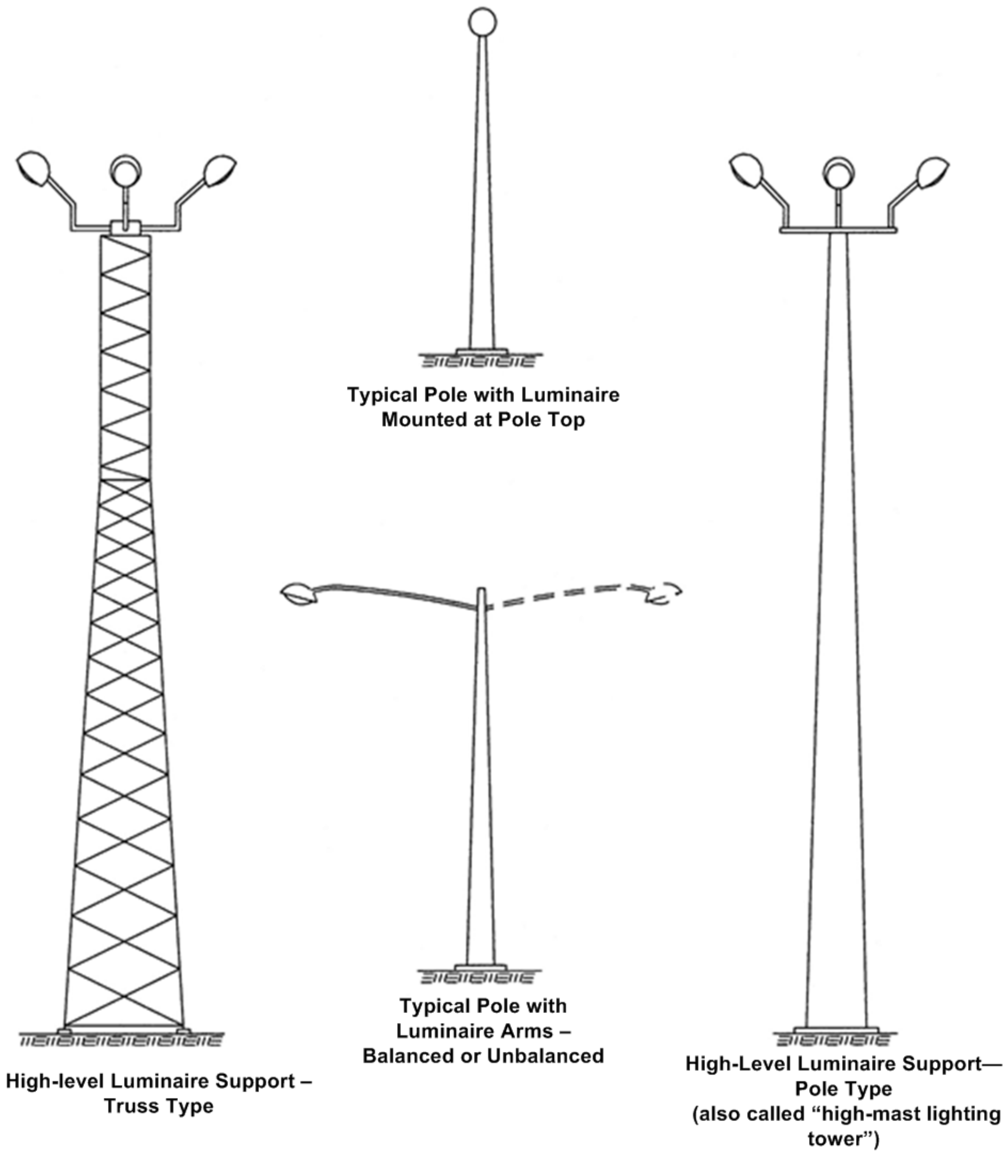

Figure C1.4.2-1—Luminaire Structural Supports

1.4.3—Traffic Signal

Structural supports for mounting traffic signals include pole top, cantilevered arms, bridge, and span wires.

C1.4.3

Typical traffic signal supports are shown in Figure C1.4.3-1.

1.4.4—Combination Structures

Combination structures include structural supports that combine any of the functions described in Articles 1.4.1, 1.4.2, and 1.4.3.

C1.4.4

Generally, combination structures are composed of a luminaire support and a traffic signal support. Other structures may combine traffic signal or luminaire supports with those for utility lines.

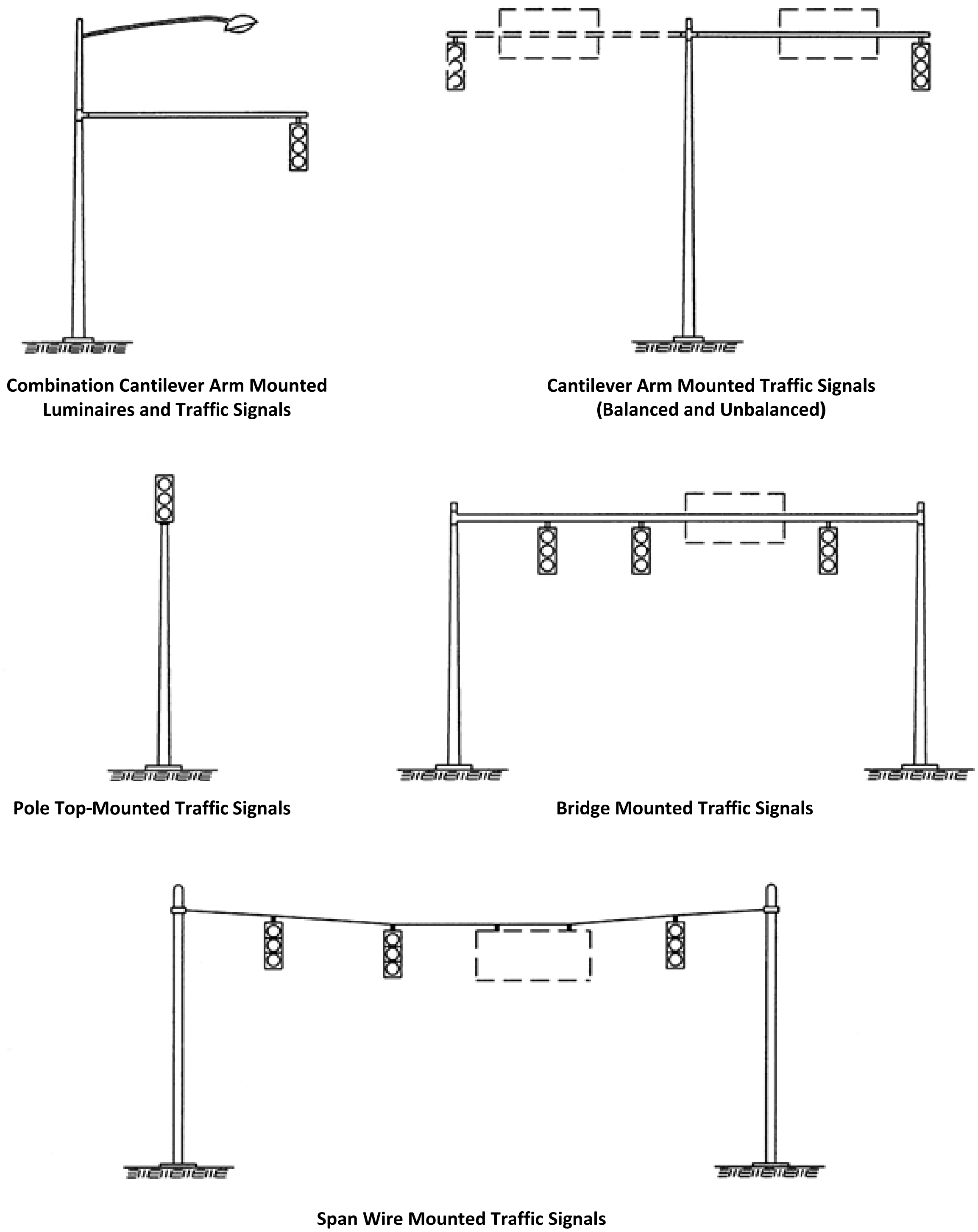

Figure C1.4.3-1—Traffic Signal Structural Supports

1.5—DESIGN PHILOSOPHY

1.5.1—General

Structures shall be designed for specified limit states to achieve the objectives of constructability, safety, and serviceability, with due regard to issues of inspectability, economy, and aesthetics.

Regardless of the type of analysis used, Eq. 1.5.2.1-1 shall be satisfied for all specified force effects and combinations thereof.

C1.5.1

The limit states specified herein are intended to provide for a buildable, serviceable structure capable of safely carrying design loads for a specified time.

The resistance of components and connections is determined in many cases on the basis of inelastic behavior, although the force effects are determined by using elastic analysis. This inconsistency is common to most current structural engineering specifications and is permitted because the lower bound theorem insures safety. The lower bound theorem has two fundamental requirements: equilibrium is satisfied in the analysis and ductility is provided. (e.g., see Barker and Puckett, 2012)

1.5.2—Limit States

1.5.2.1—General

Each component and connection shall satisfy Eq. 1.5.2.1-1 for each limit state unless otherwise specified. All limit states shall be considered of equal importance.

$$\sum \gamma_i Q_i \le \varphi R_n = R_r \qquad (1.5.2.1\text{-}1)$$

where:

γ_i = load factor: a statistically based multiplier applied to force effects,

φ = resistance factor: a statistically based multiplier applied to nominal resistance,

Q_i = force effect,

R_n = nominal resistance, and

R_r = factored resistance: φR_n.

C1.5.2.1

Eq. 1.5.2.1-1 is the basis of LRFD methodology. Assigning resistance factor φ = 1.0 to all service and fatigue limit states is a default, and may be overridden by provisions in other Sections.

Resistance factors for strength and extreme limit states are defined in the materials sections. The load factors are defined in Section 3 Loads. The resistances are prescribed in separate sections as specified in Sections 5, 6, 7, 8, 9, and 13.

1.5.2.2—Service Limit State

The service limit state shall be taken as restrictions on stress, deformation, and concrete cracking under service conditions.

C1.5.2.2

The service limit states are based upon experience and judgment and are not a formal calibration.

1.5.2.3—Fatigue Limit State

Fatigue limit state shall be used to ensure that the expected fatigue load effects remain below the constant amplitude fatigue limit resistance. Section 11 is focused upon the fatigue limit state for steel and aluminum structures.

C1.5.2.3

Recent research has primarily focused on the load effects and resistance associated with steel structures. These results are scaled to aluminum with a general factor. Only high-cycle fatigue is considered.

1.5.2.4—Strength Limit State

Strength limit state shall be used to ensure that strength and stability, both local and global, are provided to resist the specified statistically significant load combinations that a structure is expected to experience.

C1.5.2.4

The strength limit state considers stability or yielding of each structural element. If the resistance of any element, including splices and connections, is exceeded, it is assumed that the structural resistance has been exceeded.

The structural supports are often statically determinate and often cantilevered. As such they do not have significant inelastic reserve strength or opportunity for load redistribution to other components. The exception is overhead trusses and frames.

1.5.2.5—Extreme Limit State

The extreme event limit state shall be used to ensure the survival of a structure during a major wind event. For these Specifications, the wind with gravity combination is considered an extreme event.

C1.5.2.5

Extreme event limit states are considered to be unique occurrences whose return period may be significantly greater than the design life of the structure. ASCE/SEI 7-10 considers wind to have a load factor of 1.0; this is the same as seismic loads prescribed in that document. The wind speed maps in ASCE/SEI 7-10 provide maximum wind speeds greater than in the past. The wind load factor has changed from 1.6 in 2005 to 1.0 in 2010 for example. The overall wind load effect changes are relatively minor in most locales, however, in some coastal regions, the changes were significant.

1.6—REFERENCES

AASHTO. 2009. *AASHTO Transportation Glossary,* Fourth Edition. American Association of State Highway and Transportation Officials, Washington, DC.

AASHTO. 2013. *Standard Specifications for Structural Supports for Highway Signs*, *Luminaires and Traffic Signals*, Sixth Edition. American Association of State Highway and Transportation Officials. Washington, DC.

AASHTO. 2002. *AASHTO Standard Specifications for Highway Bridges*, 17th Edition. American Association of State Highway and Transportation Officials, Washington, DC.

AASHTO. 2014. *AASHTO LRFD Bridge Design Specifications,* Seventh Edition. American Association of State Highway and Transportation Officials, Washington, DC.

AASHTO. 2010. *AASHTO LRFD Bridge Construction Specifications,* Third Edition. American Association of State Highway and Transportation Officials, Washington, DC.

AASHTO. 2014. *Standard Specifications for Transportation Materials and Methods of Sampling and Testing,* 34th Edition. American Association of State Highway and Transportation Officials, Washington, DC.

American Concrete Institute. 2011. *ACI Building Code Requirements for Structural Concrete and Commentary*. Farmington, MI.

American Institute for Steel Construction. 2010. *Steel Construction Manual*. Chicago, IL.

ASCE/SEI 07–10. 2010. *Minimum Design Loads for Buildings and other Structures*. American Society of Civil Engineers, Reston, VA.

ASTM. 2012. *Book of ASTM Standards*. American Society for Testing and Materials, West Conshohocken, PA.

Aluminum Association. 2010. *Aluminum Design Manual*. Aluminum Association, Arlington, VA.

AWS. 2010. Structural Welding Code—Steel, D1.1/D1.1M, American Welding Society, Miami, FL.

AWS. 2008. Structural Welding Code—Aluminum, D1.2/D1.2M, American Welding Society, Miami, FL.

Puckett, J., Garlich, M., Barker, M., Nowak, A., Menzemer, C., 2014. Development and Calibration of AASHTO-LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, *NCHRP Report 796*. Transportation Research Board, National Research Council, Washington, DC.

AWC. 2012. National Design Specification® (NDS®) for Wood Construction, American Wood Council, Leesburg, VA.

SECTION 2: GENERAL FEATURES OF DESIGN

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SECTION 2:

GENERAL FEATURES OF DESIGN

2.1—SCOPE

Minimum requirements are provided or referenced for aesthetics, clearances, constructibility, inspectability, and maintainability of structural supports. Guidelines for determining vertical and horizontal clearances, use of breakaway supports, use of guardrails, illumination of the roadway, sizes of signs, illumination and reflectorization of signs, and maintenance are provided in the following references:

- AASHTO *A Policy on Geometric Design of Highways and Streets*,
- *Manual on Uniform Traffic Control Devices* (MUTCD),
- AASHTO *Manual for Assessing Safety Hardware* (MASH),
- NCHRP 350 *Recommended Procedures for the Safety Performance Evaluation of Highway Features,*
- AASHTO *Roadside Design Guide*,
- AASHTO *Maintenance Manual for Roadways and Bridges*, and
- AASHTO *Roadway Lighting Design Guide*.

C2.1

This Section provides the Designer with information and references to determine the configuration, overall dimensions, and location of structural supports for highway signs, luminaires, and traffic signals. The information in this Section is broad in scope. No attempt has been made to establish rigid criteria in such areas as vertical heights of traffic signal and luminaire supports and levels of illumination. This Section provides references and considerations for the different aspects of design that should be considered in the preliminary stages of a project. In addition to the requirements provided within this Section, many Owners have specific requirements.

2.2—DEFINITIONS

Barrier—Longitudinal traffic barrier, usually rigid, used to shield roadside obstacles or non-traversable terrain features. It may occasionally be used to protect pedestrians from vehicle traffic.

Breakaway—Design feature that allows a sign, luminaire, or pole top-mounted traffic signal support to yield, fracture, or separate near ground level on vehicle impact.

Clearance—Horizontal or vertical dimension to an obstruction.

Clear Zone—An unobstructed, relatively flat area beyond the edge of the traveled way for the recovery of errant vehicles. The traveled way does not include shoulder or auxiliary lanes.

CMS—Abbreviation for Changeable Message Sign.

Curb—A vertical or sloping surface, generally along and defining the edge of a roadway or roadway shoulder.

DMS—Dynamic Message Sign, see *CMS*.

FHWA—U.S. Federal Highway Administration.

Gore—Center area immediately past the point where two roadways divide at an acute angle, usually where a ramp leaves a roadway.

Guardrail—Type of longitudinal barrier that may deflect upon impact.

Mounting Height—Minimum vertical distance to the bottom of a sign or traffic signal relative to the pavement surface.

Pedestal Pole—Relatively short pole supporting a traffic signal head attached directly to the pole.

Roadside—Area between the shoulder edge and the right-of-way limits, or the area between roadways of a divided highway.

Roadway—Highway or street.

Support Facility—Transportation systems that support the roadway, e.g., parking lots, rest areas, etc.

Traveled Way—Roadway width not including shoulder or auxiliary lanes.

User—Person using the roadway including motorists, bicyclists, or pedestrians.

VMS—Variable Message Sign, see *CMS*.

2.3—AESTHETICS

The structural support should complement its surroundings, be graceful yet functional in form, and present an appearance of adequate strength. The support should have a pleasing appearance that is consistent with the aesthetic effect of the highway's other physical features. Supports should have clean, simple lines, which will present minimum hazard to motorists, cyclists, or pedestrians.

Structural supports should be designed and located so as not to distract the user's attention or obstruct the view of the highway, the view of other signs, or important roadway features. The effect that signing or lighting installations have on the surrounding environment should be considered.

C2.3

The appearance of ordinary structural supports should consider aesthetics and function. Combination poles, which serve multiple functions for lighting, traffic control, and electrical power, should be considered to reduce the number of individual poles along the highway.

"The use of [a] bridge as a support for message or directional signing or lighting should be avoided wherever possible" (*AASHTO LRFD Bridge Design Specifications* (AASHTO 2014)). Tradeoffs may exist between bridge aesthetics and sign economy and functionality.

2.4—FUNCTIONAL REQUIREMENTS

2.4.1—Lighting Systems

The Designer should select the light source, luminaire distribution, mounting height, and luminaire overhang based on factors including the geometry and character of the roadway, the environment, proposed maintenance, economics, aesthetics, and overall lighting objectives.

C2.4.1

The AASHTO *Roadway Lighting Design Guide* (AASHTO 2005) provides information on the warranting conditions for use of lighting, level and uniformity of luminance, quality of light, location of poles, use of breakaway devices, high-mast poles, and maintenance. Additional information may be found in the *FHWA Lighting Handbook* (2012). Decisions on lighting may also be guided by crash statistics and use of the *Highway Safety Manual* (HSM) (AASHTO 2010).

Some communities limit the amount of surrounding illumination, and shielding may be required. The same average illumination can usually be obtained by more than one installation arrangement.

The function for various roadway users, including pedestrians and cyclists, may have differing requirements that should be considered.

2.4.1.1—Vertical Heights for Luminaire Supports

The height of the luminaire support should be determined by the Designer to meet a particular need within the situational constraints.

C2.4.1.1

Design attributes that should be considered in determining the height of a luminaire support include:

- Glare characteristics,
- Desired level of illumination and distribution of light,
- Photometric characteristics of a selected lamp and luminaire,
- Available space for placing the supports,
- Inspection capability,
- Maintenance capability (maximum attainable servicing height),
- Compliance with local ordinances and statutes, and
- Consideration of local customs and aesthetics.

Height restrictions may be imposed by various government agencies, such as the Federal Highway Administration (FHWA) with respect to breakaway devices and the Federal Aviation Administration for airspace considerations.

2.4.1.2—Illumination of the Roadway

The Designer should consider the quality of light and the level of illumination.

C2.4.1.2

Highway illumination is provided to improve driver nighttime visibility and to promote safer and more efficient use of special roadway facilities located at ramps, intersections, and potentially hazardous areas. Other roadway users, including pedestrians and cyclists, may have different safety requirements that should be considered.

The amount of illumination that should be provided over a roadway depends on visibility, visual comfort, light distribution, and geometry. Disability and discomfort glare, pavement glare, road location, and obstructions to visibility and traffic patterns are other factors that influence the level of illumination.

A luminaire installation should provide a visual environment that is conducive to safe and comfortable night driving.

2.4.2—Structural Supports for Signs and Traffic Signals

2.4.2.1—Vertical Clearances

Vertical clearance shall be provided of not less than 17 ft to the sign, light fixture, walkway, or sign bridge over the entire width of the pavement and shoulders unless the grade separation structures or other structures nearby have lesser vertical clearance. In cases of lesser clearance, the overhead sign support may be as low as 1 ft higher than the vertical clearance of other supports.

Additional guidance on vertical clearances may be found in the *Manual on Uniform Traffic Control Devices* (MUTCD). (FHWA 2009)

C2.4.2.1

The minimum clearance should include an allowance for possible future overlays.

The additional 1-ft vertical clearance is required so that high vehicles will strike the stronger overpass structures first, thereby lessening the chance of major collision damage to the structurally weaker overhead sign support or traffic signal support structures. A depiction of this clearance limit is illustrated in Figure C2.4.2.1-1.

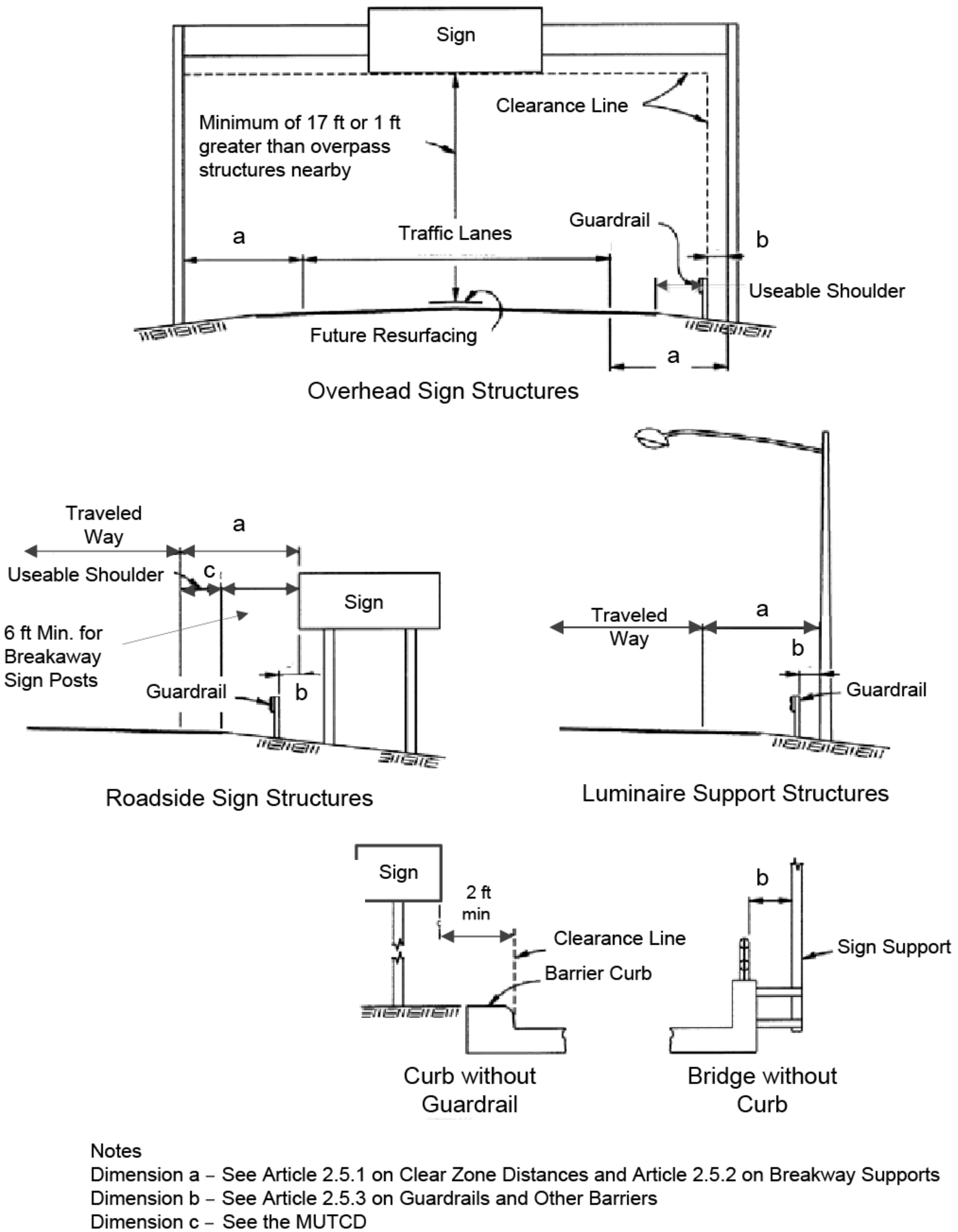

Figure C2.4.2.1-1—Location of Structural Supports

2.4.2.2—Size, Height, and Location of Signs

The MUTCD should be consulted for the sizes, heights, and placement of signs for any installation.

C2.4.2.2

The MUTCD includes information on signs for sizes, illumination and reflectorization, location, height, and lateral clearance.

2.4.2.3—Illumination and Retroreflectivity of Signs

Illumination and retroreflectivity of signs should conform with the provisions of the MUTCD.

Except where retroreflectivity is deemed adequate, all overhead sign installations should normally be illuminated. The lighting equipment should produce uniform illumination for the sign surface and the position of the lighting fixtures should not impair normal viewing of the sign or obstruct view of the roadway. Where internal illumination is used in conjunction with translucent materials, the colors of the sign should appear essentially the same by night and day.

Retroreflectivity levels are required to be maintained above minimum levels by use of a management or assessment method.

C2.4.2.3

The *Roadway Lighting Design Guide* provides additional information.

By an engineering study, headed or prismatic retroreflectivity sheeting could be used to eliminate the need for sign illumination.

2.4.2.4—Changeable Message Signs

The design of changeable message signs (CMS), enclosures, and connections to the support structure normally require additional considerations that are beyond the scope of these Specifications. The MUTCD should be consulted on size, height, and placement.

C2.4.2.4

CMS are composed of lamps or luminous elements that may be visible during the day as well as at night. The lamps and electronics are contained within an enclosure, which typically weighs significantly more than most sign panels.

The MUTCD includes information on the use and design of changeable message signs.

2.5—ROADSIDE REQUIREMENTS FOR STRUCTURAL SUPPORTS

Consideration shall be given to safe passage of vehicles adjacent to or under a structural support. The hazard to errant vehicles within the clear zone distance, defined in Article 2.5.1, should be minimized by locating obstacles a safe distance away from the traveled way. Roadside requirements and location of structural supports for highway signs, luminaires, and traffic signals should generally adhere to the principles given in Articles 2.5.1 through 2.5.9.

C2.5

Where possible, a single support should be used for dual purposes (e.g., signals and lighting). Consideration should also be given to locating luminaire supports to minimize the necessity of encroaching on the traveled way during routine maintenance.

2.5.1—Clear Zone Distance

Structural supports should be located in conformance with the clear zone concept as contained in Chapter 3, "Roadside Topography and Drainage Features," of the *Roadside Design Guide* (AASHTO 2011), or other clear zone policy accepted by FHWA. Where the practical limits of structure costs, type of structures, volume and design speed of through-traffic, and structure arrangement make conformance with the *Roadside Design Guide* impractical, the structural support should be provided with a breakaway device or protected by the use of a guardrail or other barrier.

C2.5.1

The clear zone, illustrated in Figure C2.4.2.1-1, is the roadside border area beyond the traveled way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. The desired width is dependent on the traffic volumes and speeds and on the roadside geometry.

Suggested minimum clear zone distances are provided in the *Roadside Design Guide* and are dependent on average daily traffic, slope of roadside, and design vehicle speed. Additional discussions of clear zone distances and lateral placement of structural support is provided in the MUTCD and *A Policy on Geometric Design of Highways and Streets*

(AASHTO 2011). Decisions on appropriate clear zones may also be guided by the HSM.

2.5.2—Breakaway Supports

Breakaway supports should be used for luminaire and roadside sign supports when they cannot be placed outside the roadside clear zone or behind a guardrail. The requirements of Section 12, "Breakaway Supports," shall be satisfied. The requirements of Articles 2.5.2.1 and 2.5.2.2 should be met for the proper performance of the breakaway support.

Breakaway supports housing electrical components shall have the use of electrical disconnects considered for all new installations and for existing installations that experience frequent knockdown.

C2.5.2

Generally, breakaway supports should be provided whenever the support is exposed to traffic, even if beyond the clear zone on a traversable slope. The recommended clear zone distances included in the *Roadside Design Guide* accommodate only about 80 percent of errant vehicles. The use of breakaway supports beyond the clear zone will provide an added measure of safety for the remaining 20 percent.

2.5.2.1—Foundations

The top of foundations and projections of any rigidly attached anchor bolts or anchor supports should not extend above the ground level enough to increase the hazard or to interfere with the operation of a breakaway support.

C2.5.2.1

Foundations for breakaway supports located on slopes are likely to require special details to avoid creating a notch in the slope that could impede movement of the support when broken away or a projection of the foundation that could snag the undercarriage of an impacting vehicle. Foundations should be designed considering the breakaway stub height limitations of Section 12.

2.5.2.2—Impact Height

Breakaway supports should be located such that the location of impact of an errant vehicle's bumper is consistent with the maximum bumper height used in breakaway qualification tests.

C2.5.2.2

The *Manual for Assessing Hardware Safety* (MASH) (AASHTO 2009) provides guidance.

2.5.3—Guardrails and Other Barriers

The location of roadside sign and luminaire supports behind a guardrail should provide clearance between the back of the rail and the face of the support to ensure that the rail will deflect properly when struck by a vehicle. Continuity of the railing on rigid highway structures should not be interrupted by sign or luminaire supports.

The clearance between the edge of a sign panel, which could present a hazard if struck, and the back of a barrier should also take into consideration the deflection of the barrier. The edge of a sign shall not extend inside the face of the railing.

C2.5.3

Guardrails, as illustrated in Figure C2.4.2.1-1, are provided to shield motorists from fixed objects and to protect fixed objects, such as overhead sign supports. The *Roadside Design Guide* provides guidance.

The clearance between the back of the barrier and the face of the support may vary, depending on type of barrier system used. The *Roadside Design Guide* may be used to determine the proper clearance.

2.5.4—Roadside Sign and Luminaire Supports

Roadside sign and typical luminaire supports, within the clear zone distance specified in Article 2.5.1, should be designed with a breakaway feature acceptable under MASH, NCHRP 350, or protected with a guardrail or other barrier. Where viewing conditions are favorable, roadside sign and typical luminaire supports may be placed outside the clear zone distance.

C 2.5.4

Where there is a probability of being struck by errant vehicles, even supports outside the suggested clear zone should preferably be breakaway.

For many years, NCHRP 350 was the standard for the assessment and performance of highway safety features. *The AASHTO/FHWA Joint Implementation Plan* (2009) outlines details regarding the use of NCHRP 350 and MASH for design and existing systems.

2.5.5—Overhead Sign Supports and High-Level Lighting Supports

Overhead sign and high-level lighting structural supports should be placed outside the clear zone distance or protected with a proper guardrail or other barrier.

C2.5.5

Overhead sign and high-level lighting supports are considered fixed-base support systems that do not yield or break away on impact. The large mass of these support systems and the potential safety consequences of falling to the ground necessitate a fixed-base design. Fixed-base systems are rigid obstacles and should not be used in the clear zone area unless shielded by a barrier. In some cases, it may be cost effective to place overhead sign supports outside the clear zone with no barrier protection when the added cost of the greater span structure is compared with the long-term costs of guardrail and vegetation maintenance. Structures can sometimes be located in combination with traffic barriers protecting other hazards, such as culverts, bridge ends, and embankments.

2.5.6—Traffic Signal Supports

Traffic signal supports that are installed on high-speed facilities should be placed as far away from the roadway as practical. Shielding these supports should be considered if they are within the clear zone for that particular roadway.

C2.5.6

Traffic signal structural supports with mast arms or span wires normally are not provided with a breakaway device. However, pedestal pole traffic signal supports are appropriately designed to be breakaway devices. Pedestal poles should, if possible, be placed on breakaway supports because they are usually in close proximity to traffic lanes.

2.5.7—Gores

Where obstruction in the gore is unavoidable within the clear zone, protection should be provided by an adequate crash cushion or the structure should be provided with a breakaway device.

2.5.8—Urban Areas

For sign, luminaire, and traffic signal structures located in working urban areas, the minimum lateral clearance from a barrier curb to the support is 24 in. Where no curb exists, the horizontal clearance to the support should be as much as reasonably possible, but at least 24 in.

C2.5.8

The 24-in. offset is not an urban clear zone; rather it was established to avoid interference with truck mirrors, open doors, and so forth.

2.5.9—Joint-Use Supports

Where possible, consideration should be given to the joint usage of supports in urban areas.

C2.5.9

Preference should be given to joint usage to reduce the number of supports in urban areas. For example, a traffic sign and signal support can be combined with a lighting pole.

Care should be taken at the design stage to ensure that the critical load carrying members of the support are of sufficient capacity for all the likely uses made of the support. This could be achieved by indicating in design documents (the Owner's records) limitations on use such as maximum EPA and EPA attachment eccentricity.