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CHAPTER FIFTY-EIGHT

STRUCTURAL-DESIGN LITERATURE

This Chapter discusses the major national publications available in structural-design literature. The Chapter provides a brief discussion on each publication, and the status and application of the publication by the Department. This Chapter is not all inclusive of the structural-design literature; however it does represent a hierarchy of importance. The designer must always ensure that he or she is using the latest edition of each publication.

58-1.0 AASHTO *LRFD BRIDGE DESIGN SPECIFICATIONS*

58-1.01 Description

The AASHTO *Load and Resistance Factor Design (LRFD) Bridge Design Specifications* is intended to serve as the national standard or guide for use in the development of the Department's or a local public agency's own structural specifications. The *Specifications* establishes minimum requirements, consistent with current nationwide practices, which apply to common highway bridges and other structures such as retaining walls and culverts. A long-span structure may require design provisions in addition to those provided in the *Specifications*. Because of the continually changing nature of structural design, interim revisions are issued, and periodically, AASHTO publishes a completely updated version, historically at four-year intervals.

The *LRFD Specifications* is a major update of the former AASHTO *Standard Specifications for Highway Bridges (17th Edition)* and it supersedes, partially or completely, the AASHTO structural-design publications as follows:

1. *Standard Specifications for Alternate Load Factor Design Procedures for Steel Beam Bridges Using Braced Compact Sections*;
2. *Guide Specifications for Strength Design of Truss Bridges*;
3. *Standard Specifications for Seismic Design of Highway Bridges*;
4. *Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members*;
5. *Guide Specifications – Thermal Effects in Concrete Bridge Superstructures*;
6. *Guide Specifications for Fatigue Design of Steel Bridges*;
7. *Guide Specifications for Bridge Railings*;
8. *Guide Specifications for Design and Construction of Segmental Concrete Bridges*; and
9. *Guide Specification and Commentary for Vessel Collision Design of Highway Bridges*.

The *LRFD Specifications* provides a load-and-resistance-factor methodology for the structural design of a bridge, which replaces the load-factor and allowable-stress methodologies of the previous AASHTO *Standard Specifications*. The LRFD methodology requires that bridge components be designed at strength-limit states and that they should be investigated, where appropriate, at stress-based service and fatigue-limit states. Through the use of statistical analyses, the *LRFD Specifications* reflect a uniform safety index for all structural elements, components, and systems. Construction specifications consistent with the AASHTO *LRFD Bridge Design Specifications* are the AASHTO *LRFD Bridge Construction Specifications*.

Some of the features of the *LRFD Specifications* are as follows:

1. The *Specifications* are supplemented with a comprehensive commentary placed immediately adjacent to the *Specifications* provisions.

2. The design live load, designated HL-93, consists of a combination of the design truck or design tandem, and the design lane load.

3. Alternative load factors have been introduced for permanent loads (e.g., dead loads, earth loads, horizontal earth pressures) that must be used in combination with factored transient loads to produce extreme force effects.

4. Fatigue loading consists of a single design truck with a constant 9-m spacing between the 145-kN rear axles, which can be located anywhere on the bridge deck to produce the maximum stress range for the member under consideration. The dynamic load allowance is applied to the fatigue load.

5. Two design trucks are to be used in combination with the design lane load in addition to regular load combinations for negative moments between points of contraflexure and reactions at interior piers. The distance between the lead axle of one truck and the rear axle of the other truck cannot be less than 15 m, and the combined force effect is reduced by 10%.

6. The *Specifications* includes an empirical design for a concrete bridge deck slab, which allows for a wider beam spacing or reduced deck reinforcement, if certain conditions are satisfied.

7. The *Specifications* allows for relatively easy and more precise estimates of live-load distribution by means of tabulated equations or two-dimensional analyses.

8. The *Specifications* allows the optional use of deflection criteria, although the deflection controls used in the past will be maintained.

9. If a compact steel section is used, the need for stiffeners, diaphragms, bracings, or other expensive and fatigue-prone members is reduced.

10. Composite action between the bridge deck and its supporting components is recommended.

11. Reinforced-concrete and prestressed-concrete members are no longer addressed in separate sections, as the provisions for analyzing these types of members have been combined into one section.

12. The method of shear design in concrete has been revised. Modified compression field theory and strut-and-tie models are used.

13. The *Specifications* recognizes the harmful effect of salt-laden water seeping through deck joints and promotes the notion of reducing the number of such joints to an absolute minimum.

Construction specifications consistent with the AASHTO *LRFD Bridge Design Specifications* are the AASHTO *LRFD Bridge Construction Specifications*.

58-1.02 Application

The AASHTO *LRFD Bridge Design Specifications* has been adopted as the basic document for the structural design of a highway bridge. This Part describes the specific application of the *LRFD Specifications* to structural design, which modifies, replaces, clarifies, or deletes information from the AASHTO *LRFD Specifications* for application herein.

Where conflicts are observed in the structural-design literature, the following hierarchy of priority should be used to determine the appropriate application.

1. *Indiana Design Manual*;
2. *LRFD Bridge Design Specifications*; then
3. all other publications.

58-2.0 AASHTO/AWS–D1.5M/D1.5 *BRIDGE WELDING CODE*

58-2.01 Description

This publication describes criteria for the welding of structural steel. These criteria may be used directly or may be used to develop design and construction specifications for welding.

58-2.02 Application

This publication has been adopted for the design and construction of a structural steel highway bridge.

58-3.0 AASHTO *GUIDE SPECIFICATIONS FOR SEISMIC ISOLATION DESIGN OF HIGHWAY BRIDGES*

58-3.01 Description

In 1990, the 1983 edition of this publication was adopted as the seismic design requirements of the AASHTO *Standard Specifications for Highway Bridges*. See the AASHTO *Standard Specifications for Highway Bridges,* Division I-A.

As described in Section 58-1.0, the AASHTO *LRFD Specifications* has superseded the 1983 edition. However, the 1983 edition includes useful background information and provides worked examples.

In 1999, AASHTO published the *Guide Specifications for Seismic Isolation Design* (Second Edition), which was supplemental to the *Standard Specifications for Highway Bridges*, Sixteenth Edition. The *LRFD Specifications* does not specifically address seismic isolators; therefore, these *Guide Specifications* may be used in conjunction with the *LRFD Specifications*.

58-3.02 Application

The AASHTO *Seismic Specifications*, included in the AASHTO *Standard Specifications for Highway Bridges,* Division I-A, may be used for informational purposes. The *Guide Specifications for Seismic Isolation Design* should be used, where applicable, in conjunction with the *LRFD Specifications*. See Section 67-4.06 for the use of seismic isolation bearings.

58-4.0 AASHTO *GUIDE SPECIFICATIONS FOR FRACTURE CRITICAL NON-REDUNDANT STEEL BRIDGE MEMBERS*

58-4.01 Description

This publication provides recommended requirements for identifying, fabricating, welding, and testing of a fracture critical, non-redundant steel bridge member whose failure can be expected to result in a bridge collapse. The publication includes specifications for welding requirements which are in addition to those included in the AASHTO/AWS *Bridge Welding Code*. The *Guide* also discusses the need for proper identification of fracture-critical members on the plans.

As indicated in Section 58-1.0, the AASHTO *LRFD Specifications* has superseded this publication. See Article 6.6.2. However, the publication contains useful information addressing background, example problems, etc.

58-4.02 Application

This publication may be used for informational purposes.

58-5.0 AASHTO *GUIDE SPECIFICATIONS FOR HORIZONTALLY CURVED STEEL GIRDER HIGHWAY BRIDGES* (WITH DESIGN EXAMPLES FOR I-GIRDER AND BOX GIRDER BRIDGES)

58-5.01 Description

This publication provides specifications and methodologies for the design of a steel-beam or a steel-box-girder bridge on a horizontal curve. It is applicable to a composite or non-composite structure of moderate length with either rolled or fabricated sections and simple or continuous spans. The design methodology is based on both working stress and load factor principles. Design examples and box-girder bridges are included.

58-5.02 Application

The use of this publication has been adopted as standard practice. Therefore, it should be used for the design of a horizontally-curved steel member.

58-6.0 AASHTO *GUIDE SPECIFICATIONS FOR BRIDGE RAILINGS*

58-6.01 Description

This publication describes three bridge-railing Performance Levels and associated crash tests and performance requirements plus guidance for determining the appropriate railing Performance

Level for a given bridge site. Under criteria provided in NCHRP *Report 350: Recommended Procedures for the Safety Performance Evaluation of Highway Features*, the performance of bridge railings and the associated transitions are measured in terms of Test Levels. See Section 61-6.0 for more information.

As described in Section 58-1.0, the AASHTO *LRFD Specifications* has superseded this publication. However, it includes useful information addressing background, example problems, etc.

58-6.02 Application

This publication may be used for informational purposes. Section 61-6.0 provides criteria for the selection of bridge railing type, which is consistent with *LRFD Specifications* Section 13 and the NCHRP *Report 350* criteria.

58-7.0 AASHTO *GUIDE SPECIFICATIONS FOR STRUCTURAL DESIGN OF SOUND BARRIERS*

58-7.01 Description

This publication describes the criteria for the structural design of a sound barrier to promote the uniform preparation of plans and specifications. It permits the design of a masonry sound barrier in addition to that of concrete, wood, steel, synthetics and composites, or aluminum.

58-7.02 Application

The use of this publication has been adopted as standard practice. Therefore, it should be used for the structural design of a sound barrier.

58-8.0 AASHTO *GUIDE SPECIFICATIONS AND COMMENTARY FOR VESSEL COLLISION DESIGN OF HIGHWAY BRIDGES*

58-8.01 Description

This is a comprehensive document which includes information relative to designing a bridge to resist damage from a vessel collision. To the extent feasible, it is based on probabilistic principles. The *LRFD Specifications* includes only this document's section regarding loads. This publication includes the remaining information.

58-8.02 Application

This publication, to the extent that it is consistent with the *LRFD Specifications*, should be applied to each applicable site.

58-9.0 AASHTO *STANDARD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES AND TRAFFIC SIGNALS*

58-9.01 Description

This publication describes structural-design criteria for the supports of roadside appurtenances. It includes specific criteria and methodologies for evaluating dead load, live load, ice load, and wind load. It also includes criteria for types of materials used for structural supports such as steel, aluminum, concrete, and wood.

58-9.02 Application

The use of this publication has been adopted as standard practice. The Production Management Division's Office of Structural Services is responsible for the structural analyses of these supports. Standard designs have been developed which will most often apply.

58-10.0 AASHTO *LRFD MOVABLE HIGHWAY BRIDGE DESIGN SPECIFICATIONS*

58-10.01 Description

This publication describes the design, fabrication, and erection of a movable highway bridge. The design portion describes structural work and machinery design of swing, bascule, or vertical-lift spans.

58-10.02 Application

This publication should be applied where vertical clearance over a navigable waterway must be minimized due to right of way, structure height, or other constraints.

58-11.0 AASHTO *GUIDE SPECIFICATIONS FOR DESIGN OF PEDESTRIAN BRIDGES*

58-11.01 Description

This publication applies to a bridge intended to carry primarily pedestrian traffic or bicycle traffic. Unless amended by this publication, The AASHTO *Standard Specifications for Highway Bridges* should be used with this publication, unless this publication amends it.

58-11.02 Application

This publication may be applied where applicable. It is not intended to be used in conjunction with the AASHTO *LRFD Specifications*.

58-12.0 *INDOT REQUIREMENTS FOR GEOTECHNICAL INVESTIGATION* (EXHIBIT "C")

58-12.01 Description

This INDOT publication discusses many of the techniques used for subsurface geotechnical investigations for each highway application. The objective is to describe accepted procedural and technical methods to determine the geotechnical properties of soils and rocks which will support the highway facility. The range of topics includes location and depth of borings, sampling, laboratory testing, and procedures related to geotechnical investigation (e.g., Geotechnical Report, payment). See Chapter Eighteen for elements of geotechnical engineering that the designer will be required to address.

58-12.02 Application

A geotechnical investigation should be performed in accordance with the procedures outlined in this publication and Chapter Eighteen.

58-13.0 *UNIFORM BUILDING CODE*

58-13.01 Description

This document, published by the International Conference of Building Officials, provides criteria for the design of a building. It is intended to be used directly in the development of the Department's or a local public agency's own building codes.

58-13.02 Application

A building should be designed based on this document as modified by specifications promulgated by the Indiana Department of Fire Prevention and Building Safety.

58-14.0 AISC *LRFD MANUAL OF STEEL CONSTRUCTION*

58-14.01 Description

This document, published by the American Institute of Steel Construction (AISC), provides dimensions, properties, and allowable stresses for structural steel. It includes AISC criteria for steel-building construction. The properties of the member shapes are useful for designing a bridge structure.

58-14.02 Application

This publication may be used in the design of a rest-area or weigh-station building.

58-15.0 *TIMBER CONSTRUCTION MANUAL*

58-15.01 Description

This document, published by the American Institute of Timber Construction, provides comprehensive criteria for the design of a timber structure. It includes information for both sawn and laminated timber.

58-15.02 Application

This document should be used to supplement the AASHTO publications in the design of a timber bridge. See Chapter Sixty-five for more information regarding the design of a wood superstructure. If a conflict exists between this document and the *LRFD Specifications* as supplemented by Chapter Sixty-five, the *Specifications* and Chapter Sixty-five will govern.

58-16.0 AREMA *MANUAL FOR RAILWAY ENGINEERING*

58-16.01 Description

This document, published by the American Railway Engineering and Maintenance-of-Way Association (AREMA), provides structural specifications for the design of a bridge that carries a railroad. This document has approximately the same status for a railroad bridge as the *LRFD Specifications* has for a highway bridge. It is mandatory that the structural design of a bridge that carries a railroad is in accordance with the AREMA requirements.

58-16.02 Application

The highway agency can be responsible for the design of a bridge that carries a railroad. The specifications of the *Manual for Railway Engineering* must be satisfied, except as may be modified by a railroad company. Chapter Sixty-nine describes additional information on the structural design of a bridge that carries a railroad.

58-17.0 OTHER STRUCTURAL-DESIGN PUBLICATIONS

Structural-design literature includes other publications which may be useful. These may be used at the discretion of the designer. The following describes other structural-design publications.

1. ACI *Analysis and Design of Reinforced Concrete Bridge Structures*. This American Concrete Institute (ACI) publication includes information on concrete bridge types, loads, load factors, service and ultimate load design, prestressed concrete, substructure and superstructure elements, precast concrete, reinforcing details, and metric conversion.

2. ACI *Building Code Requirements for Structural Concrete and Commentary (ACI 318)*. This publication describes the proper design and construction a reinforced-concrete building. The included subjects are permits and drawings, inspection, specifications, materials, concrete quality, mixing and placing, formwork, embedded pipes, construction joints, reinforcement details, analysis and design, strength and serviceability, slab systems, walls, footings, precast concrete, prestressed concrete, shells and folded plate members, and the strength evaluation of an existing structure.

3. AISC *Highway Structures Design Handbook*. This American Institute of Steel Construction (AISC) document addresses aspects of structural-steel materials, fabrication, economy, and design. Although the design examples apply provisions from earlier AASHTO bridge specifications, the general computational procedure will be helpful in use of the *LRFD Bridge Design Specifications*.

4. CRSI *Design Handbook*. This Concrete Reinforcing Steel Institute (CRSI) publication is in accordance with the *ACI Building Code Requirements for Reinforced Concrete*. It provides values for the design-axial-load strength method or design-moment strength method for a tied column with a square, rectangular, or round cross section, and it provides pile-cap designs.

5. CRSI *Manual of Standard Practice*. This publication explains accepted industry practices for estimating, detailing, fabricating, and placing reinforcing bars and bar supports. Reinforcing steel should be detailed as shown therein, as modified by Chapter Sixty-two.

6. FHWA *Design Manual for Highways in the River Environment, Hydraulic and Environmental Design Considerations*. This publication includes information regarding river dynamics, technical aspects, open-channel flow, alluvial materials, fluvial geomorphology, river stabilization, bank protection, scour, and data sources. See Part IV for practices regarding hydrology and hydraulics.

7. FHWA Report No. IP-87-6, *Seismic Design and Retrofit Manual for Highway Bridges*. This publication includes information concerning basic seismology, bridge dynamics, design concepts, loads, forces, and displacements, in addition to design examples, retrofitting, and comparative analyses.

8. PCI *Bridge Design Manual*. This Prestressed Concrete Institute (PCI) document is intended as a comprehensive document for the design, fabrication, and construction of a bridge with precast and prestressed concrete components, including precast post-tensioned products, produced in a permanent manufacturing plant. It includes recommendations which recognize all of the best industry practices available for use. It explains and applies the AASHTO *LFRD Specifications* pertaining to prestressed-concrete beams and provides preliminary design aids to assist in selecting a cost-effective bridge system and the sizing of precast concrete members.

9. PCI *Design Handbook*. This publication includes information regarding the analysis and design of precast or prestressed concrete products in addition to a discussion on handling, connections, and tolerances for prestressed products. It includes general design information, specifications, and standard practices.

10. PTI *Post-Tensioned Box Girder Bridges*. This Post-Tensioning Institute (PTI) publication includes information regarding economics, design parameters, analysis and detailing, installation, prestressing-steel specifications, post-tensioning tendons, systems, and sources.

11. PTI *Post-Tensioning Manual*. This publication discusses the application of post-tensioning to many types of concrete structures, including concrete bridges. The publication also discusses types of post-tensioning systems, specifications, and the analysis and design of post-tensioned structures and their construction.

12. PTI *Recommendations for Stay Cable Design, Testing and Installation*. The recommendations described herein pertain to the design, testing, and installation of stay cables for a cable-stayed bridge using prestressed wires, strands, or bars as the main tension element. Recommendations are included only for stay cables used in a redundant cable-stayed bridge.

13. USDA *Timber Bridges, Design, Construction, Inspection and Maintenance*. This is a comprehensive document which describes all aspects of traditional timber-bridge construction, plus developments in laminated deck systems using adhesives or prestressing forces.

14. U.S. Navy *Design Manual for Soil Mechanics, Foundations and Earth Structures*. This is a comprehensive document which describes embankments, exploration and sampling, spread footings, deep foundations, pressure distributions, buried substructures, special problems, seepage and drainage analysis, settlement analysis, soil classifications, stabilization, field tests and measurements, retaining walls, etc. The sections on loading included therein are superseded by the *LRFD Specifications*.