

Chapter 10

GENERAL

NDOT STRUCTURES MANUAL

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Chapter 10

GENERAL

10.1 BASIC APPROACH

The basic approach for Part II of the *NDOT Structures Manual* (the *Manual*) is as follows:

1. Application. The *Manual* is an application-oriented document.
2. Theory. The *Manual* is not a structural design theory resource or a research document. The *Manual* provides background information for NDOT's bridge design criteria and application.
3. Example Problems. Where beneficial to explain the intended application, the *Manual* provides example problems demonstrating the proper procedure for selected bridge design applications. These design examples illustrate the specific structural design criteria, practices and policies used by NDOT for the indicated applications.
4. Details. Where beneficial, the *Manual* provides design details for various structural design elements.
5. Coordination with AASHTO LRFD Bridge Design Specifications. Part II of the *Manual* is basically a Supplement to the AASHTO LRFD Bridge Design Specifications (LRFD Specifications) that:
 - in general, does not duplicate information in the LRFD Specifications, unless necessary for clarity;
 - elaborates on specific articles of the LRFD Specifications;
 - presents interpretative information, where required;
 - modifies sections from the LRFD Specifications where NDOT has adopted a different practice;
 - indicates NDOT's preference where the LRFD Specifications presents multiple options; and
 - indicates bridge design applications presented in the LRFD Specifications but which are not typically used in Nevada.

In addition, the *Manual* discusses, for selected applications, the original intent in the development of the LRFD Specifications to assist the bridge designer in the proper application of the LRFD Specifications.

6. Audience. The primary audience for Part II of the *Manual* is the structural design engineer, either experienced or a recent civil engineering graduate. The *Manual* also serves as a resource document for other NDOT Divisions and other transportation agencies.

10.2 NDOT MANUAL APPLICATION

10.2.1 Project Responsibility

The *Manual* applies to all structural design projects under the responsibility of NDOT, including projects designed by:

- NDOT personnel,
- consultants retained by NDOT,
- contractors retained by NDOT for design/build projects,
- local agencies where the project is funded with Federal money, and
- consultants retained by other agencies or private interests for work within NDOT right-of-way (e.g., for permits).

10.2.2 Hierarchy of Priority

Where conflicts are observed in those publications and documents used by NDOT, the following hierarchy of priority shall be used to determine the appropriate application:

- Structural Design Memoranda,
- the *Manual*,
- *LRFD Specifications*, and
- all other publications (see [Section 10.4](#)).

10.2.3 Structural Design Exceptions

Section 10.2.3 discusses NDOT's procedures for identifying, justifying and processing exceptions to the structural design criteria in the *Manual* and *LRFD Specifications*.

10.2.3.1 NDOT Intent

The intent of NDOT is that all design criteria in this *Manual* and the *LRFD Specifications* shall be met. However, recognizing that this may not always be practical, NDOT has established a process to evaluate and approve exceptions to its structural design criteria.

10.2.3.2 Procedures

Formal, written approvals for exceptions are only required where the criteria or policies in either the *Manual* or the *LRFD Specifications* are presented in one of the following contexts (or the like):

- "shall,"
- "mandatory," or
- "required."

In addition, at many locations in Part II of the *Manual*, the text specifically states that any proposed exceptions to the indicated structural design criteria must be approved by the Chief Structures Engineer.

Where the bridge designer proposes a design element that does not meet the requirements of the *Manual* or *LRFD Specifications* in the above context, the following procedure will apply:

1. **Documentation.** The bridge designer will prepare the justification for the exception at the earliest possible stage of the project, which may include:
 - site constraints,
 - design or detailing considerations,
 - construction costs,
 - construction considerations,
 - product availability,
 - environmental impacts, and/or
 - right-of-way impacts.

The bridge designer will document any proposed exceptions from NDOT's structural design criteria in the Bridge Type Selection Report. See [Section 2.6](#) for information on the Bridge Type Selection Report.

2. **Approval.** All proposed exceptions must be approved, in writing, by the Chief Structures Engineer. Prepare a Memorandum to the Chief Structures Engineer, which must include:
 - identification of the requesting designer/public entity;
 - project description and project identification number;
 - structure description and structure number;
 - identification of the applicable section of the *NDOT Structures Manual*, *NDOT Structural Design Memoranda* and/or *AASHTO LRFD Bridge Design Specifications*; and
 - justification for the request.

10.2.4 **Scope of Work Definitions**

The appropriate application of the structural design criteria in this *Manual* will depend, in part, on the scope of the proposed structural work. For rehabilitations and widenings, compliance with this *Manual* refers to current NDOT practices and policies, not those that were in effect at the time of original construction of existing structures.

10.2.4.1 **New Bridge**

This scope of work is defined as a new bridge at a new location. The designer shall make every effort to meet the criteria presented in this *Manual* for all new bridge projects.

10.2.4.2 Bridge Replacement

This scope of work is where the existing bridge requires complete replacement of the superstructure, substructure and foundation due to structural or functional deficiencies of the existing structure. The horizontal and vertical alignment of the existing approaching roadway is usually maintained. In general, the designer shall make every effort to meet the criteria presented in this *Manual* for the structural design of bridge replacement projects.

10.2.4.3 Bridge Widening

It may be necessary to widen an existing bridge for a variety of reasons where the existing superstructure and substructure are considered structurally sound. Reasons for bridge widening may include:

1. The existing bridge may provide an inadequate roadway width.
2. The project may include adding travel lanes to a highway segment to increase the traffic-carrying capacity of the facility.
3. A bridge may be widened to add an auxiliary lane across the structure (e.g., increasing the length of an acceleration lane for a freeway entrance, adding a truck-climbing lane, adding a weaving segment at the interior of a cloverleaf interchange).

In general, the designer shall make every effort to meet the criteria presented in this *Manual* for the structural design of the widened portion(s) of bridge widening projects. A determination must be made for whether the existing structure should be strengthened to the same load-carrying capacity as the widening and which AASHTO design standard should be used. For guidance on bridge widening, see [Section 22.10](#).

10.2.4.4 Major Bridge Rehabilitation

The need for major bridge rehabilitation may be based on any number of deficiencies. These may include the following:

- deterioration of structural elements;
- insufficient load-carrying capacity;
- deck replacement or rehabilitation;
- inadequate seismic resistance;
- safety hazard (e.g., substandard bridge rail, substandard guardrail-to-bridge-rail transition); and/or
- geometric deficiencies (e.g., narrow bridge width, inadequate horizontal alignment).

Major bridge rehabilitation may be performed where it is found to be more cost-effective than replacement. This will be determined on a case-by-case basis. As practical, the designer shall meet the criteria presented in this *Manual* for the structural design of bridge rehabilitation projects. For guidance on bridge rehabilitation, see [Chapter 22](#).

10.2.4.5 Minor Bridge Rehabilitation

Minor rehabilitation work will generally be the types of activities listed below and/or those items listed as Safety Work in [Section 10.2.4.6](#). It is not, however, limited to these activities:

- expansion joints,
- deck patching and/or sealing,
- deck waterproofing overlays,
- spot painting of structural steel,
- structural steel fatigue repairs,
- drains and drainage systems,
- grade adjustments, and/or
- concrete coatings.

10.2.4.6 Safety Work

Safety work may be performed as part of a 3R roadway improvement, but it can be performed as a “stand-alone” bridge project to correct a specific safety problem. Safety work may include:

1. Bridge Rail. Substandard bridge rail, substandard guardrail-to-bridge-rail transition, etc., may require upgrading to meet current NDOT criteria. See [Section 16.5.1](#).
2. Anti-Skid Treatment for Decks. If an existing bridge within the limits of a roadway project has low skid numbers, consider deck grinding or placement of a bridge deck overlay, especially if there is a history of wet-weather crashes.

10.3 QUALIFYING WORDS

Many qualifying words are used in structural design and in this *Manual*. For consistency and uniformity in the application of various design criteria, the following definitions apply:

1. Shall, require, will, must. A mandatory condition. Designers are obligated to adhere to the criteria and applications presented in this context or to perform the evaluation indicated. In particular, the use of the word “shall” bears a special meaning. Where used, the designer must meet the criteria or request a structural design exception. See [Section 10.2.3](#) for the exception procedure.
2. Should, recommend. An advisory condition. Designers are strongly encouraged to follow the criteria and guidance presented in this context, unless there is reasonable justification not to do so.
3. May, could, can, suggest, consider. A permissive condition. Designers are allowed to apply individual judgment and discretion to the criteria when presented in this context. The decision will be based on a case-by-case assessment.
4. Desirable, preferred. An indication that the designer should make every reasonable effort to meet the criteria and that the designer should only use a “lesser” design after due consideration of the “better” design.
5. Ideal. Indicating a standard of perfection (e.g., ideal conditions).
6. Minimum, maximum, upper, lower (limits). Representative of generally accepted limits within the structural design community, but not necessarily suggesting that these limits are inviolable. However, where the criteria presented in the “shall” context cannot be met, the designer must seek an exception.
7. Practical, feasible, cost-effective, reasonable. Advising the designer that the decision to apply the design criteria should be based on a subjective analysis of the anticipated benefits and costs associated with the impacts of the decision. No formal analysis (e.g., cost-effectiveness analysis) is intended, unless otherwise stated.
8. Possible. Indicating that which can be accomplished. Because of its rather restrictive implication, this word is rarely used in this *Manual* for the application of structural design criteria.
9. Significant, major (impact). Indicating that the consequences from a given action are obvious to most observers and, in many cases, can be readily measured.
10. Insignificant, minor (impact). Indicating that the consequences from a given action are relatively small and not an important factor in the decision-making for structural design.
11. Standard. A structural design criteria or compilation of criteria that has gained consensus or unanimous acceptance within the structural design community.
12. Guideline or Guide. Indicating a design value that establishes an approximate threshold that should be met if considered practical.
13. Criteria. A term typically used to apply to design values, usually with no suggestion on the criticality of the design value.

14. Typical. Indicating a design practice that is most often used in application and that is likely to be the “best” treatment at a given site.
15. Acceptable. Design criteria which may not meet desirable values, but yet is considered to be reasonable and safe for design purposes.
16. NDOT Practice. A statement that NDOT is presenting its preferred or typical structural design treatment with the expectation that the designer will make every reasonable effort to meet NDOT practice. Exceptions are considered on a case-by-case basis.
17. NDOT Policy. Indicating NDOT practice that NDOT has adopted that the designer is expected to follow, unless otherwise justified. However, formal structural design exceptions are only required where the statement is presented in the “shall” (or a similar) context.

10.4 STRUCTURAL DESIGN LITERATURE (National)

Section 10.4 discusses the major national publications available in the structural design literature. It provides 1) a brief discussion on each publication, and 2) the status and application of the publication by NDOT. Section 10.4 is not all inclusive of the structural design literature; however, it does represent a hierarchy of importance. In all cases, designers must ensure that they are using the latest edition of the publication, including all interim revisions to date.

10.4.1 LRFD Bridge Design Specifications

10.4.1.1 Description

10.4.1.1.1 General

The AASHTO *LRFD Bridge Design Specifications* serves as the national standard for use by bridge engineers or for the development of a transportation agency's own structural specifications. The *LRFD Specifications* establishes minimum requirements, consistent with current nationwide practices that apply to common highway bridges and other structures such as retaining walls and culverts; long-span or unique structures may require design provisions in addition to those presented in the *LRFD Specifications*. Interim revisions are issued annually and, periodically, AASHTO publishes a completely updated edition, historically at four-year intervals.

10.4.1.1.2 *LRFD Methodology*

The *LRFD Specifications* presents a load-and-resistance-factor design (LRFD) methodology for the structural design of bridges, which replaces the load factor design (LFD) and service load design (SLD) methodologies of the previous AASHTO *Standard Specifications for Highway Bridges (Standard Specifications)*. The *LRFD Specifications* applies live-load factors that are lower than the traditional AASHTO load factors but balances this reduction with an increase in vehicular live load that more accurately models actual loads on our nation's highways. Basically, the LRFD methodology requires that bridge components be designed to satisfy four sets of limit states: Strength, Service, Fatigue-and-Fracture and Extreme-Event. Through the use of statistical analyses, the provisions of the *LRFD Specifications* reflect a uniform level of safety for all structural elements, components and systems.

10.4.1.1.3 Status

For Federally funded projects, FHWA and the State DOTs have established a goal that the *LRFD Specifications* be used on all new bridge designs after September 2007 for bridges and after September 2010 for culverts, retaining walls and other standard structures. The *LRFD Specifications* reflects a fundamentally different approach to design theory than the *Standard Specifications*. The information in the *LRFD Specifications* supersedes, partially or completely, several AASHTO structural design publications. However, although superseded, some of these publications contain background information or other presentations that may have utility to a bridge designer. The *LRFD Specifications* supersedes the following publications:

1. *Standard Specifications for Alternate Load Factor Design Procedures for Steel Beam Bridges Using Braced Compact Sections*. This publication provides information on the inelastic design of compact steel members (resistance beyond first yield), historically

- known as autostress. An Appendix to the *LRFD Specifications* contains an updated inelastic design process for compact steel sections.
2. *Guide Specifications for Strength Design of Truss Bridges*. This document provides provisions for the design of steel trusses using the Load Factor Design (LFD) methodology. Herein, the load combination for long-span bridges (i.e., the Strength IV load combination of the *LRFD Specifications*) first appeared.
 3. *Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members*. This document provides recommended requirements for identifying, fabricating, welding and testing of fracture critical, non-redundant steel bridge members whose failure would be expected to cause a bridge to collapse. This document includes specifications on welding requirements that are in addition to those in the *ANSI/AASHTO/AWS Bridge Welding Code*. This document also discusses the need for proper identification of fracture critical members on plans, and it contains useful information addressing background, example problems, etc., that are not included in the *LRFD Specifications*.
 4. *Guide Specifications — Thermal Effects in Concrete Bridge Superstructures*. This publication provides guidance on the thermal effects in concrete superstructures with special attention to the thermal gradient through the depth of the superstructure. These provisions have been incorporated into the *LRFD Specifications*.
 5. *Guide Specifications for Fatigue Design of Steel Bridges*. This publication provides an alternative procedure to that of the *AASHTO Standard Specifications for Highway Bridges* wherein the actual number of cycles are used for fatigue design. Such a procedure has now been adopted in the *LRFD Specifications*.
 6. *Guide Specifications for Design and Construction of Segmental Concrete Bridges*. This document provides details on the design and construction of segmental concrete bridges. The high points have subsequently been included in the *LRFD Bridge Design Specifications* and the *LRFD Bridge Construction Specifications*.
 7. *Guide Specification and Commentary for Vessel Collision Design of Highway Bridges*. This publication is a comprehensive document that includes information relative to designing bridges to resist damage from vessel collisions. To the extent feasible, it is based on probabilistic principles. The *LRFD Specifications* contains only the load section of this document. The *Guide Specification and Commentary for Vessel Collision Design of Highway Bridges* contains considerably more information.

10.4.1.1.4 Significant Features

A few significant features of the *LRFD Specifications* are:

1. Commentary. The *LRFD Specifications* are supplemented with a comprehensive commentary placed immediately adjacent to the *LRFD Specifications* provisions in a parallel column.
2. Live Load. The vehicular live load is designated HL-93. This live-load model retains a truck configuration similar to the HS-20 design truck and a tandem slightly heavier than the traditional military loading, but the model has been modified to include simultaneously applied lane loading over full or partial span lengths to produce extreme force effects.

3. Load Factors. Maximum and minimum load factors have been introduced for permanent loads that must be used in combination with factored transient loads to produce extreme force effects. The minimum load factors are most significant for substructure design.
4. Fatigue. Fatigue loading consists of a single truck with axle weights and spacings that are the same as an HS-20 truck with a constant 30-ft spacing between the 32-kip axles that can be located anywhere on the bridge deck to produce the maximum stress range.
5. Load Combinations. In addition to regular load combinations, two design trucks within a single lane are used for negative moments and internal pier reactions in combination with the lane load; the distance between the rear and front axles of the trucks cannot be less than 50 ft; and the combined force effect is reduced by 10%.
6. Bridge Decks. The *LRFD Specifications* includes two methods for the design of concrete bridge decks:
 - the traditional bending method; and
 - an empirical deck design, which allows for reduced deck reinforcement based upon assumed internal arching.NDOT mandates the exclusive use of the traditional bending method.
7. Live-Load Distribution. The *LRFD Specifications* allows for relatively easy and more precise estimates of live-load distribution by tabulated equations.
8. Deflection. The *LRFD Specifications* allows the optional use of deflection criteria. NDOT policy is that the deflection criteria shall be used on all projects.
9. Compact Steel Sections. The *LRFD Specifications* allows for the more frequent use of compact steel sections.
10. Shear. The method of shear design in concrete has been revised; modified compression field theory and strut-and-tie models are used.
11. Deck Joints. The *LRFD Specifications* recognizes the detrimental effect of salt-laden water seeping through deck joints and promotes the objective of reducing the number of such joints to an absolute minimum.

10.4.1.2 Department Application

10.4.1.2.1 State Highway System

NDOT has adopted the use of the *LRFD Specifications* as the mandatory document for the structural design of highway bridges and other structures on the State highway system. Exceptions to this policy are indicated in [Section 10.4.2.2](#).

Part II of the *Manual* presents NDOT's specific applications of the *LRFD Specifications* to structural design, which modify, replace, clarify or delete information from the *LRFD Specifications* for NDOT's application.

10.4.1.2.2 *Off State Highway System*

For highway bridges and other structures not on the State highway system, NDOT's policy is:

1. Federal Funds. For off State highway system projects funded with Federal funds, NDOT policy on the use of the *LRFD Specifications* is identical to projects on the State highway system.
2. Locally Funded Projects. For projects funded with 100% local money, NDOT encourages (but does not require) the use of the *LRFD Specifications* and the *Manual*.

10.4.2 Standard Specifications for Highway Bridges

10.4.2.1 Description

The AASHTO *Standard Specifications for Highway Bridges (Standard Specifications)* was first published in the late 1920s with annual interim revisions and, until the adoption of the *LRFD Specifications*, served as the national standard for the design of highway bridges. The final version of the *Standard Specifications* is based on the Service Load Design (SLD) and Load Factor Design (LFD) methodologies. AASHTO maintained the AASHTO *Standard Specifications* through 2000, and published the final comprehensive 17th edition in 2002.

10.4.2.2 Department Application

NDOT only allows the use of the *Standard Specifications* for specific applications, as follows:

- existing elements for bridge widening and bridge rehabilitation projects (Note: Seismic retrofit must be considered independently);
- structural elements for which no LRFD specifications are available (e.g., pedestrian bridges, soundwalls, signs, signals, lighting); and
- other applications as approved by the Chief Structures Engineer.

The minimum highway live load for strength considerations in the application of the *Standard Specifications* shall be HS-20. An HS-25 live-load shall be used on the National Highway System (NHS) and may be considered for other bridges that carry a significant number of trucks. The HS-25 live-load model is defined as 1.25 times the HS-20 live loading as provided in the *Standard Specifications*. In addition, the P Loads discussed in [Section 12.3.2.7](#) shall also be considered for overload provisions on bridges.

10.4.3 Guide Specifications for Seismic Isolation Design

10.4.3.1 Description

AASHTO published the *Guide Specifications for Seismic Isolation Design* as a supplement to the *Standard Specifications for Seismic Design of Highway Bridges*. The *Guide Specifications for Seismic Isolation Design* presents specifications for the design of bearings to seismically isolate the superstructure from the substructure of highway bridges.

10.4.3.2 Department Application

The AASHTO *Guide Specifications for Seismic Isolation Design* should be used, where applicable, in conjunction with the *LRFD Specifications*.

10.4.4 Guide Specifications for Horizontally Curved Highway Bridges

10.4.4.1 Description

The AASHTO *Guide Specifications for Horizontally Curved Highway Bridges* presents specifications and methodologies for the design of steel I-girder and steel box girder bridges that are on a horizontal curve. This document is applicable to simple and continuous spans and to composite or non-composite structures of moderate length employing either rolled or fabricated sections. The design methodology is based on both the service load and load factor design methodologies and, therefore, is not compatible with the *LRFD Specifications*.

10.4.4.2 Department Application

A 2005 interim change to the *LRFD Specifications* integrates horizontally curved girders, both I-shaped and box girders, in common equations for both straight and curved girders. Therefore, NDOT only allows the use of the *Guide Specifications for Horizontally Curved Highway Bridges* for the same applications as for the *Standard Specifications*.

10.4.5 ANSI/AASHTO/AWS Bridge Welding Code D1.5M/D1.5

10.4.5.1 Description

The *Bridge Welding Code* presents current criteria for the welding of structural steel in bridges. The *Code* superseded the 1981 AASHTO *Standard Specifications for Welding of Structural Steel Highway Bridges* and supplements the *Structural Welding Code*, AWS D1.1.

For the first time, with the 2002 edition, the *Code* includes a commentary on selected sections.

10.4.5.2 Department Application

NDOT has adopted the mandatory use of the *Bridge Welding Code D1.5* for the design and construction of structural steel highway bridges. However, for items not specifically addressed in D1.5, such as welding on existing structures or welding on reinforcing steel, refer to the current edition of ANSI/AWS D1.1 and ANSI/AWS D1.4.

10.4.6 Manual on Subsurface Investigations

10.4.6.1 Description

The AASHTO *Manual on Subsurface Investigations* discusses many of the techniques used in the highway industry for subsurface geotechnical investigations. The objective is to describe accepted procedural and technical methods to determine the geotechnical properties of soils and rock strata that will support the highway facility. The range of topics includes data

requirements, field reconnaissance, evaluation of geotechnical data, subsurface water impacts, equipment and laboratory techniques.

10.4.6.2 Department Application

NDOT recommends that this publication be used for all subsurface investigations, which is primarily the responsibility of the NDOT Materials Division.

10.4.7 Guide Specifications for Design of Pedestrian Bridges

10.4.7.1 Description

The AASHTO *Guide Specifications for Design of Pedestrian Bridges* applies to bridges intended to carry primarily pedestrian traffic and/or bicycle traffic. This document is not based upon the LRFD design methodology, but is based upon the service load design (SLD) and load factor design (LFD) methodologies.

10.4.7.2 Department Application

The AASHTO *Guide Specifications for Design of Pedestrian Bridges* shall be used by the designer for the design of pedestrian bridges in conjunction with the *Standard Specifications*. The publication shall not be used in conjunction with the *LRFD Specifications*.

10.4.8 Guide Specifications for Distribution of Loads for Highway Bridges

10.4.8.1 Description

The AASHTO *Guide Specifications for Distribution of Loads for Highway Bridges* provides more refined live-load distribution factors than the traditional S-over factors of the *Standard Specifications*. Although the refined equations appear similar, they are not the same as those provided in the *LRFD Specifications* and shall not be used with the *LRFD Specifications*.

10.4.8.2 Application

The AASHTO *Guide Specifications for Distribution of Loads for Highway Bridges* only applies to non-LRFD applications. Therefore, this document is only used when reverting back to the *Standard Specifications* for design.

10.4.9 Guide Design Specifications for Bridge Temporary Works

10.4.9.1 Description

The AASHTO *Guide Design Specifications for Bridge Temporary Works* has been developed for use by State agencies to include in their existing construction Standard Specifications for falsework, formwork and related temporary construction used to construct highway bridge structures.

10.4.9.2 Application

The AASHTO *Guide Design Specifications for Bridge Temporary Works* should be used by the bridge designer, where applicable.

10.4.10 Guide Specifications for Structural Design of Sound Barriers

10.4.10.1 Description

The AASHTO *Guide Specifications for Structural Design of Sound Barriers* provides criteria for the structural design of sound barriers to promote the uniform preparation of plans and specifications. The publication allows the design of masonry sound barriers in addition to concrete, wood, steel, synthetics and composites and aluminum.

10.4.10.2 Department Application

The AASHTO *Guide Specifications for Structural Design of Sound Barriers* shall be used for all sound barrier designs.

10.4.11 Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals

10.4.11.1 Description

The AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals* presents structural design criteria for the supports of various roadside appurtenances. The publication presents specific criteria and methodologies for evaluating dead load, live load, ice load and wind load. This document also introduces the concept of infinite fatigue life for these structures, many of which are non-redundant. This document also includes criteria for several types of materials used for structural supports such as steel, aluminum, concrete and wood.

10.4.11.2 Department Application

NDOT has adopted the mandatory use of the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*. The NDOT Traffic Engineering Section is the primary user for these structures, but the Structures Division is responsible for their design.

10.4.12 AISC LRFD Manual of Steel Construction

10.4.12.1 Description

The *LRFD Manual of Steel Construction*, published by the American Institute of Steel Construction (AISC), provides dimensions, properties and general design guidance for structural steel for various applications. The *Manual* contains AISC criteria for steel buildings. However, the properties of the rolled structural shapes are useful for designing bridge structures.

10.4.12.2 Department Application

Designers may use the AISC *LRFD Manual of Steel Construction* to the extent it does not conflict with the *LRFD Specifications*.

10.4.13 AREMA Manual for Railway Engineering

10.4.13.1 Description

The AREMA *Manual for Railway Engineering*, published by the American Railway Engineering and Maintenance-of-Way Association (AREMA), provides detailed structural specifications for the design of railroad bridges. The AREMA specifications have approximately the same status for railroad bridges as the *LRFD Specifications* have for highway bridges; i.e., the structural design of railroad bridges shall meet the AREMA requirements.

10.4.13.2 Department Application

Occasionally, NDOT is responsible for the structural design of railroad bridges over highways. The specifications of the AREMA *Manual* must be met, except as modified by railroad companies operating in Nevada. In addition, the AREMA *Manual* contains the AREMA requirements for the geometric design of railroad tracks passing beneath a highway bridge. As appropriate, these criteria have been incorporated into [Chapter 21](#) of the *NDOT Structures Manual*.

10.4.14 Other Structural Design Publications

The structural design literature contains many other publications which may, on a case-by-case basis, be useful. The following briefly describes several other structural design publications:

1. *AF&PA National Design Specification (NDS) for Wood Construction*. This document, published by the American Forest and Paper Association (AF&PA), provides the reference design values (i.e., nominal resistance and stiffness) for wood products that are tabularized in the *LRFD Specifications*. The *LRFD Specifications* refers to the *NDS* for reference design values for lumber grades not included in the *LRFD* tables. The *NDS* publishes reference values for allowable stress design and provides format conversion factors for the use of these values with the LRFD methodology.
2. *AITC Timber Construction Manual*. This document, published by the American Institute of Timber Construction (AITC), provides comprehensive criteria for the design of timber structures, including bridges. This document contains information for both sawn and laminated timber. The designer should use the *AITC Timber Construction Manual* to supplement the AASHTO publications on the design of timber bridges.
3. *American Concrete Institute (ACI) — Analysis and Design of Reinforced Concrete Bridge Structures*. This publication contains information on various concrete bridge types, loads, load factors, service and ultimate load design, prestressed concrete, substructure and superstructure elements, precast concrete, reinforcing details and metric conversion.
4. American Concrete Institute (ACI) 318-05 *Building Code Requirements for Structural Concrete*. This document addresses the proper design and construction of buildings of

structural concrete. The Code has been written such that it may be adopted by reference in a general building code; earlier editions have been widely used in this manner. A Commentary discusses some of the considerations of the Committee in developing the Code with emphasis on the explanation of new or revised provisions that may be unfamiliar to Code users. Even though this document is intended for building design, bridge designers find it useful because it provides more detail on aspects of concrete design that are less typical in highway bridges.

5. *Concrete Reinforcing Steel Institute (CRSI) Handbook*. This publication meets the ACI Building Code Requirements for Reinforced Concrete. Among other information, it provides values for both design axial load strength and design moment strength for tied columns with square, rectangular or round cross sections, and it provides pile cap designs.
6. *CRSI Manual of Standard Practice*. This publication explains generally accepted industry practices for estimating, detailing, fabricating and placing reinforcing bars and bar supports.
7. *International Building Code*. This document, published by the International Conference of Building Officials (ICBO), provides criteria for the design of buildings throughout the United States and abroad. It is intended to be used directly by an agency or to be used in the development of an agency's own building codes. Buildings for which NDOT is responsible for their design (e.g., at rest areas) shall be designed based on the *International Building Code*. This design is typically the responsibility of the NDOT Architectural Section.
8. *National Steel Bridge Alliance (NSBA) Highway Structures Design Handbook*. This document addresses many aspects of structural steel materials, fabrication, economy and design. Recently updated with LRFD examples in both US customary units and SI units, the general computational procedure is helpful to designers using the *LRFD Specifications*.
9. *NCHRP 343 Manuals for Design of Bridge Foundations*. This publication was produced during the development of the LRFD provisions for foundation design. The publication provides valuable additional information on the application of the *LRFD Specifications* to foundations.
10. *PCA Notes on ACI 318-02 Building Code Requirements for Structural Concrete with Design Applications*. The primary purpose of the PCA Notes is to assist the engineer in the proper application of the ACI 318-02 design standard, which is the predecessor to ACI 318-05. Each chapter of the publication starts with a description of the latest Code changes. Emphasis is placed on "how-to-use" the Code. Numerous design examples illustrate the application of the Code provisions.
11. *Post-Tensioning Institute (PTI) Post-Tensioning Manual*. This publication discusses the application of post-tensioning to many types of concrete structures, including concrete bridges. This publication also discusses types of post-tensioning systems, specifications, the analysis and design of post-tensioned structures and their construction.
12. *Prestressed/Precast Concrete Institute (PCI) Bridge Design Manual*. This two-volume, comprehensive design manual includes both preliminary and final design information for standard girders and precast, prestressed concrete products and systems used for transportation structures. This document contains background, strategies for economy,

- fabrication techniques, evaluation of loads, load tables, design theory and numerous complete design examples. This publication is intended to explain and amplify the application of both the *Standard Specifications* and *LRFD Specifications*.
13. *Prestressed/Precast Concrete Institute (PCI) Design Handbook*. This publication includes information on the analysis and design of precast and/or prestressed concrete products in addition to a discussion on handling, connections and tolerances for prestressed products. It contains general design information, specifications, and standard practices.
 14. *PTI — Post-Tensioned Box Girder Bridges*. This publication contains information on economics, design parameters, analysis and detailing, installation, prestressing steel specifications, post-tensioning tendons, systems and sources.
 15. *United States Navy — Design Manual for Soil Mechanics, Foundations and Earth Structures*. This is a comprehensive document covering 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. Note that the loading sections of this document are superseded by the *LRFD Specifications*.

10.5 NDOT DOCUMENTS

NDOT has other publications in addition to the *NDOT Structures Manual* that may apply to a bridge design project. This Section briefly discusses other relevant NDOT publications that may have a significant impact on a bridge design project.

10.5.1 NDOT Project Design Development Manual

The Roadway Design Division is responsible for the *NDOT Project Design Development Manual*. This document provides guidance to the road designer on design criteria and project development. The *NDOT Project Design Development Manual* discusses:

- NDOT organization and the responsibilities of the various Divisions, Offices, Sections, etc., within NDOT;
- road design functions including design controls, design exceptions, access control, geometric criteria, roadside safety, drainage, work zones, cost estimating, contract administration, agreements, CADD, specifications, etc.; and
- project development from planning (scoping) to project letting.

10.5.2 NDOT Geotechnical Design Manual

The Geotechnical Design Section is responsible for the *NDOT Geotechnical Design Manual*. This document presents NDOT's criteria for geotechnical investigations and designs performed by NDOT. The *NDOT Geotechnical Design Manual* discusses:

- reconnaissance surveys;
- field investigations (e.g., subsurface);
- pavement section support (e.g., pavement subgrade, subgrade drainage, erosion control);
- embankments/slopes (e.g., settlement, slope stability);
- foundations for structures (e.g., geotechnical properties);
- retaining walls (e.g., external stability); and
- geotechnical involvement in construction.

10.5.3 NDOT Standard Plans for Road and Bridge Construction

The Specifications Section within the Roadway Design Division is responsible for the *NDOT Standard Plans for Road and Bridge Construction*. The *NDOT Standard Plans* provides details on various design treatments that are consistent from project to project (e.g., guardrail, drainage details). They provide information on how to layout and/or construct the design element.

10.5.4 NDOT Drainage Manual

The Hydraulics Section within the Roadway Design Division is responsible for the *NDOT Drainage Manual*, which presents design criteria on the following topics:

- hydraulic surveys;
- hydrologic methods used in Nevada;
- hydraulic design of culverts, open channels, bridge waterway openings and closed drainage systems; and
- erosion control.

10.5.5 NDOT Standard Specifications for Road and Bridge Construction

The Specifications Section within the Roadway Design Division is also responsible for the *NDOT Standard Specifications for Road and Bridge Construction*. The *Standard Specifications* presents the work methods and materials approved by NDOT for the construction of road, traffic and bridge projects. The publication is divided into three Divisions. Division I “General Requirements” includes information on the administration of a construction project. Division II “Construction Details” addresses the items of work. The sections in Division II are grouped into general work areas such as excavation, plant mix surfacing, concrete structures and guardrail. Each section can have up to five subsections that include:

1. Description. This subsection identifies the type of work addressed in the section.
2. Materials. This subsection identifies the materials that must be used in each item of work. The descriptions in this section are generally short; more extensive materials descriptions are provided in Division III.
3. Construction. This subsection describes how each item of work must be built. The description can be either a method specification, in which the contractor is told how to complete the work, or a performance specification, in which the contractor is provided the end result and is responsible for how the work will be completed.
4. Measurement. This subsection describes how each item of work is measured for payment.
5. Basis of Payment. This subsection describes how each item of work will be paid for under the contract.

Division III “Materials Details” provides a more detailed description of the materials. Each section can have up to three subsections that include:

1. Scope. This subsection describes the general materials addressed in the section.
2. Requirements. This subsection provides general requirements for the materials in this section.
3. Physical Properties and Tests. This subsection provides the specific requirements for each item of work described in this section.

10.5.6 NDOT Construction Manual

The Construction Division is responsible for the *NDOT Construction Manual*. This document is intended for use by construction personnel in the administration of construction contracts, especially the application of the *NDOT Standard Specifications for Road and Bridge Construction*. As such, the *NDOT Construction Manual* addresses each of the items listed for the *NDOT Standard Specifications for Road and Bridge Construction*, but not within the context of a contractual document.