Chapter 1
General Design Information

Introduction

The Bridge Design Manual is intended to be the primary source of information on the design practices of the Wyoming Department of Transportation's Bridge Program. Other sources of information may need to be consulted. For uniformity and consistency of the final product, the methods and practices stated in this manual should be followed, unless special conditions warrant otherwise, and approved by Bridge Program Staff.

This manual is a guide for the preparation of common structural projects and because of the many variations possible, literal conformation may not be feasible. The use of this manual does not relieve the designer of his or her responsibility, nor should it act as a restriction or inhibitor of imagination and new ideas. Although Bridge Office policy is presented here for numerous situations, content of the manual is not intended to be exhaustive. Therefore, use of this manual must be tempered with sound engineering judgment.

Design computations are a part of the permanent records and are often referred to at a later date when it may be difficult to recall many of the details, decisions, oral instructions, etc. Much of the reasoning, thinking, and data required in good plan preparation does not appear on the Plans and can only be found in the design computations.

It is imperative that the design computations are orderly, complete, and readily followed from any page by persons less familiar with the project. This point is of particular importance when we are required to furnish other agencies and engineers with our computations because they constitute a sample of our work, just like our Plans.

This manual is divided into several sections and chapters outlining various parts of the design process. This manual will be updated as procedures are updated and new information becomes available.

Consult the WYDOT Design Guides (4R-3R-2R-1R Criteria) for minimum project requirements. These handbooks supplement *AASHTO's A Policy on Geometric Design of Highways and Streets.*

General Design & Miscellaneous Information

Except as otherwise noted in this manual, all new bridges, box culverts, box culvert extensions , and retaining walls designed by or for WYDOT shall conform to the requirements of the AASHTO LRFD Bridge Design Specification. Bridge Program design standards will be issued as LRFD DESIGN NOTES and will be incorporated into this manual when updates are made. These will address design questions on the interpretation of the LRFD specification and provide consistency within the design squads.

Sign structures and luminaires shall be designed in accordance with the requirements outlined in latest edition of AASHTO's LRFD Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals.

Structure widening or rehabilitations will be designed based on the specification used for the original design. For most bridges built before 2005, the AASHTO Standard Specifications for Highway Bridges, 17th Edition will be used. For new bridges, the AASHTO LRFD Bridge Design Specification will be used.

All structures shall be rated using the design vehicle based on the design specification and the rating trucks specified by the Assistant State Bridge Engineer, Operations. Load ratings shall be accomplished in accordance with the AASHTO Manual for Bridge Evaluation.

The design vehicle for all new structures shall be the HL93. For rehabilitations and widenings, the design vehicle should be the HS20, Tandem, or HS25 as applicable.

All structures designed by the LRFD Specifications should be rated for the HL93 vehicle using the Load and Resistance Factor Rating (LRFR) method and for the HS20 and the Wyoming Type 3, Type 3S2, and the Type 3-3, SU4, SU5, SU6, SU7, EV2, and

EV3 vehicles using Load Factor Rating (LFR) method.

All widened structures designed by the Standard Specifications should be rated for the HS20 and the Wyoming Type 3, Type 3S2, and the Type 3-3, SU4, SU5, SU6, SU7, EV2, and EV3 vehicles using Load Factor Rating (LFR) method.

All AASHTO publications listed in the design shall be complete, with all revisions to date for each publication. References to AASHTO specification articles, equations, table, and figures will be shown, i.e. [Article 3.6.1.2.6]. All designs shall also consider the constraints and requirements of the *WYDOT STANDARD SPECIFICATIONS for Road & Bridge Construction*, with regard to construction.

All designs shall have a cover sheet listing the AASHTO specification with date and Interims, design method (working stress, load factor, load and resistance factor), general physical properties of the item being designed, and specific material strengths or properties.

Design computations shall be prepared by, or under the supervision of, a professional engineer registered in the State of Wyoming. The cover sheet shall bear the name of the design and checker, and the seal and signature of the Engineer, pursuant to the RULES AND REGULATIONS, Chapter V, Section 2, of the Wyoming State Board of Registration for Professional Engineers and Professional Land Surveyors.

AASHTO specifications or equations, obscure memorandums, assumptions, or any conclusions shall be listed immediately prior to said calculations or conclusions. Major decisions, and the involved parties, that affect the design shall be listed in a similar fashion.

Involved or uncommon formulas shall first be given in their general form with the variables defined. This is essential for designs utilizing spreadsheets.

Label all values with the units they are measured in (kip, kip foot, feet, inches, etc.). The following design defaults should be used unless noted in the design.

Moments: kip - ft

Shears: kips
Deflections: inches

Pressure or stress: kips / in^2 (ksi)
Weights / Loads: kips, kips / ft (klf), kips / ft^2 (ksf), kips / ft^3 (kcf)
Foundations:
Footing pressures: kips / ft^2 (ksf)
Drilled shafts: kips (end bearing or side resistance)
Piling: kips (end bearing or side resistance)

In computations for detailing, preliminary design, etc., clearly and fully state the purpose of the computations.

Generally, carry computations to a reasonable accuracy, consistent with the data used, the expected results, and the method of construction to be used. Computations shall be done in a logical progression. Final or significant numbers and conclusions shall be identified through the use of underlining, boxing, or arrowing to, so that they will stand out from the rest of the design.

Show all numbers used. Do not omit obvious steps or calculations, within reason, if it will keep persons less familiar with the design from speculating about procedures. Designs utilizing spreadsheets shall have complete headings, units, formulas, and any explanations about procedures and methods clearly defined. Show all AASHTO specification references.

Use sketches to illustrate uncommon detailing situations or loading diagrams. Design sketches and summary tables should be placed at the end of every design. Structural steel is to be dimensioned to the nearest $^1/_{16}$ of an inch, concrete is to be dimensioned to the nearest $^1/_8$ of an inch.

Use the following coefficient of thermal expansion (α) for steel and concrete:

Steel: $\alpha = 6.5 \times 10^{-6}$ (in/in/ºF)
Concrete: $\alpha = 6.0 \times 10^{-6}$ (in/in/ºF)

The modulus of elasticity (E_s) for all grades of structural steel shall be 29,000,000 pounds per square inch. The modulus of elasticity (E_c) for concrete shall be determined from the following equation:

$$E_c = 120{,}000 K_1 w_C^2 f_C'^{0.33}$$

Where: $w_c = unit\ weight = 0.145\ kcf$

$f_c' = compressive\ strength(ksi)$

$K_1 = 1.0$

The ratio of the modulus of elasticity for steel to that for concrete, or the modular ratio (n), of various design strengths shall comply with the following:

$2.4 \le f_c' < 2.9 \quad n = 10$
$2.9 \le f_c' < 3.6 \quad n = 9$
$3.6 \le f_c' < 4.6 \quad n = 8$
$4.6 \le f_c' < 6.0 \quad n = 7$

$6.0 \le f_c' \quad n = 6$

Bridge designs shall typically consider Strength, Service, Extreme Event, and Fatigue limit states. The limit state checks will vary with the component under consideration. Not all elements will require consideration of all limit states.

Where applicable, a BRASS program should be incorporated in the design. The designer should verify loads and spot check output calculations from the BRASS program. For items not covered by a BRASS program, a complete set of hand calculations shall be developed and checked.