

COLORADO DEPARTMENT OF TRANSPORTATION STAFF BRIDGE BRIDGE RATING MANUAL	Chapter: Introduction Effective: April 1, 2011 Supersedes: April 1, 2002
INTRODUCTION	

Each major structure in Colorado is rated to determine its safe live load capacity.

The purpose of this manual is to organize the rating process so that the procedures and results conform to the policies of the Colorado Department of Transportation. However, this manual should not overrule sound engineering judgment.

The user of this manual is expected to have current copies of the AASHTO LRFD Bridge Design Specifications, *AASHTO Standard Specifications for Highway Bridges*, the *AASHTO Manual for Bridge Evaluation*, and the *Staff Bridge Design Manual*, and be familiar with the applicable sections of these manuals.

Rating procedures for structure types not identified in this manual shall be developed by the rater and shall be subject to review and approval by the Staff Bridge Engineer.

The questions, "How much total live load can this bridge hold? and, "How does this bridge's capacity compare with other bridges?" are usually asked after a bridge is designed, constructed, or during service. The questions may be asked by:

- an engineer who has finished designing a bridge;
- a roadway official attempting to determine the quality of the bridges on the system;
- a funding agency which is deciding whether or not a bridge needs to be repaired or replaced; and
- a permit officer concerned about an overweight vehicle using a particular bridge.

In response to these questions a method for estimating the safe live load capacity of highway structures has been developed. This method involves the assignment of specific rating values to structures which define their live load capacity relative to selected standard vehicles. The four types of rating values used by the Colorado Department of Transportation are Inventory, Operating, Posting, and Overload Color Code.

All structures require an Inventory and an Operating rating value in terms of the HS20-44 or HL-93 loading which defines their long term high frequency load capacity, and ultimate permissible load capacity, respectively. If a structure is deficient for the maximum vehicle loads allowed by law, then its capacity is also assessed in terms of the Type "3", "3S2", and "3-2" Posting Vehicles. Structures on the state highway system are given an Overload Color Code rating which defines their capacity for loads heavier than the maximum legal loads, in terms of the Modified Tandem Vehicle, or the Colorado Permit Vehicle. Once computed, these values are recorded on a Rating Summary Sheet and kept in the structure's permanent file.

After the rating is recorded it becomes one of the most important items in a structure's records. It is utilized in reviewing the sufficiency of new designs, evaluating the relative capacities of structures on a roadway system, prioritizing the expenditure of funds for repair or replacement, and preventing structural failures when routing overloads. In summary, it becomes an essential item for insuring the safety and cost efficient maintenance of the structures on a roadway system.

Rating values are normally calculated only for a bridge's superstructure, and then, only with respect to dead and live loads. Rating values are not routinely computed for structures with spans 20 feet or less. The last page of this introduction shows how the Inventory, Operating, and Posting rating values are calculated. See Section 1-16 for an explanation of how color code rating values are computed.

When a new structure is designed, or an existing structure is modified by design, the engineers who performed the design are responsible for providing a rating. In this case, the rating is an integral part of the design and is executed at the final design phase, but before construction commences. When an existing structure is modified by field changes, e.g., collision damage, or additional asphalt, the party responsible for bridge maintenance and inspection is also responsible for insuring that the bridge is promptly rerated. In all cases, the color code for the new or modified structure should be determined.

This manual presents policies, guidelines, and examples illustrating how ratings are to be calculated in the State of Colorado. When rating a highway structure, the specifications, policies, and guidelines that are to be used are those stipulated in the current *AASHTO LRFD Bridge Design Specifications*, *AASHTO Standard Specifications for Highway Bridges*, the *AASHTO Manual for Bridge Evaluation*, the *Staff Bridge Design Manual* and *this manual*. In order to effectively perform a rating, it is imperative that the rater obtain and become familiar with these manuals.

The calculation of rating values is defined in general by the following formulas which are taken from the *AASHTO Manual for Bridge Evaluation*:

- **Load and Resistance Factor Rating (LRFR);**

$$RF_{LRFR} = \frac{C - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_P)(P)}{(\gamma_{LL}) \cdot (LL + IM)}$$

$$\text{Rating in Tons} = (RF_{LRFR}) \cdot W$$

- C = Capacity = $\phi_C \phi_S \phi_{R_n}$; where $\phi_C \phi_S \geq 0.85$ for Strength Limit State
- C = f_R for service limit state
- DC = Dead load due to structural components and attachments
- DW = Dead load due to wearing surface and utilities

f_R	=	Allowable Stress per LRFD code
IM	=	Dynamic load allowance
LL	=	Live load
P	=	Permanent loads other than dead loads
RF_{LRFR}	=	Rating factor for LRFR
R_n	=	Nominal member resistance
W	=	Weight (tons) of vehicle used to determine live load effect.
ϕ_c	=	Condition factor
ϕ_s	=	System factor
ϕ	=	LRFD resistance factor
γ_{DC}	=	Dead load factor for structural components and attachments
γ_{DW}	=	Dead load factor for wearing surface and utilities
γ_P	=	Load factor for permanent load = 1.0
γ_{LL}	=	Live load factor

- **Load Factor Rating (LFR) and Allowable Stress Rating (ASR)**

$$RF_{LFR;ASR} = \frac{C - A_1 \cdot D}{A_2 \cdot L \cdot (1 + I)}$$

$$\text{Rating in Tons} = (RF_{LFR;ASR}) \cdot W$$

$RF_{LFR;ASR}$	=	Rating factor for LFR or ASR
C	=	The capacity of the structural member
C	=	f_R for ASR
D	=	Dead load on Structural Member
f_R	=	Allowable Stress per the code
L	=	Live load effect on Structural Member
W	=	Weight (tons) of vehicle used to determine live load effect
I	=	The impact factor used with the live load effect
A_1	=	Factor for dead load
A_2	=	Factor for live load
$A_1 = A_2$	=	1.0 for ASR

The HL-93 load rating for the Load and Resistance Factor Rating (LRFR) method is reported as a rating factor. All other ratings are reported as a rating in tons.

Effective July 1, 2002 CDOT will use the AASHTOWare Virtis computer application to perform bridge ratings. With the exception of post-tensioned superstructures, all ratings performed after July 1, 2002 for bridges in CDOT right-of-way shall be based on Virtis. In addition to post-tensioned superstructures, other bridges of unusual geometry or construction type may be waived from this requirement. Post-tensioned superstructures shall be rated as provided for by the CDOT Bridge Rating Manual.

All of the instructions and examples in the CDOT Bridge Rating Manual use the strip method of analysis (see AASHTO LRFD 4.6.2) and the AASHTO LFD live load distribution factors. Until otherwise provided for by the CDOT Bridge Rating Manual, curved superstructures and bridges designed by a refined method of analysis (LRFD 4.6.3) shall be rated using Virtis and the strip method unless the Staff Bridge Branch Bridge Rating Program Engineer approves an exception. Equivalent distribution factors for composite dead loads and live loads shall be used to obtain the appropriate rating at the sections required by the CDOT Bridge Rating Manual (see AASHTO LRFD 4.6.3.1, modified here as may be required for composite dead loads).

Rating requirement have changed with time. The following is a summary of the rating method requirements in this manual.

- All on-system and off-system bridges designed after October 1, 2010 are to be rated with LRFR.
- All on-system and off-system LRFD bridges rated or rerated after October 1, 2010 are to be rated with LRFR.
- All on-system and off-system ASD & LFD bridges rated or rerated after January 1, 1994 are to be rated with LFR, to the extent LFR is applicable to the structure type per the AASHTO specifications.
- All on-system and off-system ASD and LFD bridges on the NHS are to be rated with LFR, to the extent LFR is applicable to the structure type per the AASHTO specifications.
- When any on-system bridges that were constructed after 1985 are rated or rerated they shall receive a permit vehicle operating rating for interior and exterior girders with full impact and multilanes loaded.
- When any on-system bridges constructed before or during 1985 are rated or rerated they shall receive permit vehicle and modified tandem operating ratings with full impact and one lane loaded.

For the maintenance of the CDOT's Opis/Virtis database it is essential to use the most current version of Virtis. Ratings submitted to CDOT that are based on older versions will be rejected. Check with the CDOT Rating Engineer to verify the software version in use by CDOT.