SECTION 1
GENERAL REQUIREMENTS

1.1 DEAD LOADS USED TO DETERMINE BRIDGE RATINGS

The dead load unit weights given in the current AASHTO LRFD Bridge Design Specifications and the current CDOT Bridge Design Manual shall be used, except where superseded by this Manual in Table 1-1.

Bridge decks with bare or asphalt wearing shall be rated for a minimum asphalt thickness of 3”; or an average asphalt thickness that is shown in the most current inspection report, whichever governs.

Bridge decks with Polyester Polymer Concrete (PPC) overlay shall be rated for a minimum overlay thickness of ¾”; or a thickness that is shown in the as-built plans, whichever governs. The overlay of PPC shall be omitted from the deck section properties.

The unit weight of fill soil on all buried structures shall be per Table 1-1, unless otherwise specified in the as-built plans. A pavement thickness of 6” above the buried structure shall be assumed if the roadway pavement thickness is unknown.

The uniform weight of permanent steel deck form shall be included if it is used for concrete decks placed between girders, and inside box girders.

Table 1-1: Unit Weights of Materials

Material	Unit	Unit Weight
Asphalt	lbs/ft^3	146.67
Polyester Polymer Concrete (PPC)	lbs/ft^3	135.0
Fill Soil	lbs/ft^3	125.0
Permanent Steel Deck Form	lbs/ft^2	5.0
Reinforced Cast-in-Place Concrete	lbs/ft^3	150.0
Reinforced Precast Concrete	lbs/ft^3	163.0

The weight of bridge rails to be used for rating shall be based on the most current as-built plans. Verifications of bridge rail weight shall be required, except values from Table 1-2 can be used for the MASH (Manual for Assessing Safety Hardware) bridge rails (i.e. Type 8R, Type 9 and Type 10), and the previous standard bridge rails (i.e. Type 3, Type 4, Type 7, Type 8, and Type 10).

Table 1-2: Unit Weights of Standard Rail Systems

Rail Type	Structural Steel (lbs/ft)	Concrete Curb (*) (lbs/ft)	Total (lbs/ft)
Type 3	45.4	142.6	187
Type 4	N.A.	426.1	426
Type 7	N.A.	481.8	482
Type 7, style C-C	N.A.	538.4	538
Type 8	26.5	437.4	464
Type 8R MASH	19.5	262.5	282
Type 9 MASH	N.A.	483.8	484
Type 9, style CC MASH	N.A.	758.8	759
Type 10 MASH	45.8	243.7	290
Type 10 (10, 10M, 10R)	45.1	244.4	290

(*) The concrete curb weights are computed from the Figure 1-1. The concrete curb weight shall be re-computed if the existing curb geometry is different.

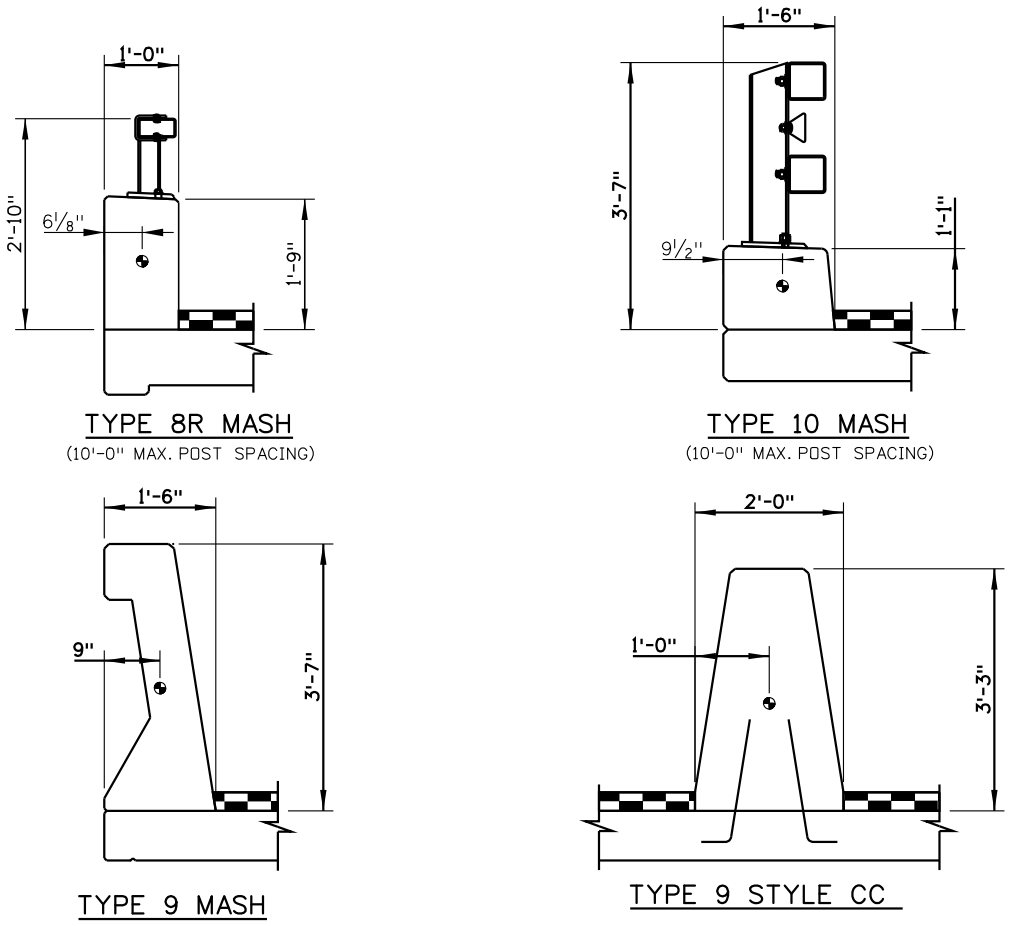


Figure 1-1
MASH Bridge Rails

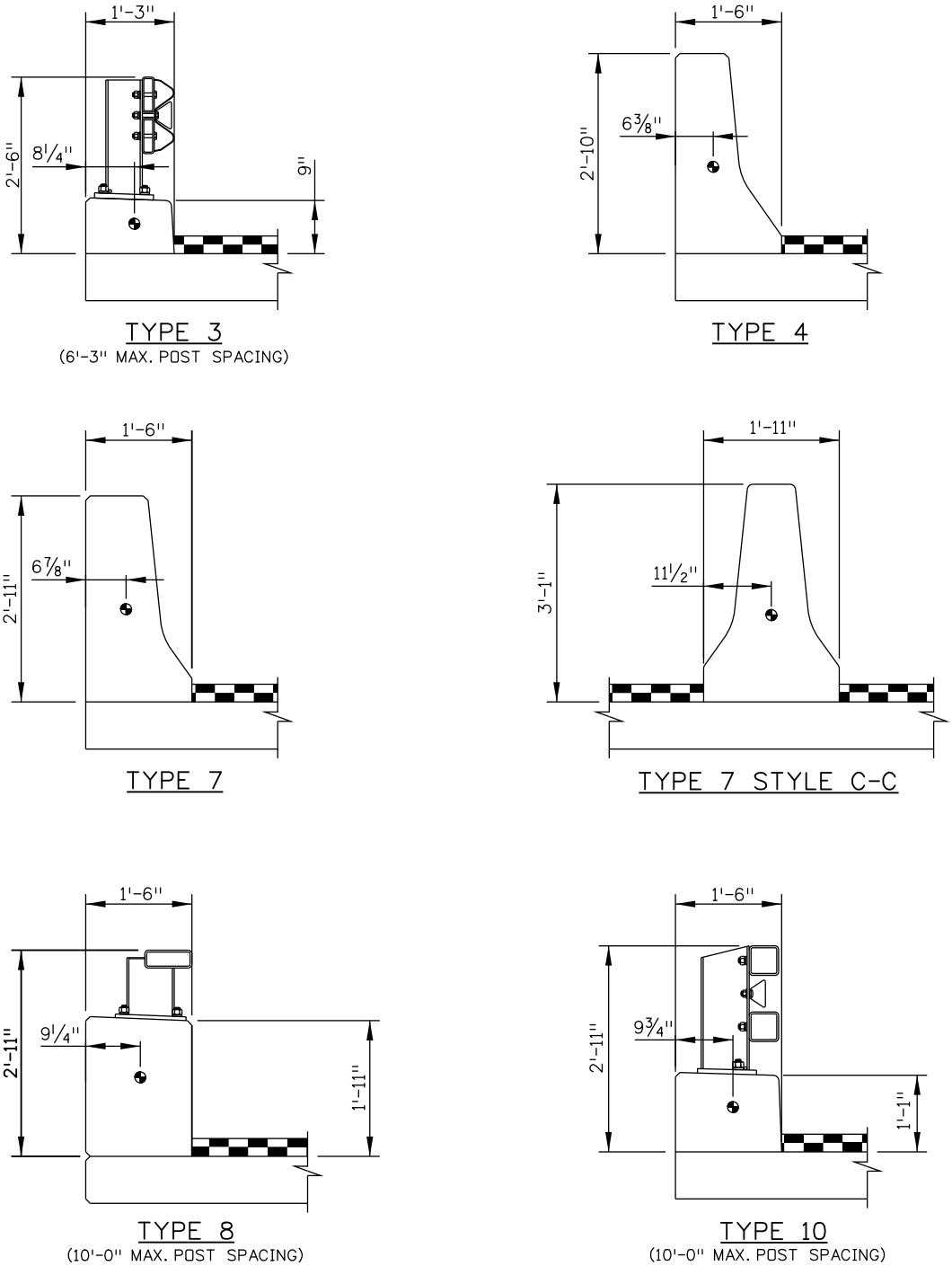


Figure 1-1 (Continued)
Old Standard Bridge Rails

1.2 LIVE LOADS USED TO DETERMINE BRIDGE RATINGS

Colorado Bridge Ratings are required at three different levels: Design Load Rating, Legal Load Rating, and Permit Load Rating and shall be reported on the Rating Summary Sheet. The vehicles of three levels are as specified hereon and in the current AASHTO Manual for Bridge Evaluation (MBE).

These three different levels shall be used to compute the load ratings for all structure types and for all 3 rating methods: Allowable Stress Rating (ASR), Load Factor Rating (LFR), and Load and Resistance Factor Rating (LRFR).

1.2.1 Design Load Rating Level

A) For ASR and LFR methods: The HS20-44 Loading consisting of a Standard HS20 Truck or Standard Lane Load shall be used when computing the Inventory and Operating Load Ratings in US tons. See Figure 1-2.
B) For LRFR method: The HL-93 Design Load shall be used when computing the Inventory and Operating Rating Factors. See Figure 1-3.
Additional HL-93 Load Models:
- 90% of Design Truck pair that is spaced a minimum of 50 feet between the lead axle of one truck and the rear axle of the other truck, combined with 90% of the Design Lane Load shall be used to compute the ratings factor at the pier(s) for negative moment.
- For steel bridges, the fatigue truck shall be required to compute the Inventory Rating Factor. The fatigue truck consists of one design truck, similar to the truck in Figure 1-3, but with a constant spacing of 30 feet between the 32-kip axles.

1.2.2 Legal Load Rating Level

The Legal Vehicles are required to be used when computing the Operating Load Rating in US tons. The structure is required to be posted when the load rating is less than the gross vehicle weight limit.

A) Colorado Legal Vehicles:
- Colorado Legal Trucks of Type 3, Type 3S2, and Type 3-2 shall be used for bridges on State highway routes or Interstate business routes. See Figure 1-4.
- Interstate Legal Trucks of Type 3, Type 3S2, and Type 3-2 are State-Specific Vehicles modified from the AASHTO and the Colorado Legal Loads. See Figure 1-5. These Interstate Legal trucks shall be used for bridges on Interstate highway routes or Interstate access ramps.

Legal Vehicles are composed of the maximum vehicle loads allowed by law in Colorado. The difference between the live loads in Figures 1-4, and 1-5, is due to the maximum legal loads allowed on Interstate highways being different from those allowed on other Colorado roadways.

B) Specialized Hauling Vehicles (SHV):
- Notional Rating Load (NRL). See Figure 1-6.
- Single Unit Bridge Posting Loads of SU4, SU5, SU6 and SU7. See Figure 1-6.

C) FAST Act's Emergency Vehicles (Fixing America's Surface Transportation Act):
- Emergency Vehicles of EV2 and EV3 are Notional vehicles. See Figure 1-7.

NOTE: AASHTO Legal Loads of Type 3, Type 3S2 and Type 3-3, and AASHTO Lane-Type Legal Load Model are NOT required for load ratings.
Colorado has a grandfather provision under Federal law (23 CFR Part 658, Appendix C) to allow the Interstate Legal Trucks of Type 3, Type 3S2, and Type 3-2 supplanting the AASHTO Legal Loads of Type 3, Type 3S2 and Type 3-3 on the Interstate highways.

If the load rating factor for the NRL is 1.0 or greater, then there is no need to rate for the single-unit SU4, SU5, SU6 and SU7 Vehicles. See Subsection 1.14 for how to report the rating results.

Legal Vehicle Weight Limits:

- *Maximum gross weight of vehicle that is legal on any Non-Interstate Colorado highways shall be satisfied with the Colorado Bridge Formula.*
  Gross Weight (lbs) = (L + 40) x 1,000 (C.R.S. 42-4-508 (1)(b))
- *Maximum gross weight of vehicle that is legal on any Interstate highways shall be satisfied with the Federal Bridge Formula B except Emergency Vehicles.*
  Gross Weight (lbs) = 500 (LN / N-1 + 12N + 36)
  Where:
  L = the distance in feet between the outer axles of any two or more consecutive axles.
  N = the number of axles.

The Gross Vehicle Weight (GVW) of SU6 and SU7 do not meet the Colorado Bridge Formula. See Subsections 1.15.1 & 1.15.2 for how to post weight limits of SU6 & SU7 on non-interstate roads.

The GVW of EV2 and EV3 do not meet Federal Bridge Formula B, but could cover situations when emergency vehicles need access to Interstate Highways, or Reasonable Access.

1.2.3 Permit Load Rating Level

The Operating Load Ratings in US tons of the Permit Load Rating Vehicles shall be used to determine the Color Code of the bridge. See Subsection 1.16.

A) Colorado Permit Vehicle. See Figure 1-8.
   The Colorado Permit Vehicle is also required to be used for the design of new bridges for AASHTO LRFD Load Combination Strength II. Therefore, the Colorado Permit Trucks' configurations are currently used to institute the Colorado maximum allowable permit weight per axle group.
B) Colorado Modified Tandem Vehicle. See Figure 1-8.

HS20-44 Loading

Used to determine the Inventory and Operating load ratings in US tons

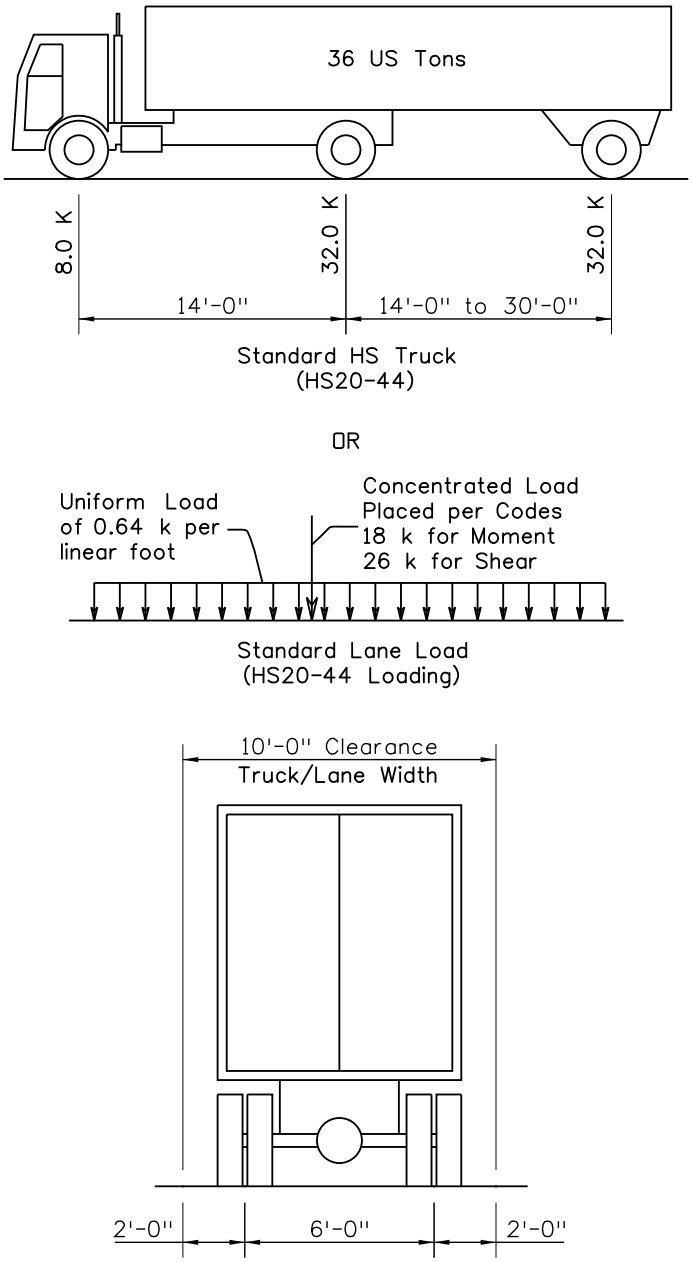
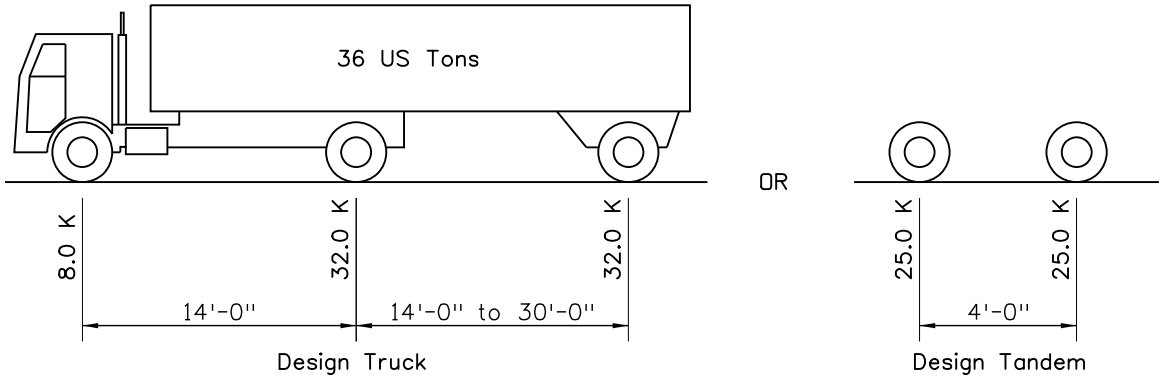


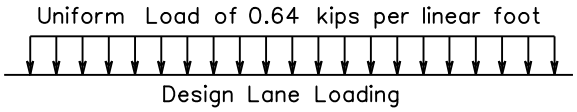
Figure 1-2

HL-93 Design Load - Notional Vehicle

Used to determine the Inventory and Operating rating factors



PLUS



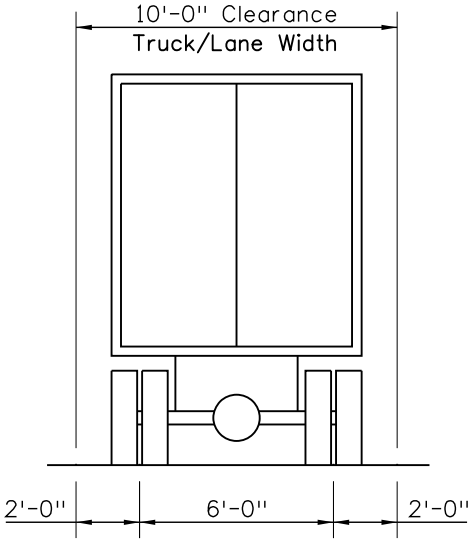
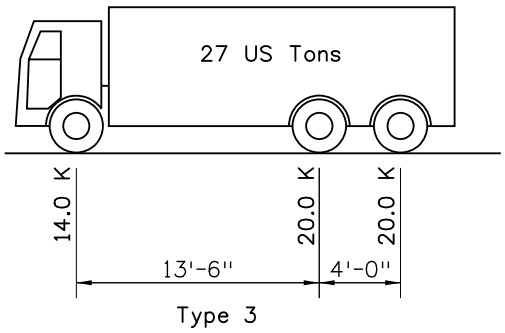


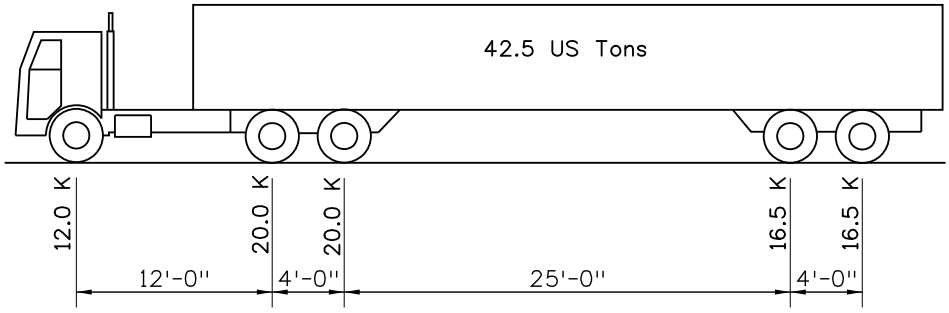
Figure 1-3

Colorado Legal Trucks

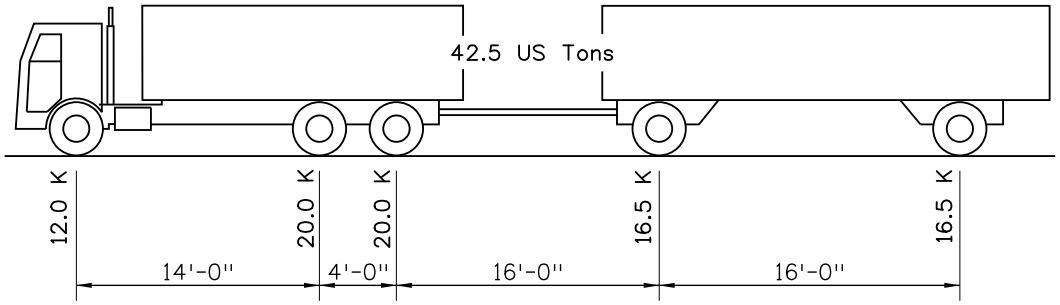
Used to determine the Operating load ratings in US tons along Colorado State Highways
Truck width: 10’-0”
Axle gage width: 6’-0”



Type 3



Type 3S2

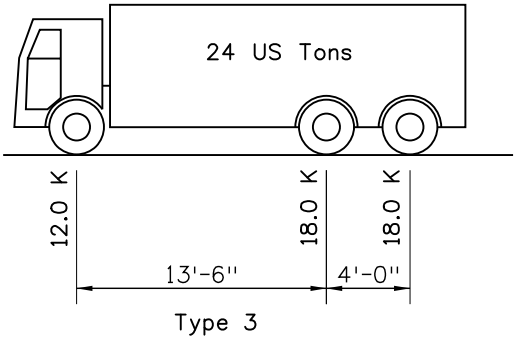


Type 3-2

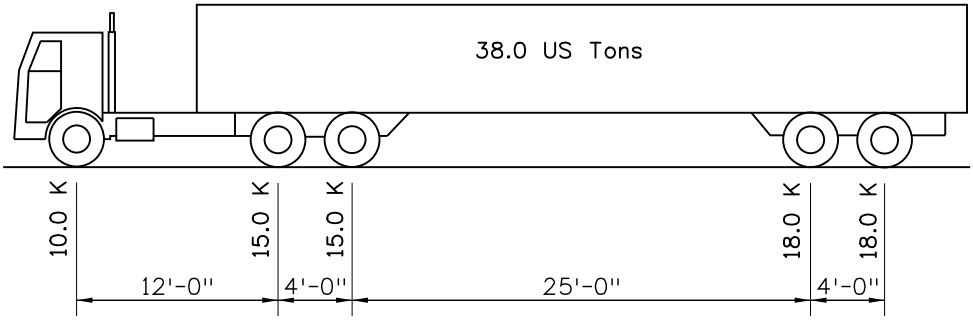
Figure 1-4

Interstate Legal Trucks

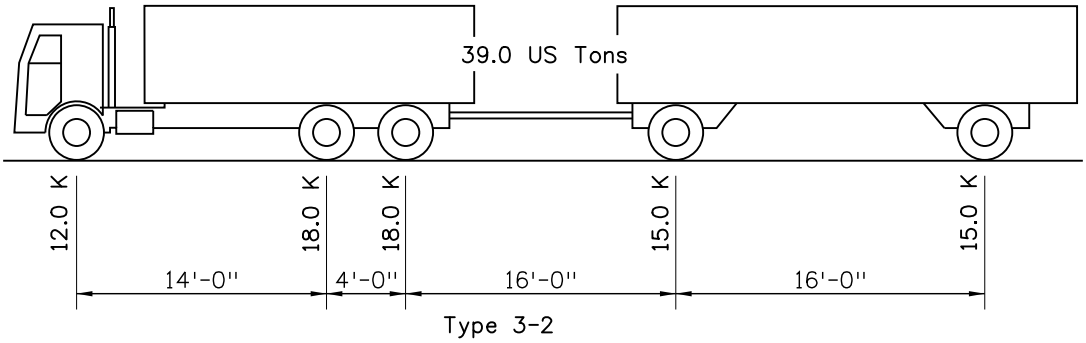
Used to determine the Operating load ratings in US tons along Interstate Highways
Truck width: 10’-0”
Axle gage width: 6’-0”



Type 3



Type 3S2

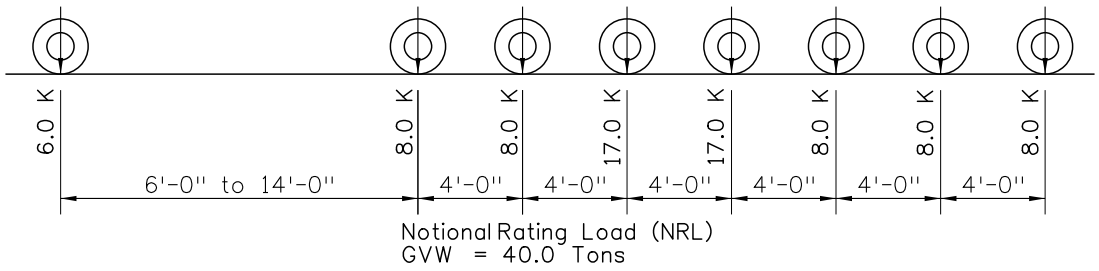


Type 3-2

Figure 1-5

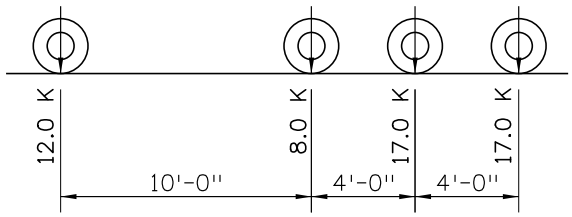
Specialized Hauling Vehicles
Used to determine the Operating load ratings in US tons
Truck width: 10'-0"
Axle gage width: 6'-0"

A. Notional Rating Load (NRL)

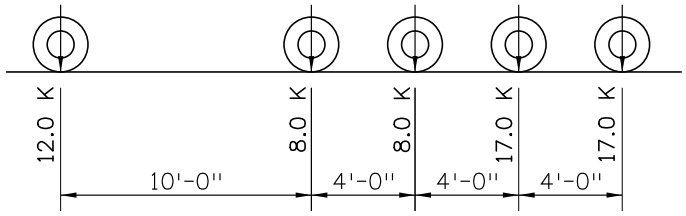


B. Single Unit Bridge Posting Loads

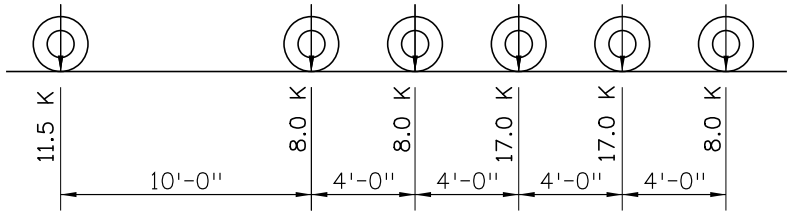
GVW = Gross Vehicle Weight



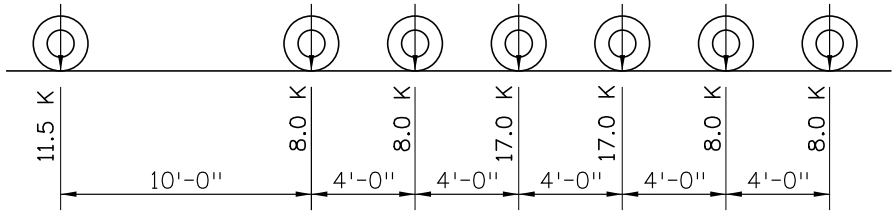
SU4 Truck
GVW = 27.0 Tons



SU5 Truck
GVW = 31.0 Tons



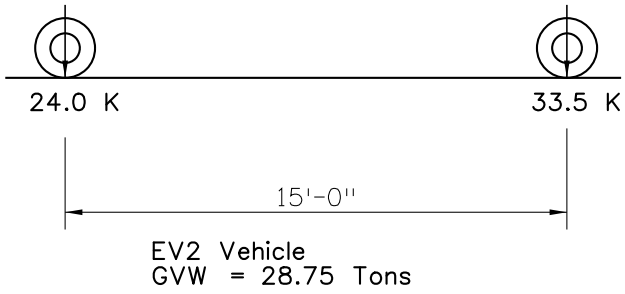
SU6 Truck
GVW = 34.75 Tons

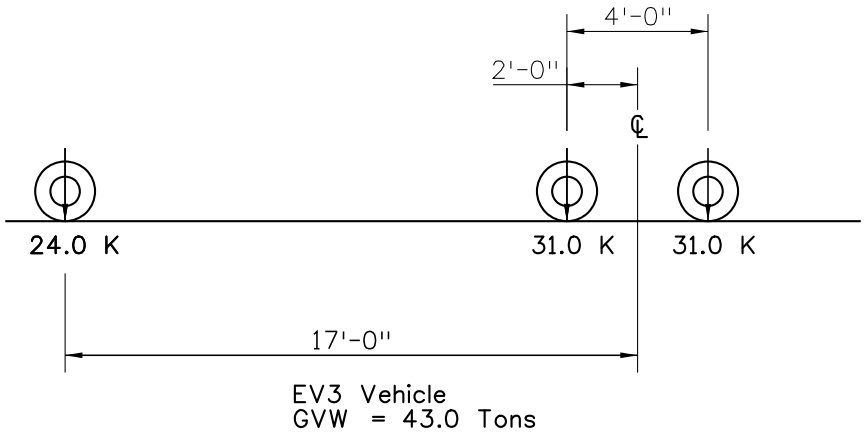


SU7 Truck
GVW = 38.75 Tons

Figure 1-6

Emergency Vehicles – Notional Vehicles
Used to determine the Operating load ratings in US tons
Truck width: 10’-0”
Axle gage width: 6’-0”

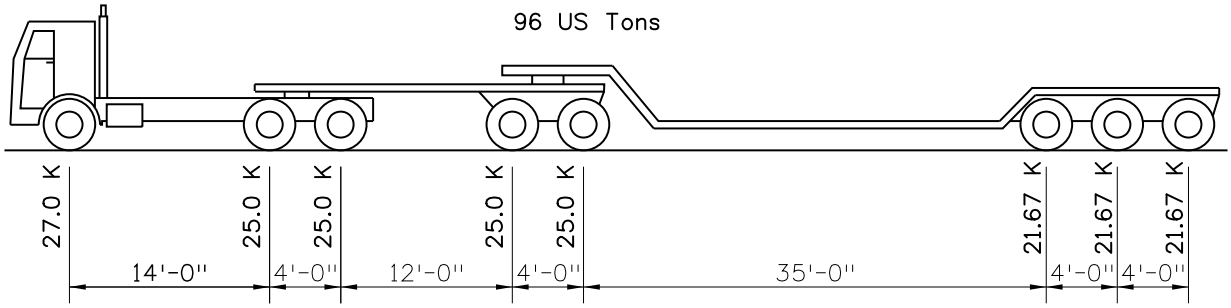




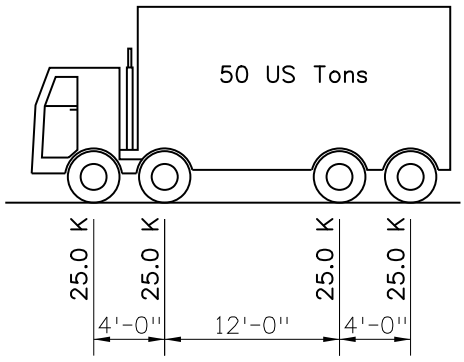
GVW = Gross Vehicle Weight

Figure 1-7

Colorado Permit Trucks
Used to determine the Operating load ratings in US tons
Truck width: 10’-0”
Axle gage width: 6’-0”



Colorado Permit Vehicle



Colorado Modified Tandem Vehicle

Figure 1-8

1.3 IMPACT, LOAD FACTOR, AND DISTRIBUTION OF LIVE LOADS

The live load impact used for rating shall be as specified in the current AASHTO LRFD and Standard Specifications for Highway Bridges, as applicable, except as noted. The live load impact shall be applied for all bridge types, except to timber bridges.

The live load distribution factors used for rating shall be as specified in the current AASHTO LRFD and Standard Specifications for Highway Bridges, except as noted and elsewhere in the manual.

The load factors used for rating shall be as specified in the Standard Specifications for Highway Bridges and the current AASHTO Manual for Bridge Evaluation, except as noted and elsewhere in the CDOT Rating Manual.

A) Based on CDOT historical practice of overload permit analysis using LFR method (e.g., gross vehicle weight over 200,000 lbs), when reduced vehicle speed to 10 mph is enforced, impact can be reduced by 67% when crossing the structure.

B) Impact shall not be considered for timber bridges.

C) For bridges constructed or rehabilitated after 1985, all ratings shall use multi-lane live loaded distribution factor. A single lane live load distribution factor for Permit Vehicles may be used with approval by the Bridge Rating Engineer.

D) For bridges constructed in 1985 or earlier, or bridges with one-lane traffic, rating and re-rating for Legal Load vehicles and Colorado Permit vehicles may be performed using a single lane live load distribution factor. The vehicle may be assumed to occupy the center of a single driving lane without concurrent live loading in any other lane. Non-redundant (fracture-critical) structures shall only utilize multi-lane live loaded distribution factors due to the likelihood of failure of entire structure if one part fails. The design vehicle ratings shall be rated with multi-lane live load distribution factor.

E) When bridge geometric constraints (e.g., span length, number of girder and girder spacing) are outside the range of live load distribution formulas specified in the AASHTO Specifications, the lever rule method or other software may be used to calculate the live load (single or multi-lane) distribution factors.

F) When the lever rule method is used to determine distribution factors for exterior stringers, exterior deck girders, through girders, and trusses, place the first truck wheel 2’-0” from the front face of curb or railing. The transverse distance from centerline to centerline of the standard gage trucks shall be 12’-0” or the width of one traffic lane for narrow bridges.

G) For any load rating methods, the placement of the wheel load shall be 1 foot from the face of the curb or railing for rating of deck overhang, and 2 feet for rating of girders.

H) For LFR load ratings, when ratings for Legal or the Permit vehicles are less than the gross vehicle weight limits, the Rater may use the Distribution Factor-Line Girder setting in BrR (NSG analysis) to improve the load ratings with approval by the Bridge Rating Engineer. The NSG analysis shall not be used for culverts, timber, or fracture-critical structures.

I) For LRFR load ratings, the refined distribution factor method is not allowed for load ratings of bridges, except if it is approved in advance by the Staff Bridge Rating Engineer.

J) Live load distribution factors for two-girder bridge systems and trusses shall be calculated using the lever rule method.

K) The distribution of non-composite and composite dead loads shall be as specified in the current CDOT Bridge Design Manual.

L) For all bridge types, load factors for load rating shall comply with the AASHTO MBE, except a minimum live load factor of 1.3 for operating rating may be used for Emergency Vehicles on all levels of traffic volume for LRFR and LFR methods.

M) For all buried pipe/arch culverts and CBCs, the LRFR live load factor for operating rating of 1.35 shall be used for design vehicle, 2.0 for legal loads, and 1.4 for permit loads on all levels of traffic volume. Only the single loaded lane with multiple presence factor of 1.0 may use for legal load and permit load ratings; while 1.2 is used for design load rating.

N) The maximum and minimum depths of fill on CBCs may be determined at the roadway pavement areas. Distribution of wheel loads through earth fills shall be neglected where the depth of fill exceeds the limits as specified in the current AASHTO LRFD, Section 3.6.1.2.6. See Subsection 1.14 for how to report the rating results.

O) The Emergency Vehicles may be performed using a single lane live load distribution factor for existing or new bridges.

P) For reinforced and prestressed concrete structures, the service I & III limit states may ignore in ratings for the Legal and Permit Vehicles.

Q) For timber structures with stagger stringers at piers, an average stringer spacing of the exterior bays on both sides may be used for ratings.

R) For two-girder bridge systems, trusses, floor-beams, and culverts, an equivalent double-dolly truckload to a regular 10 feet wide truckload shall NOT be allowed for overload permit ratings.

1.4 STRUCTURAL ANALYSIS METHODS USED TO DETERMINE BRIDGE RATINGS

The load ratings shall include analysis of the superstructure for components defined as primary members such as girders, in-span hinges, stringers, deck, truss, floor-beams, truss connections, etc. The substructures / foundations will not be required for load ratings except as requested by the Bridge Inspection Engineer, being necessary due to vehicle impact and scour substructure elements, etc.

Major structures (i.e. total span length greater than 20 feet) are required to have load ratings, and minor structures (i.e. span length from 4 feet to less than or equal to 20 feet) will be required to have load ratings per Subsection 1.8.

A) All bridges designed with LRFD method or designed after September 30th, 2010 shall be rated or re-rated with LRFR method.

B) All existing ASD & LFD bridges designed before October 1st, 2010, except existing timber bridges, shall be rated or re-rated with LFR or LRFR methods.

C) All timber bridges shall rated or re-rated with ASR method.

D) All existing buried pipe/arch culverts may be rated or re-rated with LFR or LRFR methods. New buried culverts shall be rated with LRFR method.

E) For multiple lines of buried pipe structure that meets the minimum spacing between pipes per AASHTO LRFD, Section 12.6.7, a single pipe instead of multi-pipe may be modeled for load rating analysis.

F) All existing concrete and metal plank decks of bridges designed before October 1st, 2010, shall be rated or re-rated with LFR method. Bridges constructed with partial or full-depth precast pre-stressed concrete decks are not required for ratings except as requested.

G) All concrete decks of bridges designed after September 30th, 2010 are not required to be rated except as requested. New metal plank decks shall be rated with LRFR method.

H) All decks shall be rated for design trucks only.

I) When existing bridges are re-decked, the girders shall be re-rated with the same method used to design the new deck, except if approved in advance by the Bridge Rating Engineer.

J) When existing LFD or ASD bridges are widened with LRFD method, the widened portion shall be rated with LRFR method, and the original part may be re-rated with LFR method.

K) For precast pre-stressed concrete girders, the transformed section properties and the AASHTO refined method for losses may be used for load ratings.

L) For multi-span precast pre-stressed concrete continuous girders that are designed with LRFD method, the degree of continuity at pier(s) shall be determined in accordance with the current CDOT Bridge Design Manual, Section 5.7.3.

M) For LRFD reinforced and pre-stressed concrete bridges constructed after December 2001, the load ratings for shear shall be required.
Commentary: Per CDOT-Staff Bridge's Technical Memorandum dated Jan. 31st, 2000, all structures shall be designed and checked with the LRFD design method beginning in January 2002.

N) For existing reinforced and pre-stressed concrete bridges constructed in December 2001 or earlier, when the LFR load-rating factor for shear is less than 1.0, the bridges may be rated with LRFR Modified Compression Field Theory (MCFT) method.

O) For existing reinforced and pre-stressed concrete bridges constructed in December 2001 or earlier, the load ratings for shear shall be required for bridges that have visible signs of shear distress; or if the Colorado NBI condition coding is less than 5. The shear load rating may be ignored by the Bridge Rating Engineer approval for bridges that have no visible signs of shear distress, and the Colorado NBI condition coding is 5 or greater.

P) For all steel bridges, the load ratings for shear shall be required.

Q) For ASD and LFD steel bridges, the field splices and pin connections are not required for ratings, except as requested by the Inspection Unit due to severe corrosion or section loss by vehicular hit.

R) All LRFD steel bridges shall include field splices and pin connections in ratings.

S) Pedestrian bridges that are designed to carry maintenance or emergency vehicles shall be rated in accordance with the current CDOT Bridge Design Manual. The pedestrian load shall not be considered concurrently with the vehicle load.

T) For roadway bridges with sidewalk, the use of pedestrian load shall not exceed the value given in AASHTO Standard Specifications, Section 3.14.1.1. If the sidewalk is not protected by a traffic barrier, the sidewalk loadings shall be considered for two cases:
- Vehicles on the sidewalk without pedestrian load.
- Full pedestrian load on the sidewalk without vehicle load.

U) For a curved bridge with straight girders, and variable overhangs, the bridge may be modeled with maximum overhang on one side and minimum overhang on the other.

V) Existing ASD or LFD multi-span continuous bridges designed with simple span made continuous that have load ratings for negative moments less than the gross vehicle weight limits may be rated or re-rated for single span by applying a hinge at the pier location or by using single span models with approval in advance by the Bridge Rating Engineer.

W) If a curved bridge can be designed as straight segments, as per the requirements of the AASHTO LRFD Section 4.6, the horizontally curved girders may be rated as straight girders with a span length based on the arc length of the longest interior girder. This engineering judgment shall be approved in advance by the Bridge Rating Engineer.

X) For LRFR method, the frequency of the permit vehicle properties will be selected for unlimited crossing, and the loading condition will be selected for mixed with traffic.

Y) For complex structures such as curved, and varying skews at supports that cannot be modeled in the BrR program, a 3-D finite element model or appropriate software may be used for rating with approved in advance by the Bridge Rating Engineer.

Z) Any engineering judgment that is made for structural analysis shall be approved in advance by the Bridge Rating Engineer.

AA) For CBCs constructed before 1992, the loading data that is specified in the corresponding M-Standards, as-built plans, or in the corresponding design specifications may be used for LFR, or LRFR ratings.

1.5 MATERIAL PROPERTIES USED TO DETERMINE BRIDGE RATINGS

For all structures, the material properties used for the rating shall be based on the material grade or design stresses specified in the plans. When plans are not available or do not specify material grade or design stresses, the Rater must then use their best judgment to determine the appropriate material properties based on the information available. Normally, this decision is based on the year the bridge was constructed.

The year of construction may also be determined by engineering judgement by using comparable structures with known plans or other similarly constructed bridges such as parallel bridges.

Table 1-3 shows the material properties based on year of construction, used by the Colorado Department of Transportation. This material property table is based on the predominant grade of materials used by the Colorado Department of Transportation during the years indicated.

After making a thorough investigation into all possible sources of information concerning an existing structure, if the rater is still unable to determine the grade of material used, or year of construction, then a conservative estimate of the construction year should be made. Then, the material property in Table 1-3 can be used.

For steel structures, it is possible that the year of construction and the year of member fabrication do not coincide; e.g., when salvaged members have been utilized. In this case, the year of fabrication shall be used in determining the steel yield stress (F_y).

For metal and plastic pipe/arch culverts, the material properties shall use default values from the CANDE rating software.

Year of Construction for CDOT Bridge Rating

(When the Actual Grade of the Material is Unknown)

LFR and LRFR Ratings

Material	Year of Construction	LFR or LRFR	ASR	
		F_y or f'_c (psi)	Inventory (psi)	Operating (psi)
			0.55 F_y	0.75 F_y
Structural Steel - Bending	Prior to 1905	26,000	14,000	19,500
	1906 to 1936	30,000	16,000	22,500
	1937 to 1963	33,000	18,000	24,500
	After 1963	36,000	20,000	27,000
				0.45 F_y
Structural Steel - Web Shear	Prior to 1905	26,000	8,500	11,500
	1906 to 1936	30,000	9,500	13,500
	1937 to 1963	33,000	11,000	15,000
	After 1963	36,000	12,000	16,000
Reinforcing Steel	Prior to 1954	33,000	18,000	25,000
	1955 to 1971	40,000	20,000	28,000
	After 1971	60,000	24,000	36,000
Structural Concrete	Prior to 1959	2,500	1,000	1,500
	1960 to 1976	3,000	1,200	1,900
	1977 to 1981	4,000	1,600	2,200
	After 1981	4,500	1,800	2,450
Prestressed Concrete	Based on the Actual Grade of Material Used			
Prestressing Steel Strands	Based on the Actual Grade of Material Used			

Allowable Stress Ratings (ASR)

Material	All Years of Construction	Inventory (psi)	Operating (psi)
Timber (Douglas Fir Select Structural)	Bending (F_b)	1,600	2,128
	Shear (F_v) *	113	150
	Shear (F_v) **	98	*c* 130
	Shear (F_v) ***	85	113

* Use when more than 75% of the total number of stringers have NO splits or shear critical cracks.
** Use when 25% or more of the total number of stringers are repaired for splits or shear critical cracks.
*** Use when 25% or more of the total number of stringers are not repaired for splits or shear critical cracks.

c Agreeing to Anthony J. Lamanna, Arda Akbiyik, James C. ray, and Gerardo I. Velazquez (May 2007), "Feasibility Investigation into Strengthening of Timber Bridge Stringers". Use approximately a 44% increase of operating shear strength after timber stringers with horizontal splits or cracks are repaired.

Table 1-3

1.6 AVAILABLE RATING COMPUTER PROGRAMS

A) BrR Software:
CDOT requires the use of AASHTOWare Bridge Rating (BrR) software to perform load ratings for bridges and reinforced concrete box culverts (CBC).

https://www.aashtowarebridge.com/bridge-rating-and-design/

The main advantages of the program are:

- Its utility for automated batch analysis.
- Easily updated load rating when the condition of a structure changes or with new live loads requirements.
- The BrR software is currently used for CDOT Oversize Overweight Permitting and Routing (COOPR) program.

Due to limitations of the BrR software or for other reasons, such as post-tensioned bridges other than the post-tensioned multi-cell box girders, steel box girders, flexible culverts, or complex structures, hand calculations or other software that complies with AASHTO codes may be used to determine the load ratings with approval in advance by the Bridge Rating Engineer.

The BrR software is the AASHTO analytical engine for Load and Resistance Factor Rating (LRFR), Load Factor Rating (LFR), and Allowable Stress Rating (ASR). This software supports two or three dimensional bridge descriptions.

The BrR software can perform load ratings for most common bridge types. The software allows the user to define many bridge alternatives (models) with different structure types to the same bridge.

The BrR software can select the desired analysis type from the Analysis Settings window for CDOT's bridge ratings:

- Line Girder setting (Standard Analysis) is required for all ASR, LFR or LRFR load ratings.
- Distribution Factor-Line Girder setting (NSG) can be used for non-standard gage vehicles, or improving the LFR load ratings for legal or permit vehicles as stated in Subsections 1,3 (H), 1.15.1 & 1.16.
- 3D Finite Element Method setting (FEM) may be used for complex structures (i.e. curved bridges) with approval in advance by the Bridge Rating Engineer.

The BrR tolerance feature can be set by clicking on the CONFIGURATION BROWSER / SYSTEM DEFAULTS / TOLERANCE in the interface WINDOW. Failure to set the tolerance values will cause errors during the analysis. When a newer version of the software is installed, the BrR tolerances must be reset on each user's computer.
The following tolerance values shall be used with bridge ratings located in CDOT's jurisdiction:

US Unit	Tolerance	SI Unit	Tolerance
ft.	0.01	m	0.003048
in.	0.25	mm	6.35
mi.	0.01	km	0.01

For structures that designed in SI unit, the Raters should perform the rating in the SI unit. Advantageously, the BrR load rating outputs will automatically report in US unit.

When rating a structure in BrR, the structure number provided by the Bridge Asset Management Unit (Staff Bridge) will be used for the Structure ID Number. The following naming convention shall be used to organize the explorer window in BrR.
Overload critical bridges used for routing will be assigned the prefix (Z). Only structures on the critical list (e.g. older posted and color coded bridges) should be assigned the prefix (Z). When a rating is in progress or when re-rating a structure, BrR users will add a (7) as the prefix. Once a rating is completed and sent to the Bridge Rating Unit, the Staff Bridge Rating Coordinator will remove any prefix before placing in the BrR global database. Therefore, any structure without a prefix is the final rated structure.
Examples:
F-17-BY: a final accepted rated structure
7F-17-BY: a structure being re-rated or a new rating in progress.
ZF-17-BY: a structure on the critical list used for overload routing.

Before finalizing the rating package for submittal, BrR users shall verify with the Staff Bridge Rating Coordinator that the correct version of the software is used in the analysis. This ensures proper maintenance of CDOT'S BrR database for future use. Ratings submitted to CDOT that are based on older versions will be rejected.

Consultants working with CDOT, or various City and County agencies within the State of Colorado, can obtain BrR at a discounted rate from the AASHTO; however, a written certification is required from CDOT Staff Bridge Rating Engineer.

B) CANDE Software:
CANDE software is a program that requires two parts of analysis including CANDE modeling & CANDE toolbox. CANDE Modeling software is used to model half of culvert in 2D finite element (levels 1 & 2 analysis), and CANDE Toolbox software uses to convert the half culvert model to full culvert model (level 3 analysis), and compute the Rating factor (RF) for any vehicles. Both parts shall be used together to rate the buried pipe/arch culverts for all shapes and materials including reinforced concrete, metal and plastic.

The CANDE software can be downloaded for free at the following address:

http://www.candeforculverts.com/download.html

Buried pipe/arch culverts that are rated with the LRFR method shall use the latest version of CANDE software.
See BRM Section 14A for culvert rating example with CANDE.
CANDE software is an AASHTO sponsored culvert analysis and design software. Programs other than the CANDE must be approved in advance by the CDOT Bridge Rating Engineer.

C) Staff Bridge Software Library:
Below is a current list of computer rating software available from the Staff Bridge Branch Software Library available online at:

https://www.codot.gov/business/engineeringapplications/available-software.html

Any questions regarding the software, including software access, should be directed to the Staff Bridge Rating Engineer.

1) PLANK-Corrugated Steel Plank Rating: Rates asphalt filled, corrugated metal plank decks placed perpendicular to traffic.

2) SLAB-Concrete Slab Rating: Rates slabs continuous over three or more supports with reinforcing placed perpendicular to traffic. The slab must be supported by longitudinal girders, and cannot be pre-stressed.

3) Timber Bridge Rating: Rates plank timber decks with asphalt filled placed perpendicular to traffic. Do not use this program for timber stringer rating.

D) Other Structural Software:
When BrR is not applicable for load ratings, other structural software that complies with the AASHTO codes may be used to support the hand calculations with Staff Bridge Rating Engineer's approval. The following software programs are used by CDOT:

CSI Bridge
SAP2000
LARSA
MDX
LEAP
BRASS
MathCad
Excel, and
Other software as approved

1.7 LOAD RATING OF BRIDGES WITHOUT PLANS

Structural dimensions and material properties are needed to perform load ratings. However, existing bridges built years ago may not have the construction plans (as-built plans).

The Rater shall cooperate with the Bridge Asset Management Unit to search for the as-built plans and any design/rating calculation notes that are available in the ProjectWise database, bridge Briar server, or structure paper inspection folder; and shall make a notification to the Bridge Rating Coordinator if the bridge's information is not available.

Alternatively, the as-built plans may be determined by engineering judgement of comparable structures with known Standard plans, or plans of other similarly constructed bridges such as parallel bridges.

When the as-built plans cannot be located, the following may be used to determine the load carrying capacity:

1.7.1 Bridge Ratings with Field Investigation and Year of Construction

Steel or timber structures may be rated with BrR software using field dimensions, and year of construction:

- Measurable superstructure dimensions such as span length, girder dimension, girder spacing, diaphragm dimensions and locations, deck width, deck overhang, and deck thickness.
- Based on year of construction, the material properties can be determined by using Table 1-3.

1.7.2 Bridge Ratings Based on Physical Inspection

A) Load Capacity Ratings through Engineer Judgment for existing On-system Concrete Bridges:
As per AASHTO Manual for Bridge Evaluation, 3rd Edition 2018 Section 6.1.4: *"A concrete bridge with unknown details need not be posted for restricted loading if it has been carrying normal traffic for an appreciable period of time and shows no distress. The bridge shall be inspected regularly to verify satisfactory performance"*; therefore, the concrete bridges without as-built plans, evaluated with a Colorado NBI condition coding of 5 or better for girders, and showing no signs of distress due to load, can be considered having sufficient live load capacity for the design vehicles.

History of CDOT's design vehicles according to year of construction:

< 1944	H20 Design Vehicle
1944 to Dec., 1993	HS20 Design Vehicle
Jan., 1994 to Dec., 2001	HS25 Design Vehicle
Jan., 2002 to present	HL93 Design Vehicle

The Rater uses the appropriate design vehicle above to back-calculate for reinforced steel area:

1. Determine the material properties based on year of construction by using Table 1-3.
2. Measurable superstructure dimensions such as span length, girder dimension, girder spacing, diaphragm dimensions and locations, deck width, deck overhang, and deck thickness.
3. Based on the field girder dimensions, determine the cracking moment (M_{CR}) of the concrete girders.
4. Determine the factored moment (LL + DL) using the multi-lane design vehicle with full impact.
5. Estimate the reinforcing area or pre-stressed steel area based on the greater of the factored moment (LL + DL) and the cracking moment.
6. The estimated reinforcing or pre-stressed steel area and field dimensions shall be used for load rating with BrR software.

B) Field Inspection Load Ratings for Concrete Culverts and off-system bridges:
When an existing major Concrete Box Culvert (CBC), concrete arch/pipe, masonry arch, concrete deck, or off-system concrete bridge without as-built plans that is evaluated with a Colorado NBI condition coding of 5 or better (item 59 for bridges, or item 62 for culverts); shows no signs of distress due to load, and no change of earth fills or dead loads for an appreciable period of time, the Professional Engineer registered in the State of Colorado can assign maximum load ratings as followings:

- Assign inventory load rating = 36 tons, and operating load rating = 40 tons for the Design Vehicle.
- Assign weight limits for the Legal Vehicles by using Table 1-4. Omit the Single-Unit and Emergency Vehicles on the Rating Summary Sheet (RSS).

- Assign load rating = 96 tons for the Permit Vehicle. Value not necessary for off-system structures.

When there are signs of distress, change of earth fill, or deterioration on the structure rating components, an appropriate judgment should be made to reduce live load carrying capacities as guidance in sections 8.4 & 14.2.

1.7.3 Non-Destructive Test Loading in the Field

For concrete bridges or concrete culverts, when the amount of reinforcing steel is unknown and the Colorado NBI condition coding is less than 5, or shows signs of distress due to load, a non-destructive diagnostic load test in the field shall be required to estimate the reinforcing area based on the field strain data. The estimated steel area and field dimension shall be used for load rating with BrR software. For other methods of determining the steel area, CDOT is not currently confident with scanning. Destructive load tests are not advised per stability concerns.

Notes for bridges without plans:

1. For steel bridges, if the top flanges of the steel girders are embedded into the bottom of the concrete deck, the steel girders and concrete deck should be considered as non-composite slab-girder.
   Commentary: per CDOT historic practical design for simplest steel girder types of non-composite sections, when the top flanges of the steel girders do not have shear studs, the top flanges shall be embedded into the bottom of the concrete deck for receiving full lateral bracing.
2. For concrete bridges, the concrete girders and concrete deck shall be considered as composite slab-girder.
3. For concrete bridges with no visible shear distress, the non-destructive test loading for shear is not required.
4. The existing multi-span continuous bridges may be rated as a single span as specified in Subsection 1.4.

1.8 MINOR STRUCTURE LOAD RATINGS

A minor structure such as a bridge, culvert or cattle/deer guard is a structure where the total crossing length, parallel to the centerline of the roadway, is 4.0 ft. to 20.0 ft. The following shall be considered for load ratings:

A) All existing minor structures will not require load ratings, except when the structural physical condition does not ensure the safe use of such a structure for vehicles.
   - Load ratings are required for all existing minor bridges or culverts with a Colorado NBI condition coding of 4 or lower for item 59, superstructure or item 62, culvert. The Bridge Inspector shall review the bridge inspection report, and make a request as needed. The load rating shall be completed within 60 days after the Rating Engineer receives the notice.

B) All new or widened minor structures shall require load ratings as follows:
   - Steel pipes, steel arches, reinforced concrete pipes, reinforced concrete arches, cast-in-place CBCs, and precast CBCs that do not meet minimum requirements for section modulus, material properties, or construction details from the CDOT M-Standards or ASTM Standards.
   - New Cattle/Deer guards within CDOT ROW not meeting the minimum M-standard requirements will require a rating unless they service private roads or accesses.

- All girder, slab, and truss bridges.

C) Load ratings are not required for minor structures when the earth fill depth exceeds the limit as specified in the AASHTO LRFD, Section 3.6.1.2.6:
- For single span structures, load ratings are not required where the depth of fill is more than 8.0 ft. and exceeds the span length.
- For multiple spans structures, load ratings are not required where the depth of fill exceeds the distance between inside faces of end walls or abutments.

1.9 OFF-SYSTEM STRUCTURE LOAD RATINGS

There is no different load rating performance between on-system and off-system bridges. The current AASHTO Manual for Bridge Evaluation, and the CDOT Bridge Rating Manual (except the Overload Color Code Rating, Subsection 1.16) shall be applied to the off-system structure ratings.

(SUBSECTION 1.10 RESERVED FOR FUTURE USE)

1.11 SUMMARY OF RATING PROCEDURE (IN-HOUSE)

1.11.1 Purpose

The purpose of the rating process is twofold. First, it determines and documents the maximum safe inventory and operating live load capacities of bridges. Second, the rating process can help find possible miscalculations or omissions in new superstructure designs. The design can then be corrected and the plans revised before the structure is built.

1.11.2 Responsibility

The Rater is the person selected to compute the ratings of a bridge. The Rater is responsible for gathering all of the required materials, making all of the necessary calculations, and completing the rating package as outlined in Subsection 1.13. The Rater must also ensure that the most up-to-date Rating Summary Sheet, computer program manuals, and any other materials required to perform bridge ratings are used.

The Checker is the person responsible for verifying that the rating is accurate, that follows established procedures, and that the rating package is complete. If the Checker finds any inaccuracies or omissions, the Checker will return the rating package to the Rater for corrections.
Either the Rater, the Checker or the Engineer responsibly in charge must be a Colorado Registered Professional Engineer and shall stamp the Rating Summary Sheet (RSS).

1.11.3 Procedure

See Figures 1.9, 1.10, 1.11 and 1.12 for flow charts of the following:
Rating: The Rater makes the necessary sketches and calculations to show how the structure was modeled, dead loads were derived, and how other computer input was defined. The rater shall indicate the source of the structural data. The only sources of information used for rating shall be Advanced Plans, Construction

Plans, As-Constructed Plans, and Field Surveys. The ratings are then completed using the proper rating procedure for the type of structure being assessed.
For new or rehabilitated bridges, if any load rating value is not equal to or greater than the rating factor limit of 1.0 or the gross vehicle weight limit, the bridge should be investigated to determine whether or not a re-design is needed. To finish the rating documentation and complete the rating package, the Rater shall do all of the following:

A) Completely fill in all of the required forms.
B) Initial and date the computer output.
C) When rating a new design, on a separate sheet of paper, document the construction status for BMS (Bridge Management System) and state if the rating is for a new bridge or for the reconstruction of an existing bridge. This sheet is to be kept with the Rating Summary Sheet.
D) Bind the rating package together.
E) Forward the rating package to the Checker.

Checking: The Checker shall verify all calculations and ratings, e.g., proper modeling of the structure, accurate calculations, and proper computer input. If the rating is not complete, it shall be returned to the Rater. The Checker shall sign and date all of the rating material including RSS, load rating result outputs from computer programs, and QA/QC check list form once the rating is accepted as complete and accurate.

Final Step: When the rating and checking is completed, the rating package shall be forwarded to the Bridge Rating Unit by the Rater via email. The Rating unit will review the package and if the documentation is incomplete or has errors, the package will be returned to the Rater. The completed rating package shall be archived and updated into the BrR & BrM (Bridge Management) database by the Bridge Rating Unit.

If the load rating is for a new bridge or bridge rehabilitation, the completed rating package shall be sent to the Bridge Rating Unit at Final Submittal and placed in ProjectWise prior to Advertisement in accordance with the current CDOT Bridge Design Manual.

For a description of what shall be included in the rating package, see Section 1.13.

1.11.4 Rating Engineer (Rating Program Manager)

The Staff Bridge Rating Engineer is responsible for the following: managing the BrR global database for all structures, testing the new versions of the BrR software for updating the BrR database, provide assistance to in-house staff and Consultants on bridge rating issues, update the CDOT Rating Manual; coordinate BrDR migration, coordinate bridge rating software needs; and act as a liaison for Office of Information Technology (OIT) on bridge rating related matters.

If the rating of an existing structure requires posting or color code, the Bridge Rating Engineer shall report to the State Bridge Engineer for final determination and will notify the Region RTD, Region Maintenance Superintendent and the Permit Office. The Bridge Rating Engineer shall be the signing authority on RSS for posted or color coded structures based on the Bridge Engineer decision.

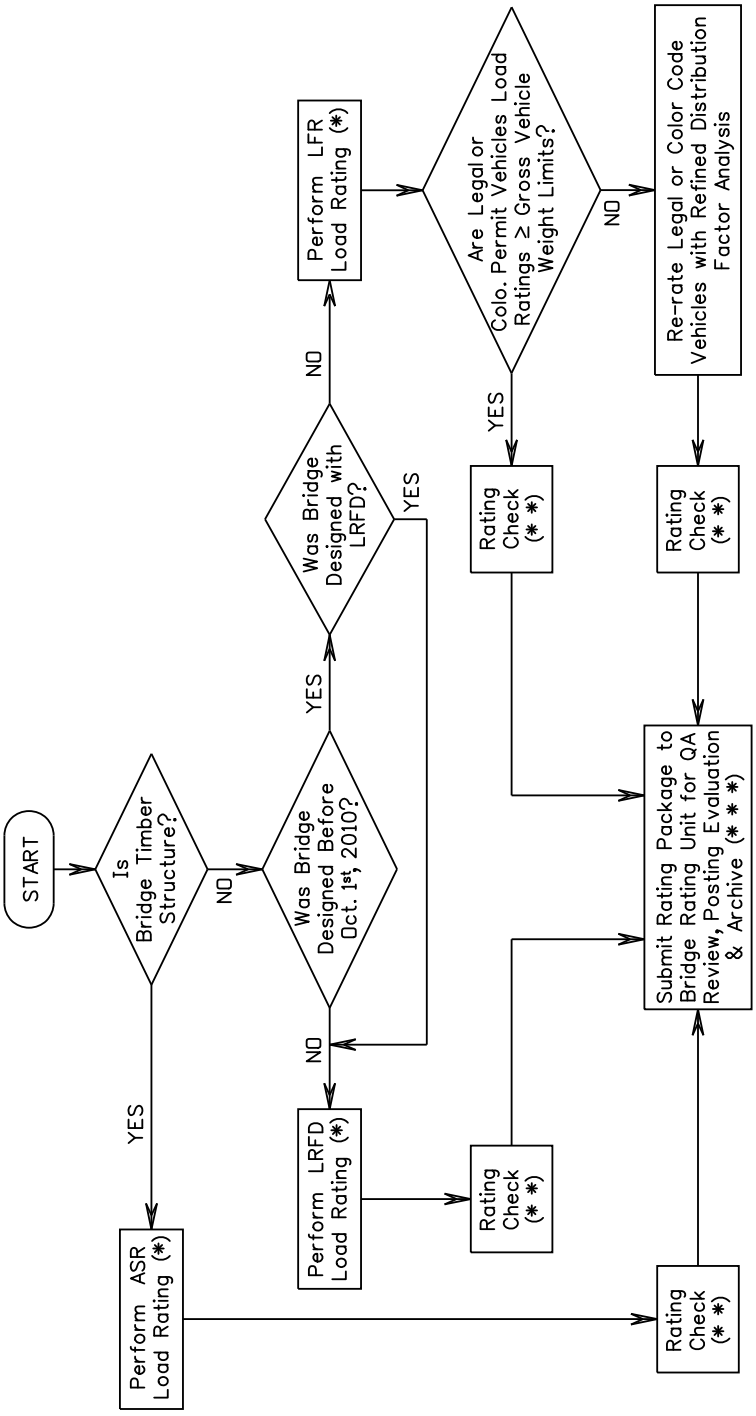


Figure 1.9 Flowchart for Load Rating

(*) Rater Responsibilities, see Figure 1.10
(**) Checker Responsibilities, see Figure 1.11
(***) Bridge Rating Unit Responsibilities, see Figure 1.12

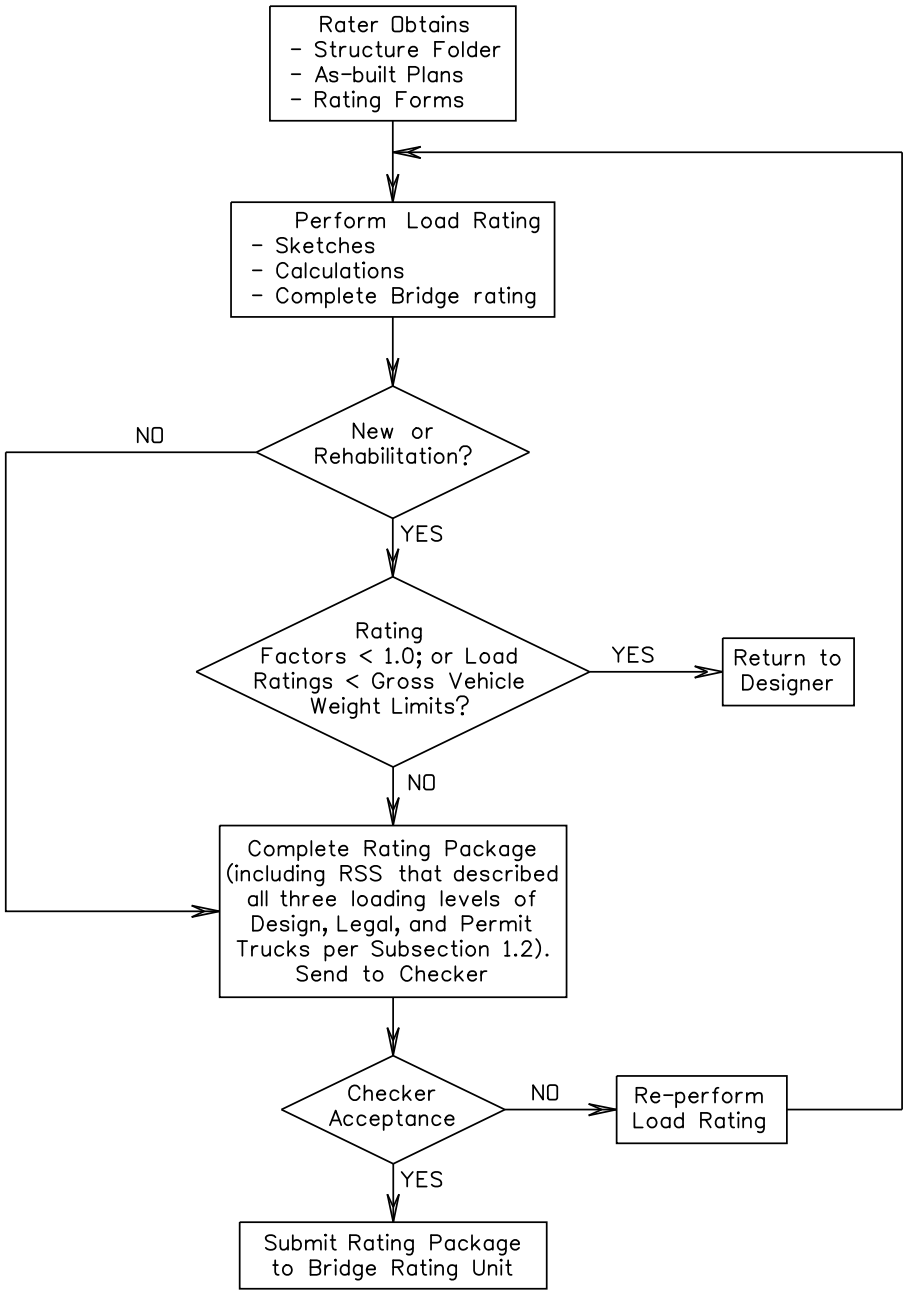


Figure 1.10 Flowchart for Rater Responsibilities

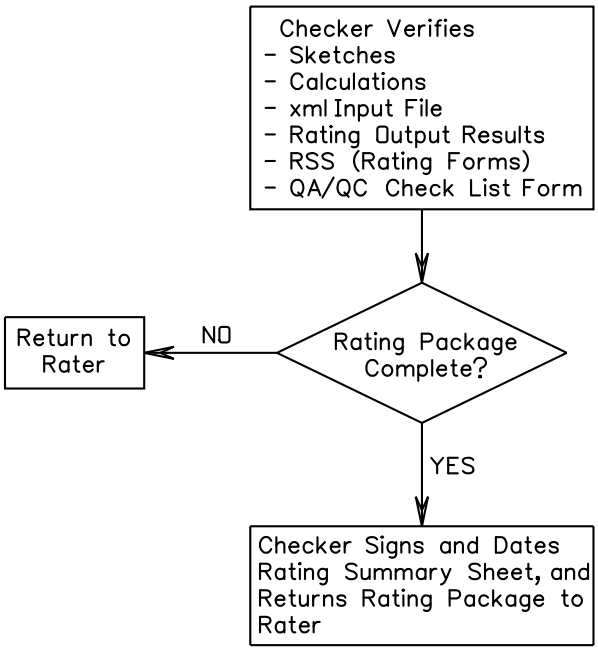


Figure 1.11 Flowchart for Checker Responsibilities

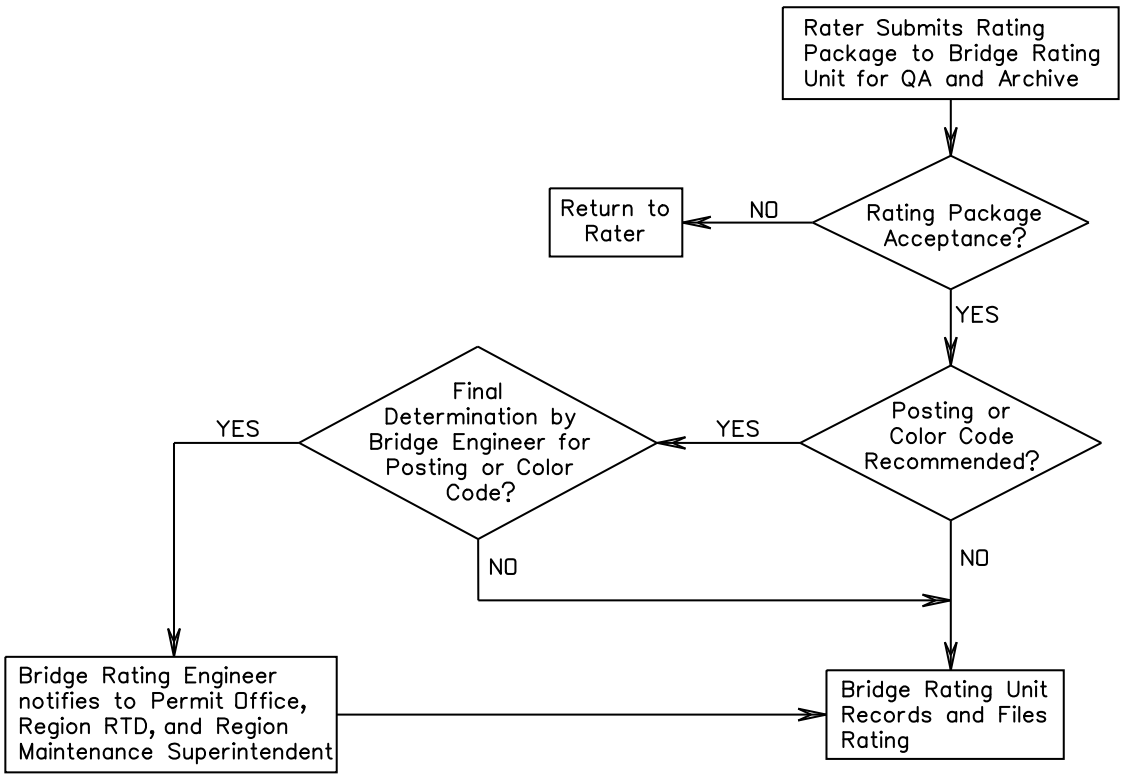


Figure 1.12 Flowchart for Bridge Rating Unit Responsibilities

1.12 SUMMARY OF RATING PROCEDURE (CONSULTANTS)

The rating procedure for consultants is similar to the procedure described for Staff Bridge Design's "In-House" ratings. The differences arise in preparing for rating, defining responsibilities, and in directing lines of communications. Nonetheless, a complete description of the process, with defined responsibilities and definitions follows.

See Figure 1.9, 1.10, 1.11 & 1.12 for flow charts of the following:

Rating: For ratings performed by Consultants, the term Rater, as used in this subsection, relates to an individual who is an agent of the hired consultant. This person will be responsible for structure ratings and will be the point of contact with the Colorado Department of Transportation Staff Bridge Design. The Staff Bridge Design contact for the Rater will be arranged at the outset of the contract. Any rating questions or requests should be communicated between the consultant's rater and the identified Staff Bridge Design contact.

The Rater will be responsible for gathering all the required materials, performing all the necessary calculations, and completing the rating package as stipulated in Subsection 1.13.

The Rater must have the most up-to-date computer program manuals, Rating Summary Sheets, and any other materials required to perform bridge ratings. The Rater can do this by simply checking with their Staff Bridge Design contact.

The formal rating analysis now begins. The Rater shall make the necessary calculations and sketches to show how the structure was modeled, how dead loads were derived, and to identify any other pertinent information. The rater shall indicate the source of the structural data. The only sources of information used for rating shall be, advance plans, construction plans, as-constructed plans, and field surveys. At no time shall design notes be used to rate a structure.

After this information is compiled, the Rater shall then use the appropriate analysis and computer programs to determine the structural capacity of the bridge. Subsection 1.6 in this manual covers the appropriate structural type for a description of the computer programs and analysis to be used.

If the rating is for an existing bridge, completely constructed and in service, then all the rating documents shall be completed, signed, and dated by the Rater, and then forwarded to the Checker.

If the rating is for a new design, the Rater shall check to see that the new design is adequate. If any load rating value is not equal to or greater than the rating factor limit of 1.0 or the gross vehicle weight limit, the cause should be identified and the structural designer contacted for a possible redesign. Otherwise, all the rating material shall be completed, signed, and dated by the Rater and forwarded to the Checker.

The Consulting firm's name shall also appear on all submitted sheets of the rating package.

Checking: The term Checker, as used in this subsection, refers to a person who is an agent of the hired consultant. The Checker has the responsibility for verifying that the rating calculations, structure modeling, and computer inputs are proper and accurate. If the Checker finds any errors or omissions, the Checker shall return the rating to the Rater for corrections. Once the rating is complete, the Checker shall sign and date all rating materials before forwarding them for the final step.

Either the Rater, the Checker or the Engineer responsibly in charge must be a Colorado Registered Professional Engineer and shall stamp the Rating Summary Sheet.

Final Step: The rating package shall be submitted by the Consultant to the appropriate Staff Bridge Design contact via e-mail. This ensures that the contact is aware of the rating submittal.

If the load rating is for a new bridge or bridge rehabilitation, the completed rating package shall be sent to the Bridge Rating Unit at Final Submittal and placed in ProjectWise prior to Advertisement in accordance with the current CDOT Bridge Design Manual.

The package of materials received by the Staff Bridge Design contact will then be transmitted to the Bridge Rating Unit for recording. Bridge Rating Unit DOES NOT verify the accuracy of bridge ratings. If the information is not complete at this step, the rating will be returned to Staff Bridge Design's contact for completion. The contact will have the Rater complete the rating documentation before returning it to the Bridge Rating Unit. The completed rating package will be recorded and filed by the Bridge Rating Unit. For a description of what shall be included in the rating package, see Subsection 1.13.

If the rating is for an off-system bridge, a duplicate submittal of the rating package shall be delivered to the applicable entity by the Rater if requested or required by the entity.

1.13 RATING PACKAGE REQUIREMENTS

The following defines what the minimum requirements are for a complete rating package submittal. The rating examples contained in this manual further illustrate what is described below.

A) For a completed Rating Summary Sheet, refer to Subsection 1.14 of this manual for a description on how this sheet shall be filled out. The summary sheet should be printed on colored paper to designate the analysis method used. See Appendix A for copies of these forms.

B) A set of calculation sheets showing the derivation of dead loads, live load distribution factors, sketches for how the structure was modeled, engineering judgment, computer input information, emails, and other relevant considerations. Where applicable, the calculation sheets should show how any deterioration or damage was modeled. Indicate from what source the information was gathered. The only sources of rating information shall be, Advance Plans, Construction Plans, As-constructed Plans, Field Surveys, and the most updated Structure Inspection Report. Design notes are not acceptable. One copy of pertinent plan sheets used during the rating process, preferably 8.5"x14", shall be included with the rating package (includes new structures and existing structures rerated for designed changes).

C) BrR users shall use the tabular report format to generate the output report to be included in the rating package. For users of other computer programs, output from each of the programs used to rate a structure shall be included in the rating package.

D) To enable CDOT to reproduce an analysis of the structure in the future, all rating packages shall include rating input files in electronic format as follows:

1) File names shall be based on Structure Number (i.e. H-02-FK.PDF or H02FK.SLB or H02FK.XML).

2) File extensions should generally refer to the rating package used (i.e. *.SLB refers to SLAB Rating Program and *.xml refers to BrR Rating Program).

3) The electronic file submittal must be placed in ProjectWise unless otherwise specified by the Rating Engineer.

This is required for all bridges, regardless of what software is used for rating.

A) A rating for the bridge deck, except for LRFR rating, shall accompany each package.

B) When the rating is for a new design, on a separate sheet of paper, state the status of construction for the project and state if the rating is for a new bridge or for the reconstruction of an existing bridge. This sheet is to be kept with the Rating Summary Sheet.

C) The Rater and Checker's signature, date, and a Colorado PE seal from either the Rater, Checker or the Engineer in responsible charge are required on the Rating Summary Sheet. For other items in the rating package (e.g., calculation sheets, first page of each set of computer output), the Rater and Checker’s initial and date are required. In addition, the structure number is required to be shown on all items in the rating package.

D) All of the items that compose the rating package shall be placed in an inspection file folder and an electronic rating folder that is clearly labeled with the structure number. Each structure rated shall have its own folder with a complete rating package. This requirement includes structures whose rating results or calculations duplicate those used for another structure.

1.14 REPORTING THE RESULTS OF RATING CALCULATIONS

The results of rating calculations are to be reported by the Rater on the appropriate CDOT Rating Summary Sheet (Timber/ASD Rating Summary or Load Factor Rating Summary or Load and Resistance Factor Rating Summary). See Figures 1.13, 1.14, and 1.15. The electronic editable of these forms are also available in the Appendix A for Rater’s use.

- Yellow paper shall designate use of the AASHTO ASD method.
- Green paper shall designate use of the AASHTO LFD method.
- Blue paper shall designate use of the AASHTO LRFR method.

For load rating of a special vehicle that is not specified in the Rating Summary Sheet such as maintenance H5 truck used for pedestrian bridge, the Rater may modify the Rating Summary Sheet.

For structures that do not need to be rated, such as the case when the depth of fill exceeds the limits, or structures that no required ratings for the single-unit trucks when the NRL rating factor is 1.0 or greater. The Raters may use the Gross Vehicle Weight (GVW) as shown in the Figures 1-1 to 1-8 of Subsection 1.2 to report on the RSS. The inventory and operating of the design vehicles may be reported as 36 tons and 40 tons respectively for LFR methods, and RFs of 1.0 and 1.1 for LRFR method.

The Rating Summary Sheet is retained in the structure folder as a record of the adequacy of the structure. The following items are to be observed when filling out the sheet.

A) The sheet is to be filled out in black ink.

B) All lettering should be clearly printed.

C) Crossing out of incorrect data will not be permitted. If an error is made, fill out a new RSS.

D) The sheet must be signed and dated by both the Rater and Checker. Do not initial the sheet. When rating is performed by a consultant, the name of the consulting firm shall also be shown. The sheet must be PE-sealed by either the Rater, Checker or Engineer in responsible charge registered in the State of Colorado.

E) When the bridge is re-rated, the old Rating Summary Sheet shall be crossed out, and still kept in the inspection structure folder.

Information to be shown by the Rater on the Rating Summary Sheet:

A) Record the structure number, state highway number, BrR BID number (to be filled in at a later date in the Rating Unit), abbreviation of structure type and, when appropriate, the parallel structure number. In addition to entering the state highway number, if the structure is located on a divided highway and carries traffic in one direction only, indicate the direction of traffic (EB, SB, etc.). Indicate if the structure carries ramp traffic.

B) Within the Summary Sheet, record the Inventory and Operating ratings obtained for each element requiring an analysis, show controlling load ratings in the comments box. All ratings shall be reported in truncated tenths of a US ton, or truncated hundredth of a rating factor if applicable (see also section 15-9 for LRFR reporting).

1) Stringers or Girders
   a) When an exterior girder is rated, both the interior and the exterior girder ratings shall be shown. The columns of the Summary Sheet shall be marked to identify the interior and exterior girders.
   b) When the refined distribution factor method is used for the legal loads or permit vehicles to avoid the posting or color code action, the controlling load ratings of interior girder or exterior girder shall be shown on a separated column named “NSG”. The exterior girder load rating of the permit vehicles does not need to be recorded on this column.
   c) For rolled steel beams, state the girder type and size.
   d) When applicable, state if the girder is an original girder or a girder installed during structure widening.

Note: If a structure is widened with girders that are different from the original in either cross-section or material properties, both the original and the widened girders shall be rated and the critical original and critical widened girder loads shown on the summary sheet.

2) Decks
   a) For all existing decks designed before October 1st, 2010, and new metal / timber plank decks, record load ratings for design truck only.
      - Transversely mild steel reinforced concrete deck slab that are continuous over more than 3 supporting girders shall not be used to control the overall bridge load rating.
      - The load rating of other deck types (e.g. timber decks, metal plank decks, etc.) may be used to control the bridge load rating.
   b) For new concrete decks, no need to record load ratings except as requested.

3) Trusses
   a) Record the critical member ratings, gusset plate, floor beam or stringer ratings in the appropriate columns of the Rating Summary Sheet.
   b) Label the truss members shown in the report using standard truss notation. See Section 10A.

C) If a posting vehicle analysis is required for Colorado Legal Vehicles, record the posting ratings in the chart portion of the summary sheet only. For State on-system Highway bridges, the State Bridge Engineer will make the determination of actual posting load and the pictorial trucks will then be filled in. For bridges that are not on the state system, the appropriate entity officials will determine structure load postings for structures under their jurisdiction.

D) Indicate the amount of surfacing used in the rating calculations.

E) The Comments section of the Rating Summary Sheet should contain the following information, when applicable:

1) State if the individual critical member rates considerably below the other structure members, and is not representative of the entire structure.

2) State any reductions in cross-section or allowable stresses used to rate the member and the reason for the reduction.

3) The recommended color code for on-system bridges. The State Bridge Engineer must approve any color code recommendations of black, orange, and yellow.

4) State reason for rating: New structure or Rerating due to asphalt changes / dead load changes/ Damage per Inspection, etc.

F) If an original structure rated by LFR method, and the widening part is rated by LRFR, both Rating Summary Sheets of LFR and LRFR need to be filled out appropriately.

G) When rating timber members, the “Comments” section of the Rating Summary Sheet shall contain the allowable stresses for moment and shear used to rate the structure. A statement should be made to indicate if the rating was controlled by moment or shear.

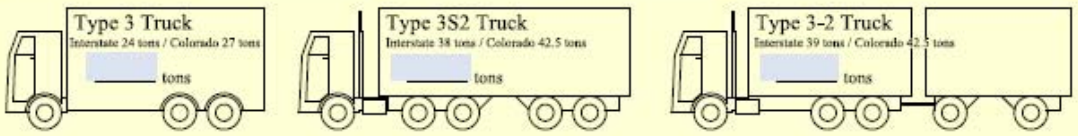
COLORADO DEPARTMENT OF TRANSPORTATION

TIMBER RATING SUMMARY

Structure #	
State Highway #	
Batch I.D.	
Structure Type	
Parallel Structure #	

Rated using:
Asphalt thickness: _____ in.
☐ Colorado legal loads ☐ Multi-lane for Legal & Permit Vehicles
☐ Interstate legal loads ☐ Single lane for Legal & Permit Vehicles

Structural Member					
	Tons				
Inventory					
Operating					
Type 3 truck					
Type 3S2 truck					
Type 3-2 truck					
Type SU4 truck (27T)					
Type SU5 truck (31T)					
Type SU6 truck (35T)					
Type SU7 truck (39T)					
NRL (40T)					
EV2 (28.75T)					
EV3 (43T)					
Permit Truck (96T)					
Modified Tandem (50T)					



Comments:

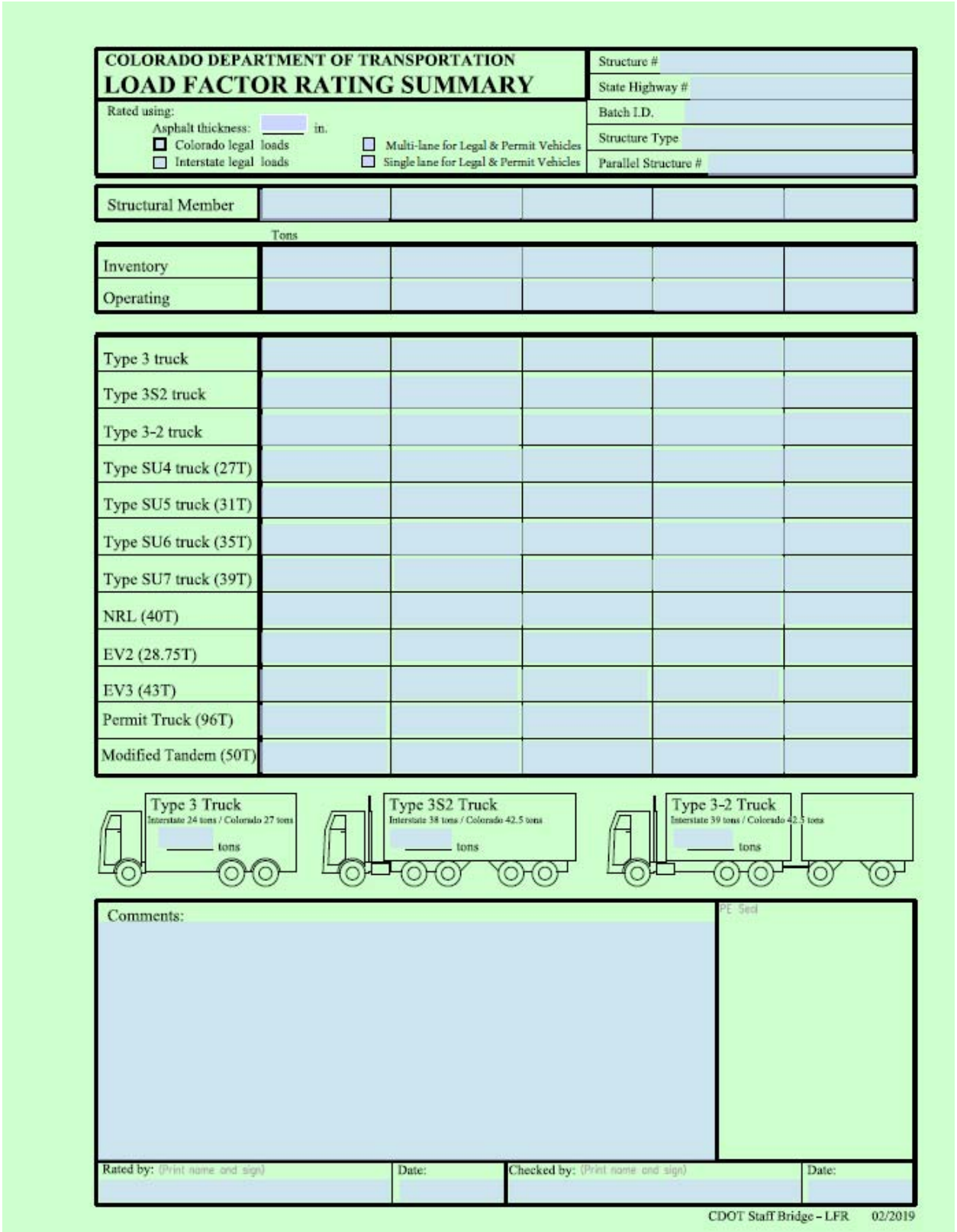
PE Seal

Rated by: (Print name and sign) Date:

Checked by: (Print name and sign) Date:

CDOT Staff Bridge – ASR 02/2019

Figure 1.13



COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

Structure #
State Highway #
Batch I.D.
Structure Type
Parallel Structure #

Rated using:
Asphalt thickness: ____ in.
☐ Colorado legal loads
☐ Interstate legal loads
☐ Multi-lane for Legal & Permit Vehicles
☐ Single lane for Legal & Permit Vehicles

Structural Member					
Tons					
Inventory					
Operating					
Type 3 truck					
Type 3S2 truck					
Type 3-2 truck					
Type SU4 truck (27T)					
Type SU5 truck (31T)					
Type SU6 truck (35T)					
Type SU7 truck (39T)					
NRL (40T)					
EV2 (28.75T)					
EV3 (43T)					
Permit Truck (96T)					
Modified Tandem (50T)					

Type 3 Truck
Interstate 24 tons / Colorado 27 tons
____ tons

Type 3S2 Truck
Interstate 38 tons / Colorado 42.5 tons
____ tons

Type 3-2 Truck
Interstate 39 tons / Colorado 42.5 tons
____ tons

Comments:

PE Seal

Rated by: (Print name and sign) Date:

Checked by: (Print name and sign) Date:

CDOT Staff Bridge – LFR 02/2019

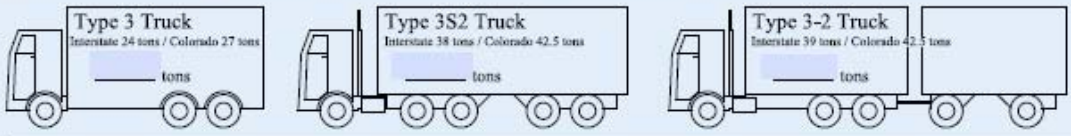
Figure 1.14

COLORADO DEPARTMENT OF TRANSPORTATION
LOAD & RESISTANCE FACTOR RATING SUMMARY

Rated using:
Asphalt thickness: _____ in.
☐ Colorado legal loads ☐ Multi-lane for Legal & Permit Vehicles
☐ Interstate legal loads ☐ Single lane for Legal & Permit Vehicles

Structure #	
State Highway #	
Batch I.D.	
Structure Type	
Parallel Structure #	

Structural Member					
	Rating Factor				
Inventory					
Operating					
	Tons				
Type 3 truck					
Type 3S2 truck					
Type 3-2 truck					
Type SU4 truck (27T)					
Type SU5 truck (31T)					
Type SU6 truck (35T)					
Type SU7 truck (39T)					
NRL (40T)					
Lane-Type Legal					
EV2 (28.75T)					
EV3 (43T)					
Permit Truck (96T)					
Modified Tandem (50T)					



Comments:

PE Seal

Rated by: (Print name and sign) Date:

Checked by: (Print name and sign) Date:

CDOT Staff Bridge – LRFR 02/2019

Figure 1.15

1.15 POSTING AND CLOSURE OF A BRIDGE DUE TO RATING REPORT OF LEGAL LOAD VEHICLES

1.15.1 Posting Legal Load Vehicles

Posting vehicles are used to determine the maximum legal load vehicles that will be allowed to travel on bridges. The posting for legal load vehicles are composed of the maximum vehicle loads currently permitted by law. Consequently, the Posting Ratings are a means for ensuring the safe use of bridges by vehicles that do not exceed the legal loads.

The legal load vehicles for posting are as follows:
A) Colorado or Interstate Legal Loads Type 3, Type 3S2 and Type 3-2.
B) Single-Unit trucks SU4, SU5, SU6 and SU7.
C) Emergency vehicles EV2 and EV3.

The maximum weight limits for Colorado legal vehicles, Single-Unit Truck and Emergency Truck are shown in Tables 1-4, 1-5 and 1-6 respectively.

Postings for the Single-Unit trucks SU4, SU5, SU6 and SU7 loads are not required if the load rating for the NRL vehicle has the capacity of 40 tons or greater. Otherwise, load ratings for the single-unit SU4, SU5, SU6 and SU7 loads shall be performed to determine which single-unit vehicles will be restricted from crossing the structure. Currently, the gross vehicle weights of SU6 and SU7 do not meet the Colorado Bridge Formula. Therefore, maximum gross weight limits for posting of SU6 & SU7 on non-interstate roads shall supersede with values that are determined by the Colorado Bridge Formula. See Table 1-5.

The deck slab ratings are not to be used in the determination of legal load postings.

The posting load for Emergency Vehicles shall only be required for bridges on the Interstate highways, and within one-road-mile of the reasonable access.

NOTE: Reasonable access is the access between the Interstate highways and the facilities for food, fuel, repairs, and rest, which includes the Interstate access ramps, and the State's roads.

Based on successful of CDOT historical practice, a safe posting load as specified in the MBE, equation 6A.8.3-1 should not use.

The posting load for Legal vehicles shall be based on the lowest load rating in truncated US tons of any primary members such as girders, in-span hinge, stringers, truss, floor-beam, and truss connections, etc.

When the operating rating factor of any legal load vehicle falls below 0.3, then the bridge shall be restricted for all legal load vehicles.

For possibilities of adjustment to the distribution of live load to increase load ratings and avoid the posting action, see Subsection 1.3 (H).

For structures that do not use 1.3 (H), when the operating ratings of the legal loads are greater than or equal to 95%, the structure can be exempted from posting requirements.

The State Bridge Engineer will make a final determination for posting. The decision for bridge posting shall be based on the bridge physical condition, visible distress, structure redundancy, and traffic volume. If a structure rating indicates a need for posting, the Bridge Rating Engineer is the signing authority for structure posting, and shall notify to the Permit Office, Region RTD and Region Maintenance Superintendent. The Region Maintenance or bridge owner has 30 days to install the posting signs after receiving the formal letter.

	US Units	Non-interstate Road	Interstate Hwy
Type 3 Vehicle	Tons	27.0	24.0
Type 3S2 Vehicle	Tons	42.5	38.0
Type 3-2 Vehicle	Tons	42.5	39.0

Table 1-4: Maximum Weight Limit for Type 3, Type 3S2, and Type 3-2 Legal Trucks.

	US Units	Non-interstate Road	Interstate Hwy
SU4	Tons	27.0	27.0
SU5	Tons	31.0	31.0
SU6	Tons	33.0 (∗)	34.75
SU7	Tons	35.0 (∗)	38.75

Table 1-5: Maximum Weight Limit for Single-Unit Trucks

(∗) Use maximum gross weight limits computed from the Colorado Bridge Formula for non-interstate roads.

	US Units	Non-interstate Road	Interstate & Reasonable Access Roads
EV2	Tons	N/A	28.75 (∗∗)
EV3	Tons	N/A	43.0 (∗∗)

Table 1-6: Maximum Weight Limit for Emergency Trucks.

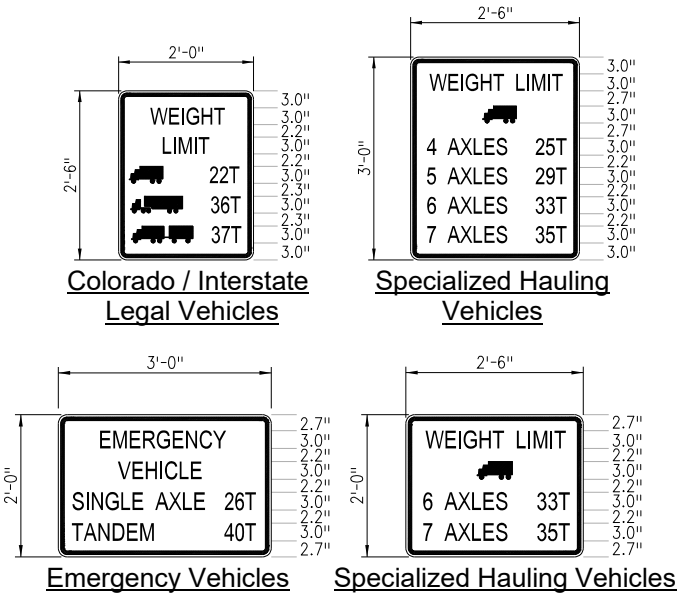
(∗∗) Does not meet Federal Bridge Formula B, but they could cover situations when Emergency Vehicles need access to Interstate Highways, or Reasonable Access.

1.15.2 Posting Signs

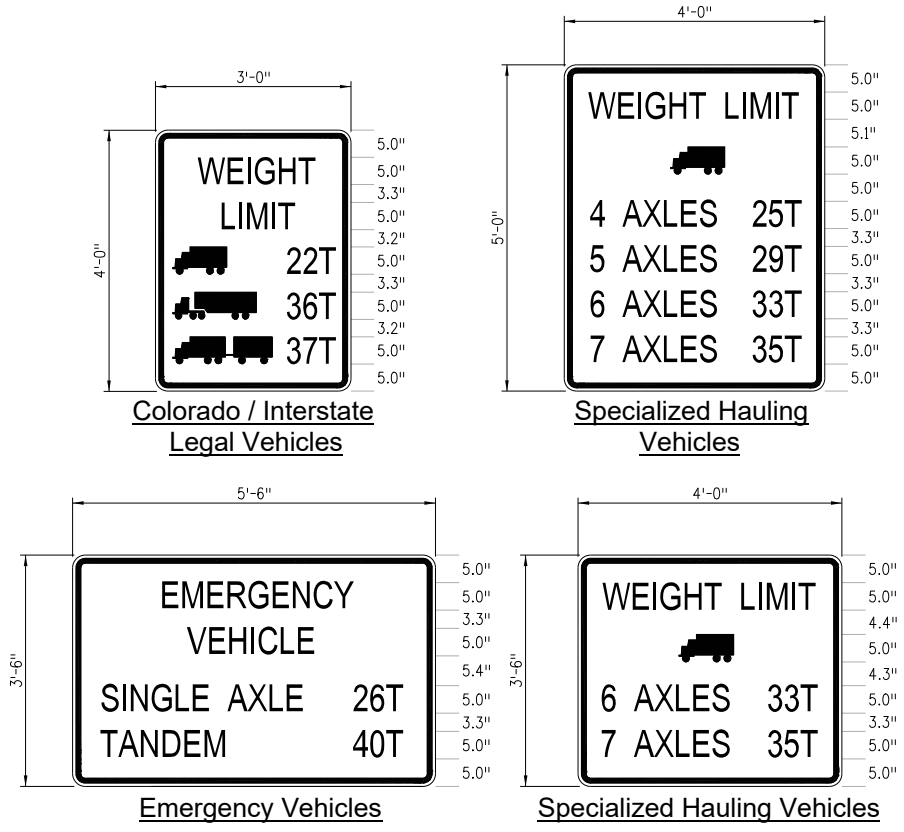
The posting signs shall comply with the MUTCD (Manual on Uniform Traffic Control Devices) requirements, and CDOT's Sign Design Manual, latest edition.

Figure 1.16 shows examples for weight limit posting signs of Colorado/Interstate Legal Vehicles, Specialized Hauling Legal Vehicles, and Emergency Vehicles, which are appropriate for conventional roads, expressways, and freeways using different letter heights of 3.0", 5.0", and 6.0" respectively.

- Conventional road is a road that allows direct access to homes and businesses along it, or a low-volume highway of less than 400 Annual Average Daily Traffic (AADT).
- Expressway is a highway that allows partial control of access.
- Freeway is an Interstate highway that allows full control of access.

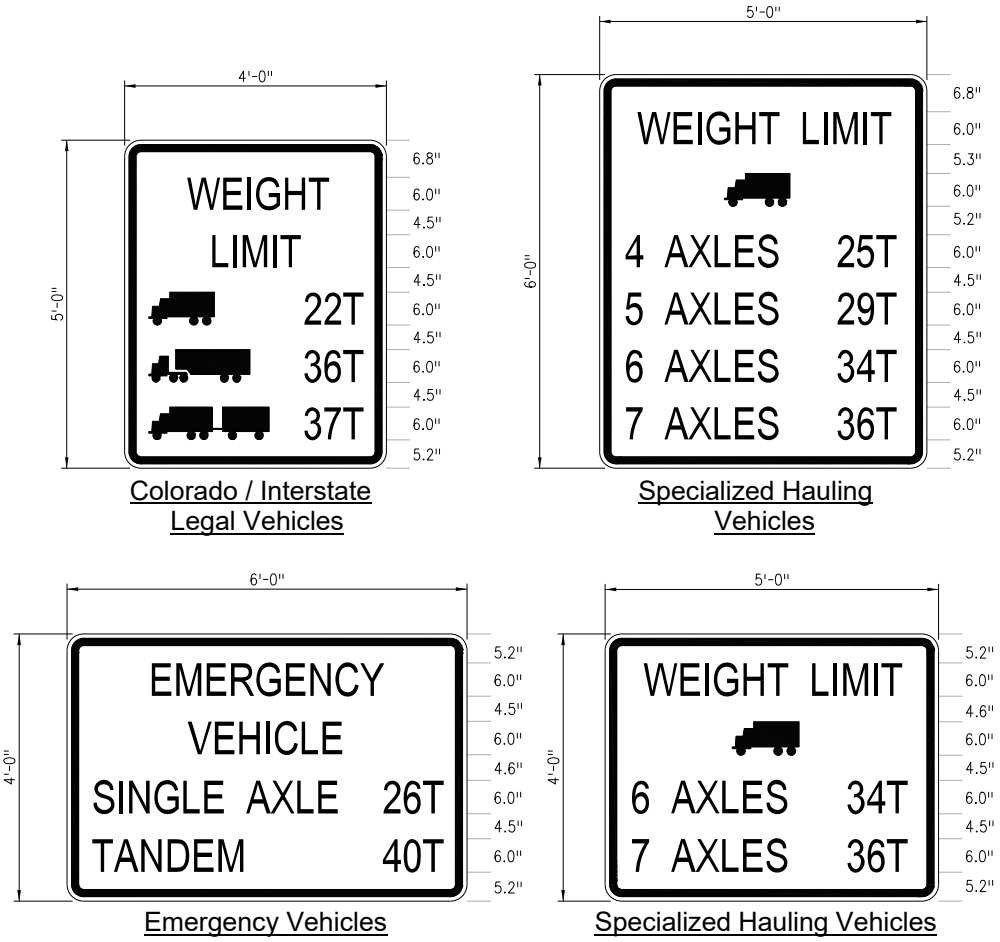


LEGAL LOAD POSTING SIGNS FOR CONVENTIONAL ROADS
(3.0" Letter Height, Series E)



LEGAL LOAD POSTING SIGNS FOR EXPRESSWAYS
(5.0" Letter Height, Series E)

Figure 1.16



LEGAL LOAD POSTING SIGNS FOR FREEWAYS
(6.0” Letter Height, Series E)

Figure 1.16 (Continued)

1.15.3 Closure of a Bridge Due to a Rating Report of Legal Load Vehicles

When the operating load rating of any Legal Load vehicle type not capable of carrying a minimum gross live load weight of three tons, the bridge must be closed.

The Rating Engineer and the Inspection Engineer shall review the rating package and the inspection report accordingly before making a recommendation to the State Bridge Engineer to close or restrict the bridge. An appropriate Plan of Action (POA) for closing the bridge shall be determined by the State Bridge Engineer that follows the procedures of the Structure Management Manual (SMM).

1.16 OVERLOAD COLOR CODE RATING

The Overload Color Code ratings are used to determine the routes, and the maximum group axle weights of the permit vehicles that will be allowed to travel on Colorado bridges.

The Colorado Permit Load Rating Vehicles (Colorado Permit Vehicle and Colorado Modified Tandem Vehicle) need to be used to determine the Overload Color Code.

The Overload Color Code shall be based on the primary element ratings such as interior girders, in-span hinges, truss members, exterior/interior stringers of a truss structure, floor-beams, truss connections, etc. The deck slab and the exterior girder ratings are not to be used in the determination of Color Code.

When a bridge that was constructed or rehabilitated after 1985 is rated or re-rated, it shall receive a Colorado Permit Vehicle operating rating with full impact and multi-lanes loaded as per Subsection 1.3.

When a bridge that was constructed in 1985 or earlier is rated or re-rated, it may receive Colorado Permit Vehicle operating rating with full impact and one lane loaded as specified in the Subsection 1.3.

When a bridge with span length of 60’ or less that was constructed in 1985 or earlier is rated or re-rated, it may receive Colorado Permit Vehicle and Colorado Modified Tandem operating ratings with full impact and one lane loaded as specified in the Subsection 1.3. If the Overload Color Code based on the Colorado Permit Vehicle rating causes more severe restriction on the bridge, the Colorado Modified Tandem Vehicle rating may be used to determine for bridge’s color code.

When existing LFD bridges are widened with the LRFD method, the permit vehicle load ratings of the original structure part shall be used to determine the Overload Color Code.

For possibilities of adjustment to the distribution of live load to increase load ratings and avoid the color code action, see Subsection 1.3 (H).

Overload Color Code is not applicable to off-system structures.

The Overload Color Codes Table is shown below:

Table 1-7: Overload Color Codes

Unit	White	Yellow	Orange	Black
Permit Vehicle	US tons	96 ≤ X	96 > X ≥ 88.5	88.5 > X ≥ 80.5	80.5 > X
Modified Tandem Vehicle	US tons	50 ≤ X	50 > X ≥ 46	46 > X ≥ 42	42 > X

X = Operating load rating value of Colorado Permit Vehicle or Modified Tandem Vehicle.

The State Bridge Engineer will make a final determination for the structure color code. The decision for bridge color shall be based on the bridge physical condition, visible distress, structure redundancy, and traffic volume. If a structure rating indicates a need for colors of BLACK, ORANGE, or YELLOW, the Bridge Rating Engineer will be notified for approval and generation of a formal letter to the Permit Office, Region RTD and Region Maintenance Superintendent. The Bridge Rating Engineer shall be the signing authority on RSS for color coded structure based on the State Bridge Engineer decision.

1.17 RE-RATING EXISTING / NEW BRIDGES

When the condition of a structure changes such as the condition state, dead load, new live loads requirements, or rehabilitations, a re-rating of the structure may be required. Examples when re-rating may be considered:

- Bridge damaged by vehicular hits.
- Bridge deterioration due to severe corrosion / section loss in steel elements, cracking / spalling in concrete superstructure, or split / decay in timber stringers.
- Additional loads of sidewalk, railing, barrier, utilities, fill or deck overlay, etc.
- Deck replacement, widening, adding new girders.
- Section loss reported on gusset plates.
- New Federal regulation or specification requiring new live loads such as Notional Rating Load (NRL) Vehicles, Single-Unit vehicles, and Emergency Vehicles.

Specifically, the requirements for re-rating of the structures are as followings:

A) When requested from the Inspection Unit after the bridge inspection report, or the accident report was reviewed by a senior Inspection Engineer, due to reduced structural capacity at critical locations. The load re-rating shall be completed in-house, within the Staff Bridge Rating Unit within 60 days after the Rating Engineer receives notice.

B) For any structural design work on an existing bridge that has not yet been rated with the BrR program, the bridge shall be re-rated by the Design Engineer or Staff Bridge Rating Unit.

C) For changes of dead load due to a structural work on the existing structure that is rated with BrR program, if the operating load rating for any vehicle changes more than 3.0%; or affects the posting and the color code, the BrR input file and the Rating Summary Sheet (RSS) shall be updated by the Design Checker or Designer.

D) When two parallel structures are connected by a median closure project, the bridge shall be re-rated by the Design Checker or Designer.

E) For culvert extension, bridge widening, or rehabilitation, the bridge shall be re-rated by the Design Checker or Designer.

F) For structure under construction revised by a Value Engineering Change Proposal (VECP), or a Contract Modification Order (CMO), the proposed structure shall be rated / re-rated by the Contractor's Engineer, or the Engineer of record.

G) A re-rating is required for a change in thickness of asphalt overlay greater than or equal to 3".

H) If 25% of the total number of timber girders or stringers are split, cracked, or repaired, a new load rating based on reduction of allowable stresses is required.