Infrastructure Delivery and Operations

Bridge Load Rating Guidelines

ADOT Bridge Group;
Bridge Management Section

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6.1 SCOPE

The Arizona Department of Transportation (ADOT) Bridge Load Rating Guidelines are intended to supplement and provide interpretation of the following documents:

ADOT Bridge Design Guidelines
AASHTO Manual for Bridge Evaluation
AASHTO LRFD Bridge Design Specifications
AASHTO Standard Specifications for Highway Bridges, 17th Edition

These guidelines provide for consistency of bridge load rating throughout Arizona. Any deviation of these guidelines requires approval of the ADOT Bridge Group.

Adhering to these guidelines does not relieve the load rating engineer from the responsibility of applying sound engineering principles throughout the structural analysis of a bridge or any structural component. While the guidelines apply to the majority of bridge load rating issues in Arizona, they are not intended to be exhaustive.

AASHTO's Manual for Bridge Evaluation includes Section 6 which covers load rating. The numbering of the Sections in this document is intended to match the numbering of the Sections in the AASHTO Manual for Bridge Evaluation. Sub-Section numbers will be skipped whenever additional guidance to the AASHTO Manual is not required. In some instances, same or similar language from the AASHTO Manual will be repeated in this document for emphasis or for ease of reference and clarification. Topics that are not covered by the AASHTO Manual are included at the end of corresponding Sections without numbering references. Definitions and notations are only included if not covered by the AASHTO Manual.

Bridge load rating calculations provide a basis for determining the safe load capacity of a bridge. Load rating requires engineering judgment in determining a rating value that is reflective of the current capacity of the structure and is applicable to maintaining the safe use of the bridge and arriving at posting and permit decisions. The load rating calculations shall be based on the most recent inspection report available from ADOT bridge files.

Bridge substructure elements generally do not govern the rating of a bridge. Substructure rating should be investigated only when it is determined that the condition of the substructure will influence the overall load capacity ratings of the bridge.

These guidelines provide a choice of load rating methods. Part A incorporates provisions specific to the Load and Resistance Factor Rating (LRFR) method developed to provide uniform reliability in bridge load ratings, load postings, and permit decisions. Part B provides safety criteria and procedures for the Allowable Stress and Load Factor methods of evaluation.

These guidelines are intended for use in evaluating the types of highways bridges commonly in use in Arizona. Methods for the evaluation of existing bridges for extreme events such as earthquakes, vessel collision, wind, flood, ice, or fire are not included herein. Rating of long-span bridges, movable bridges, and other complex bridges may involve addition considerations and loadings not specifically addressed in this Section and the rating procedures should be augmented with additional evaluation criteria where required.

Due to the transition from LFR to LRFR rating method and as a part of our quality control and quality assurance procedures, all bridges should be rated using either LFR or LRFR methods.

6.1.9 Documentation of Load Rating

Load rating documentation shall include dead and live loads, distribution factors, inspection reports, and bridge plans. The final bridge load rating report shall be stored in Bridge Technical Section, with a copy stored in Bridge Management Section. The report shall be sealed and signed by a civil or structural engineer licensed in the State of Arizona. An example of a rating report is included in the Appendix of these guidelines. Load rating models shall be saved for future use. Currently, most of the ADOT bridge rating models are stored in AASHTOWare's BrR software database. Other rating software input files are saved in Bridge Technical Section for future use.

6.2 LOAD RATING INITIATION, QUALITY CONTROL AND ASSURANCE

6.2.1 Definitions

- Load Rating Initiation (LRI): The Process is initiated when a new bridge is added to the inventory or a reconstruction or rehabilitation project in Arizona is completed. ADOT Bridge Inspection Section (BIS) will notify Bridge Management Section (BMS) to perform a load rating analysis prior to an initial or special inspection of these bridges.
  BMS will perform load rating when contract bridge plans are uploaded into BrM. Bridge load rating will be reviewed later after bridge record drawings become available.
- Quality Control (QC): A process of applying systematic procedures to ensure accuracy and consistency during bridge load rating analyses and their documentation. QC should be applied to all stages of the bridge load rating analysis.
- Quality Assurance (QA): A process of applying systematic procedures to ensure that the quality control process was followed during the bridge load rating analysis.
- Rater: The engineer performing a bridge load rating analysis.
- Checker: The engineer implementing the QC process to a bridge load rating analysis performed by a rater.
- QA manager: A professional engineer licensed by the State of Arizona who is in charge of the Bridge Load Rating Program. The QA Manager shall stamp the rating report in the event that the rater does not posses an Arizona professional engineering license.

6.2.2 QC/QA Procedures

During load rating analyses, it is essential that the assumptions, procedures, and data used are accurate; otherwise erroneous bridge load ratings conclusions would be reached leading to

adverse consequences. To ensure quality, all rating analyses shall be reviewed and verified by a checker.
The following steps shall be followed by the checker when performing Bridge Load Rating QC:

- The checker may use the same model that is created by the rater to check the analysis. In some instances, the Bridge Technical Leader will instruct the checker to create his own independent model. If the same model that was generated by the rater is being used, the checker shall make a copy of said model and run it independently with appropriate parameters to verify the load rating results obtained by the rater.
- The checker shall review the latest inspection report to see if there are any issues which may affect the rating analysis.
- The checker shall use as-built bridge plans and other available documents to verify the input parameters for the rating analysis.
- The checker shall independently calculate and document the parameters which will affect the load rating. The following list contains some of these parameters:
    - thickness of the existing overlay on the structure
    - span length
    - girder spacing
    - ultimate strength of structural material, such as concrete, steel or wood
    - allowable tension or compression of the structural material
    - section properties of the structural elements, such as girders, slabs, etc.
    - quantity of mild steel used in the analysis
    - P-jack load or number of pre-stressing strands used in the analysis
    - dead load and live load
- The checker shall verify the proper application of composite and non-composite loads.
- The checker shall verify the proper application of the boundary condition, such as fix, pin, roller, and the values of the rotational springs if used.

To maintain a high quality of bridge load rating analyses, the QA manager shall conduct a review prior to the rater preparing a final rating report. The review will ensure that the QC procedures were followed. The names of the engineers performing the bridge load rating, checking and reviewing shall be documented in the final rating report (see Appendix).

PART A - LOAD AND RESISTANCE FACTOR RATING

6A.2 LOADS FOR EVALUATION

6A.2.2.1 Dead Loads: DC and DW

The dead load effects on the structure shall be computed in accordance with the conditions existing at the time of analysis. Dead loads should be based on dimensions shown on the plans and verified with field measurements. Where present, utilities, attachments, and thickness of wearing surface should be field verified at the time of inspection. Minimum unit weights of materials used in computing dead loads should be in accordance with AASHTO LRFD Bridge Design Specifications Table 3.5.1-1, in the absence of more precise information.

Existing overlays shall be included to the structure as documented on ADOT's Structure, Inventory and Appraisal (SI&A) report. The weight of these overlays shall be taken as 12.5-psf for every 1 inch of thickness. Dead loads shall be applied to the appropriate loading stage such as non-composite or composite. When the load capacity ratings of a bridge is calculated, all composite section properties and effective flange widths shall be based on the actual concrete deck thickness minus ½-inch. This ½-inch of top sacrificial deck concrete shall be added to the dead loads acting on the non-composite section for the steel or pre-tensioned concrete girder bridges and to the initial dead load for the post-tensioned bridges. Weights due to concrete buildup (haunch), diaphragms and stay-in-place forms should be considered as non-composite dead load. Buildup (haunch) thickness shall not be used in calculating composite section properties.

Dead loads such as barriers, medians, wearing surface, utilities, etc. shall be distributed equally to all girders.

Barriers, fences, wearing surface, raised median, sidewalks, utilities, etc. shall be included as composite dead load for steel and pre-tensioned concrete girder bridges, but as superimposed dead load for post-tensioned concrete bridges. Additionally, diaphragms and lost forms in concrete box girder bridges shall be included as initial dead load.

6A.4 LOAD RATING PROCEDURES

6A.4.2 General Load Rating Equation

6A.4.2.1 General

The following general expression shall be used in determining the load rating of each component and connection subjected to a single force effect (i.e., axial force, flexure, or shear):

$$\mathrm{RF} = \frac{\mathrm{C} - (\gamma_{\mathrm{DC}})(DC) - (\gamma_{DW})(DW) \pm (\gamma_P)(P)}{(\gamma_{\mathrm{LL}})(LL + IM)} \qquad (6A.4.2.1\text{-}1)$$

For the Strength Limit States:

$$\mathrm{C} = \varphi_c \varphi_s \varphi R_n \qquad (6A.4.2.1\text{-}2)$$

Where the following lower limit shall apply:

$$\varphi_c \varphi_s \geq 0.85 \qquad (6A.4.2.1\text{-}3)$$

For the Service Limit States:

$$C = f_R \qquad (6A.4.2.1\text{-}4)$$

Where:

RF = Rating Factor
C = Capacity
f'_c = Specified compressive strength of concrete (ksi)
f'_{ci} = Specified compressive strength of concrete at time of initial loading or prestressing (ksi)
f_R = Allowable stress specified in the LRFD code or as stated
R_n = Nominal member resistance (as calculated)
DC = Dead load effect due to structural components and attachments
DW = Dead load effect due to wearing surface and utilities
P = Permanent loads other than dead loads
LL = Live load effect
IM = Dynamic load allowance
γ_{DC} = LRFD load factor for structural components and attachments
γ_{DW} = LRFD load factor for wearing surfaces and utilities
γ_p = LRFD load factor for permanent loads other than dead loads = 1.0
γ_{LL} = Evaluation live load factor
φ_c = Condition factor
φ_S = System factor
φ = LRFD resistance factor

The load rating shall be carried out at each applicable limit state and load effect with the lowest value determining the controlling rating factor. Limit states and load factors for load rating shall be selected from AASHTO's Manual for Bridge Evaluation Table 6A.4.2.2-1 which is included below.

Components subjected to combined load effects shall be load rated considering the interaction of load effects (i.e., axial-bending interaction or shear-bending interaction), as provided in the AASHTO Manual for Bridge Evaluation under the sections on resistance of structures.

Secondary effects from prestressing of continuous spans and locked-in force effects from the construction process should be included as permanent loads other than dead loads, *P* (see Articles 6A.2.2.2. and 6A.2.2.3 of the AASHTO Manual for Bridge Evaluation).

6A.4.2.2 Limit States

Strength is the primary limit state for load rating; service and fatigue limit states are selectively applied in accordance with the provisions of the AASHTO Manual for Bridge Evaluation.

Applicable limit states are summarized in Table 6A.4.2.2-1 of the AASHTO Manual for Bridge Evaluation.

Table 6A.4.2.2-1 Limit States and Load Factors for Load Rating

Bridge Type	Limit State*	Dead Load γ_{DC}	Dead Load γ_{DW}	Design Load Inventory γ_{LL}	Design Load Operating γ_{LL}	Legal Load γ_{LL}	Permit Load γ_{LL}
Steel	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	—	Table 6A.4.5.4.2a-1
	Service II	1.00	1.00	1.30	1.00	1.30	1.00
	Fatigue	0.00	0.00	0.75	—	—	—
Reinforced Concrete	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	—	Table 6A.4.5.4.2a-1
	Service I	1.00	1.00	—	—	—	1.00
Prestressed Concrete	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	—	Table 6A.4.5.4.2a-1
	Service III	1.00	1.00	0.80	—	1.00	—
	Service I	1.00	1.00	—	—	—	1.00
Wood	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	—	Table 6A.4.5.4.2a-1

* Defined in the AASHTO LRFD Bridge Design Specifications.

Notes:

- Reference tables are shown in the AASHTO Manual for Bridge Evaluation.
- Shaded cells of the table indicate optional checks.
- Service I is used to check the 0.9 F_y stress limit in reinforcing steel.
- Fatigue limit state is checked using the LRFD fatigue truck (see Article 6A.6.4.1 of the AASHTO Manual for Bridge Evaluation).

The following concrete stress limits shall apply for Prestressed Concrete members:

		Load Cases				
		Before Time-Dependent Losses	**After Losses**			
			DC + Prestress	**Service Limit I**	**Service Limit III**	**0.5(DW+DC+ Prestress) + (LL + IM)**
Compression (ksi)		$0.6f_{ci}^{'}$	$0.45f_c^{'}$	$0.6\phi_w f_c^{'}$	N/A	$0.4f_c^{'}$
Tension (ksi)	Any region of a prestressed component in which prestressing causes compressive stresses and service load effects cause tensile stresses	N/A	0 for post-tensioned boxes N/A for precast prestressed members	N/A	$0.0948\sqrt{f_c^{'}}$ (For post-tensioned structures built on falsework, this value shall be zero. No tension shall be allowed)	N/A
	Other Regions	$0.0948\sqrt{f_{ci}^{'}}$ $\leq 0.2ksi$	N/A	N/A	N/A	N/A

6A.4.2.3 Condition Factor: φ_c

This condition factor provides a reduction to account for the increased uncertainty in the resistance of deteriorated members and the likely increased future deterioration of these members during the period between inspection cycles. The following table is repeated from the AASHTO Manual for Bridge Evaluation.

Table 6A.4.2.3-1 Condition Factor: φ_c

Structural Condition of Member	φ_c
Good or Satisfactory	1.00
Fair	0.95
Poor	0.85

6A.4.2.4 System Factor: φ_s

System factors are multipliers applied to the nominal resistance to reflect the level of redundancy of the complete superstructure system. Bridges that are less redundant will have their factored member capacities reduced, and accordingly will have lower ratings.

Table 6A.4.2.4-1 System Factor: φ_s for Flexural and Axial Effects

Structural Type	φ_s
Welded Members in Two-Girder/Truss/Arch Bridges	0.85
Riveted Members in Two Girder/Truss/Arch Bridges	0.90
Multiple Eyebar Members in Truss Bridges	0.90
Three-Girder Brides with Girder Spacing 6 ft	0.85
Four-Girder Brides with Girder Spacing ≤4 ft	0.95
All Other Girder Bridges and Slab Bridges	1.00
Floorbeams with Spacing >12 ft and Noncontinuous Stringers	0.85
Redundant Stringer Subsystems between Floorbeams	1.00

If the simplified system factors presented in Table 6A.4.2-1 are used, they should be applied only when checking flexural and axial effects at the strength limit state of typical spans and geometries.

A constant value of $\varphi_s = 1.0$ is to be applied when checking shear at the strength limit state.

For evaluating timber bridges, a constant value of $\varphi_s = 1.0$ is assigned for flexure and shear.

6A.5 CONCRETE STRUCTURES

6A.5.1 Scope

The provisions of Article 6A.5 apply to the evaluation of concrete bridge components reinforced with steel bars and/or prestressing strands or bars. The provisions of Article 6A.5 combine and unify the requirements for reinforced and prestressed concrete.

For integral abutments of bridges with substantial restraint in rotation, moment spring constants should be used in the analysis instead of rollers, pins or fixed conditions at the support. To account for uncertainties in foundation depth, fixities, and soil properties, the effective rotational spring constants should be assumed to be two thirds of the theoretically calculated values for use in the analysis.

6A.5.13 Rating of Conventionally Reinforced Concrete Bridges

6A.5.13.1 Slab Bridges

Slab bridges should be modeled and rated by using the AASHTOWare BrR program. During the quality control process, CONBOX or other software may be used as an independent check.

Some older design of slab bridges did not provide steel reinforcement at the top of the slab within the positive moment region. If modeled as shown on the plans, BrR will return rating factors that are artificially low in this region. Therefore, the model must be modified to account for this anomaly by providing minimum reinforcement at the top of the slab to adequately develop a factored flexural resistance of at least 1.2 times the cracking moment of the deck slab as specified in the AASHTO LRFD Bridge Design specifications. This approach will ensure that the negative moment load rating in the positive moment region shall not control the bridge load capacity rating.

6A.5.13.2 T-Beam Bridges

T-beam bridges should be modeled and rated by using the AASHTOWare BrR program. During the quality control process, CONBOX or other software may be used as an independent check.

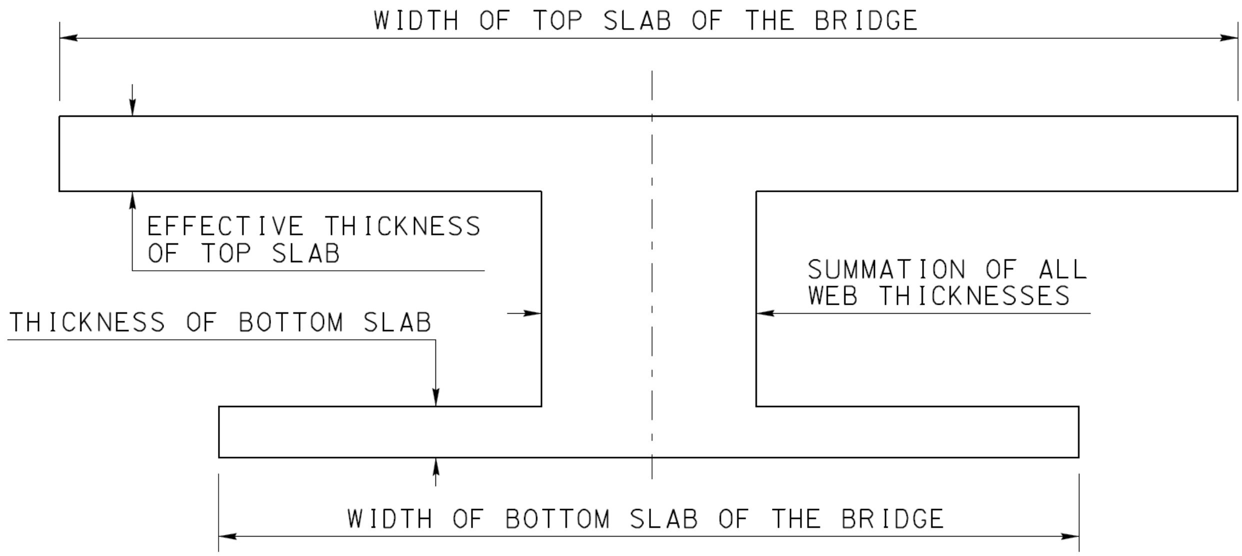
The slab limits for the longitudinal reinforcement shall be that contained within the tributary width of the slab for each girder. Negative moment ratings should be determined at the face of the supports. Shear rating should be determined at a distance of “d” from the face of the supports where “d” is the effective depth of the section where the shear rating is considered.

6A.5.13.3 - Concrete Box Girder Bridges

Conventionally reinforced concrete box girder bridges should be modeled and rated by using the AASHTOWare BrR program. During the quality control process, CONBOX may be used as an independent check.

In BrR, the entire bridge shall be modeled as an equivalent one I-girder. Top and bottom flange widths and thicknesses of this I girder shall be the same as the original bridge flanges, and the web thickness shall be the summation of the thicknesses of all webs.

Figure 1



The lane live load distribution factor should be calculated from AASHTO LRFD Bridge Design Specifications Article 4.6.2.2.2 and 4.6.2.2.3 for an interior girder, multiplied by the number of girders (webs). To determine the wheel distribution factor for the live load (for BrR use), the lane live load distribution factor should be multiplied by two.

All longitudinal reinforcement for the entire bridge, as specified in the bridge plans, shall be used in the bridge analysis model for load capacity ratings.

Negative moment ratings may be determined at the face of the supports. Shear rating may be determined at a distance of “d” from the face of the supports where “d” is the effective depth of the section where the shear rating is considered.

6A.5.14 Rating of Prestressed Concrete Bridges

6A.5.14.1 Pre-tensioned Concrete Bridges

Pre-tensioned concrete bridges should be modeled and rated by using the AASHTOWare BrR program. During the quality control process, CONSPAN may be used as an independent check.

Pre-tensioned Continuous Concrete Girder bridges shall be analyzed as a series of simply supported spans using composite section properties for dead and transient loads.

Shear ratings may be determined at a distance “0.8H” from the face of the supports, where “H” is the total depth of the superstructure at the section where the shear ratings are considered.

Pre-tensioned concrete bridges designed before 1980 shall be rated and modeled with stress relieved prestressing strands. Lump sum prestressing steel losses used for the load ratings of bridges shall be as stated on the project plans. In the event that the lump sum prestressing steel losses are unknown, the loss calculation as specified in the AASHTO LFRD Bridge design Specifications shall be used in the bridge model. For bridges which were designed before 1973, the lump sum losses shall be taken as 35 ksi.

In case the bridge construction plans do not indicate the value of the jacking force, 0.75 f_{pu} shall be used for low relaxation strands and 0.70 f_{pu} shall be used for stress relieved strands, where f_{pu} is the specified tensile strength of the prestressing strands.

A value of 40% shall be used for the relative humidity in the bridge model for the purpose of load capacity ratings.

It should be noted that in the CONSPAN software, the modification of design stress parameters will not automatically be reflected to the load capacity rating stress parameters. Load capacity rating stress parameters have to be modified manually within the load capacity ratings block; otherwise, the software default values will be used.

Section properties shall be based on gross area of bonded prestressing strands for precast prestressed members.

6A.5.14.2 Post-tensioned Concrete Bridges

Post-tensioned concrete bridges should be modeled and rated by using AASHTOWare BrR, CONBOX or similar software.

Longitudinal top and bottom slab reinforcements shall not be used in the model for load capacity rating.

Negative moment ratings should be taken at the face of the supports.

Shear rating may be taken at a distance of “d” from the face of the supports where “d” is the effective depth of the section where the shear rating is considered.

Post-tensioned concrete bridges designed before 1980 shall be rated and modeled with stress relieved prestressing strands.

In the event that the lump sum prestressing steel losses are unknown, the loss calculation as specified in the AASHTO LFRD Bridge design Specifications shall be used in the bridge model. For bridges which were designed before 1982, the lump sum losses shall be taken as 33 ksi.

In case the bridge construction plans do not indicate the value of the jacking force, 0.75 f_{pu} shall be used for low relaxation strands and 0.70 f_{pu} shall be used for stress relieved strands, where f_{pu} is the specified tensile strength of the prestressing strands.

A value of 40% shall be used for the relative humidity in the bridge model for the purpose of load capacity ratings.

It should be noted that in the CONBOX software, the modification of design stress parameters will not automatically be reflected to the load capacity rating stress parameters. Load capacity rating stress parameters have to be modified manually within the load capacity ratings block; otherwise, the software default values will be used.

Section properties shall be based on gross area of members for cast-in-place post-tensioned members.

6A.6 STEEL STRUCTURES

6A.6.13 Steel Girder Bridges

Steel girder bridges should be modeled and rated by using the AASHTOWare BrR program. During the quality control process, MDX or SIMON may be used as an independent check.

Longitudinal deck reinforcements within the tributary width of the slab for each girder shall not be used in the bridge load-rating model.

6A.6.14 Steel Truss Bridges

Steel truss bridges should be modeled and rated by using the AASHTOWare BrR program. During the quality control process, GT STRUDL or similar software may be used as an independent check.

6A.8 Posting of Bridges

6A.8.1 General

Arizona Department of Transportation's current practice is to post structures at the Operating Rating Level based on the LFR methodology and to follow the posting load analysis as described in AASHTO's Manual for Bridge Evaluation (MBE). No load posting is necessary if the legal load operating rating factor of the structure is equal to or greater than 1.0.

For concrete slab bridges with an operating rating below 1.0 and having a superstructure condition rating of 6 or more and for condition rating "5" with bridge group approval, a refined analysis method for calculating the effective slab width developed by Florida Department of Transportation (FDOT Structures Research Center -"Solid Concrete Slab Bridges-Effective Width Recommendations"), may be used to reduce the live load distribution factor and increase the operating load rating.

6A.8.1A

In performing load ratings for Emergency Vehicle (EV2 and EV3) loads and when an operating load rating falls below 1.0, the live load factor may be reduced from 1.3 to 1.1 in re-evaluating the operating load factor. This option is based on proposed revisions to the MBE for live load factors for Emergency Vehicles as a result of research performed under NCHRP 20.07 Task 410.

6A.8.2 Posting Loads

6A.8.2A AASHTO Legal Loads - Type 3 (50k; 3 axles), Type 3-3 (80k; 6 axles), Type 3 S2 (72k; 5 axles)

6A.8.2B SHV Loads - SU4 (54k; 4 axles), SU5 (62k; 5 axles), SU6 (69.5k; 6 axles), SU7 (77.5k; 7 axles)

6A.8.2C EV Loads – EV2 (57.5k; 2 axles), EV3 (86k; 3 axles)

6A.8.3 Posting Weight Limit Analysis

If the calculated operating rating of a structure is less than 1.0 ; the structure must be load posted.

Posting weight limit for legal loads will be calculated based on the MBE or estimated a value in between the inventory and the operating rating capacities which is determined to be safe for the structure.

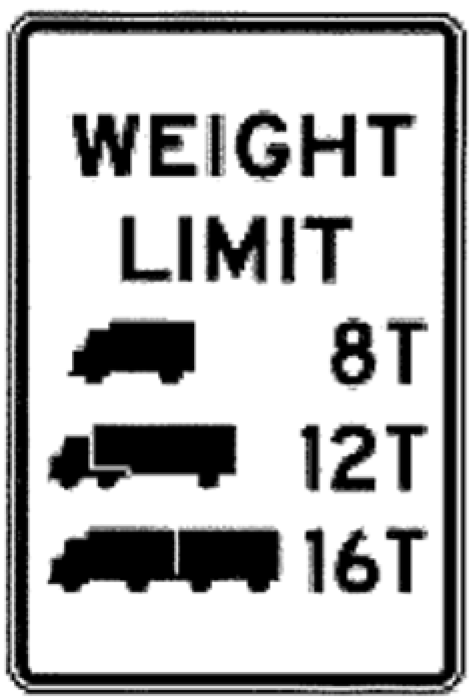
FHWA memos and guidelines shall be followed to calculate the posted weight limits for SHV and EV loads.

6A.8.3A Posting Signs

The posting signs shall conform to the *Manual on Uniform Traffic Control Devices* (MUTCD). Sample posting signs are shown below:

Load Posting Sign for Legal Load

Load Posting Sign for SHV Load



Load Posting Sign for Emergency Vehicle Load

R12-7

EMERGENCY VECHICLE WEIGHT LIMIT

★ Reduce character spacing 30%.

A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
30	36	0.375	0.625	4	3 D	2	3 C	11.542	7.939	12.525	1.163	2	9.363	13.5
48	60	0.75	1.25	6.875	5 D	3.75	4.5 C	19.237	13.232	20.833	1.979	3.25	15.605	20.833

R	S	T	U	V	W	X	Y	Z	AA	BB	CC	DD	EE	FF
10.477	1.5	1.523	5.944	VAR	VAR	12.695	0.805	VAR	VAR	10.354	3.146	VAR	VAR	1.5
15.715	2.5	2.618	8.583	VAR	VAR	19.043	1.790	VAR	VAR	15.531	5.302	VAR	VAR	3

COLORS: LEGEND, BORDER — BLACK
BACKGROUND — WHITE (RETROREFLECTIVE)

X-XX

R12-7aP
Issued 3/15/2017

R12-7aP
EMERGENCY VEHICLE WEIGHT LIMIT (PLAQUE)

★ Reduce character spacing 30%.

A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
30	0.375	0.625	3.5	3 D	2	3 C	3.5	11.542	9.111	9.110	13.5	10.477	1.5	1.523
48	0.75	1.25	5.25	5 D	3.75	4.5 C	5	19.237	15.184	15.184	20.833	15.715	2.5	2.618

R	S	T	U	V	W	X	Y	Z	AA	BB	CC
5.944	VAR	VAR	12.695	0.805	VAR	VAR	10.354	3.146	VAR	VAR	1.5
8.583	VAR	VAR	19.043	1.790	VAR	VAR	15.531	5.302	VAR	VAR	3

COLORS: LEGEND, BORDER — BLACK
BACKGROUND — WHITE (RETROREFLECTIVE)

X-XX

6A.8.3B Installation of Load Posting Signs

Once the load rating of a structure is complete, and it is determined that the load posting is needed, then the Bridge Management Section (BMS) leader will notify the Bridge Group Preservation Manager with a copy of the complete load rating summary sheet, which will be sent to the respective city, county, or ADOT construction district contact for the purpose of installation of the proper posting sign. Upon receiving the request letter from ADOT Bridge Group, the city or county or ADOT construction district shall immediately arrange the installation of the signs at the two ends of the referenced structure. After signs are installed, the ADOT Bridge Group Preservation Manager will be notified with pictures of posted signs in place.

FHWA Memorandum on 'Timeframe for Installing Load Posting Signs at Bridges' issued on April 17, 2019, requires bridge load postings are to be made as soon as possible but no later than 30 days after a load rating determines a need for such posting.

PART B – ALLOWABLE STRESS RATING AND LOAD FACTOR RATING

6B.5 NOMINAL CAPACITY: C

6B.5.3 Load Factor Method

6B.5.3.1 Structural Steel

6B.5.3.1.1 Rating Equations

Inventory

$$RF = \frac{\varphi R_n - 1.3D}{2.17L(1+I)}$$ Flexural and Shear Strength

$$RF = \frac{0.95f_y - (F_d)}{1.67F_1}$$ Flexural Stress

Operating

$$RF = \frac{\varphi R_n - 1.3D}{1.3L(1+I)}$$ Flexural and Shear Strength

$$RF = \frac{0.95f_y - (F_d)}{F_1}$$ Flexural Stress

where:

RF = Rating factor

f_y = Specified yield strength of reinforcement (psi)
F_d = Unfactored dead load stress
F_l = Unfactored live load stress including impact
φR_n = Normal strength of section satisfying the ductility limitations of Article 9.18 and Article 9.20 of the AASHTO Standard Specifications. Both moment, φM_n, and shear, φV_n, should be evaluated.
D = Unfactored dead load moment or shear
L = Unfactored live load moment or shear
I = Impact factor
φ = 1.0 for precast member flexural strength reduction factor
φ = 0.95 for post-tensioned member flexural strength reduction factor
φ = 0.90 for precast or post-tension member shear strength reduction factor
φ = 0.90 for reinforced concrete member flexural strength reduction
φ = 0.85 for reinforced concrete member shear strength reduction

6B.5.3.1.2 Steel Girder Bridges

The requirements of Article 6A.6.13 of these guidelines shall apply.

6B.5.3.1.3 Steel Truss Bridges

The requirements of Article 6A.6.14 of these guidelines shall apply.

6B.5.3.2 Reinforced Concrete

The following are the yield stresses for reinforcing steel.

Reinforcing Steel	Yield Point, F_y (psi)
Unknown steel (prior to 1954)	33,000
Structural Grade	36,000
Billet or Intermediate Grade and Unknown after 1954 (Grade 40)	40,000
Rail or Hard Grade (Grade 50)	50,000
Grade 60	60,000

The capacity of concrete members should be based on the strength requirements stated in AASHTO Standard Specifications (Article 8.16). Appendix L6B of the AASHTO Manual for Bridge Evaluation contains formulas for the capacity, C, of typical reinforced concrete members. The area of tension steel at yield to be used in computing the ultimate moment capacity of flexural members should not exceed that available in the section or 75 percent of the reinforcement required for balanced conditions.

6B.5.3.2.1 Rating Equations

Inventory

$$RF \frac{\varphi R_n - 1.3D}{2.17L(1+I)}$$ Flexural and Shear Strength

Operating

$$RF = \frac{\varphi R_n - 1.3D}{1.3L(1+I)}$$ Flexural and Shear Strength

where:

RF = Rating factor
D = Unfactored dead load moment or shear
φR_n = Normal strength of section satisfying the ductility limitations of Article 9.18 and Article 9.20 of the AASHTO Standard Specifications. Both moment, φM_n , and shear, φV_n , should be evaluated.
L = Unfactored live load moment or shear
I = Impact factor
φ = 1.0 for precast member flexural strength reduction factor
φ = 0.95 for post-tensioned member flexural strength reduction factor
φ = 0.90 for precast or post-tension member shear strength reduction factor
φ = 0.90 for reinforced concrete member flexural strength reduction
φ = 0.85 for reinforced concrete member shear strength reduction

6B.5.3.2.2 Slab Bridges

The requirements of Article 6A.5.13.1 of these guidelines shall apply.

6B.5.3.2.3 T-Beam Bridges

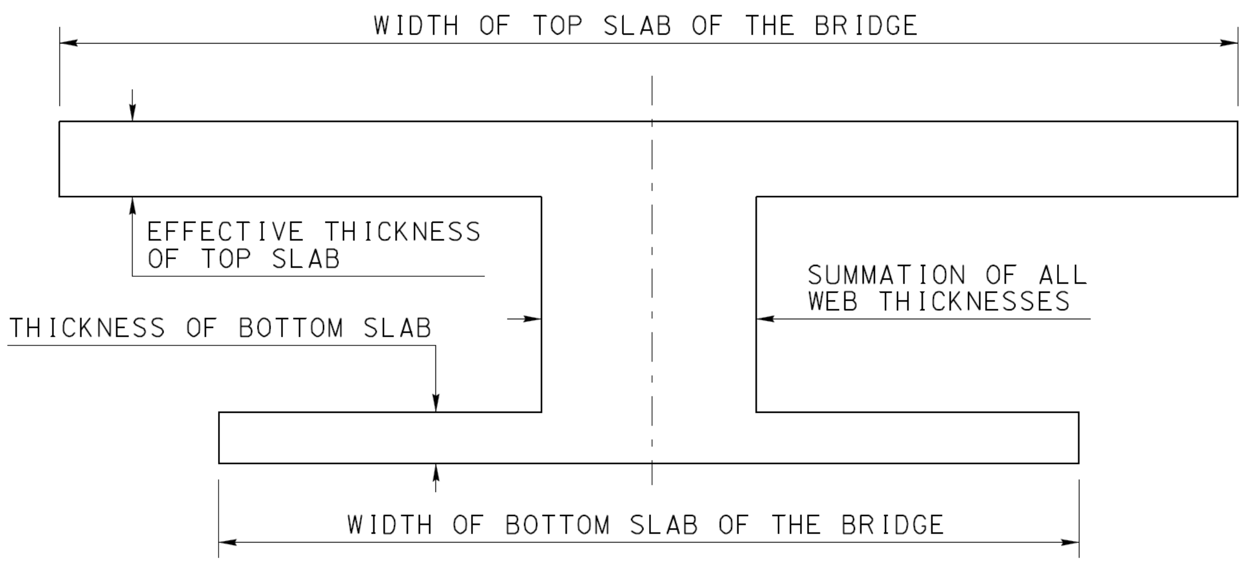
The requirements of Article 6A.5.13.2 of these guidelines shall apply.

6B.5.3.2.4 Concrete Box Girder Bridges

Conventionally reinforced concrete box girder bridges should be modeled and rated by using the AASHTOWare BrR program. During the quality control process, CONBOX may be used as an independent check.

In BrR, the entire bridge shall be modeled as an equivalent one I-girder. Top and bottom flange widths and thicknesses of this I-girder shall be the same as the original bridge flanges, and the web thickness shall be the summation of the thicknesses of all webs.

Figure 2



For multiple lane load, Live load distribution factor will be equal to the out-to-out bridge width divided by seven, which is the wheel distribution factor for live load.

For single lane load, Live load distribution factor will be equal to the out-to-out bridge width divided by eight, which is the wheel distribution factor for live load.

All longitudinal reinforcement for the entire bridge, as specified in the bridge plans, shall be used in the bridge models for load capacity ratings.

Negative moment ratings should be taken at the face of the supports.

Shear rating should be taken at a distance of "d" from the face of the supports where "d" is the effective depth of the section where the shear rating is considered.

6B.5.3.3 Prestressed Concrete

A summary of the strength and allowable stress rating equations is presented at the end of this Section.

Typically, prestressed concrete members used in bridge structures will meet the minimum reinforcement requirements of Article 9.18.2.1 of the AASHTO Standard Specifications. While there is no reduction in the flexural strength of the member in the event that the provisions are not satisfied, a rater, as part of the flexural rating, may choose to limit live loads to those that preserve the relationship between φM_n and M_{cr} that is prescribed for a new design. The use of this option necessitates an adjustment to the value of the nominal moment capacity φM_n, used in the flexural strength rating equations. Thus when $\varphi M_n < 1.2\ M_{cr}$, the nominal moment capacity becomes $(k)(\varphi)(M_n)$, where k is the larger of:

$k = \varphi M_n / 1.2\ M_u$

or,

$k = \varphi M_n / 1.33\ M_u$

Rating Equations

Inventory Rating

$$RF = \frac{3\sqrt{f'_c} - (F_d + F_P + F_S)}{F_1}$$ Concrete Tension (for pre-tensioned bridges or for post-tensioned bridges built on soffit fill)

$$RF = \frac{0.00 - (F_d + F_P + F_S)}{F_1}$$ Concrete Tension (for post-tensioned bridges built on false work or when the construction method is unknown)

$$RF = \frac{0.4 f'_C - \frac{1}{2}(F_d + F_P + F_S)}{F_1}$$ Concrete Compression

$$RF = \frac{0.8 f^*_y - (F_d + F_P + F_S)}{F_1}$$ Prestressing Steel Tension

$$RF = \frac{\varphi R_n - (1.3D + S)}{2.17L(1+I)}$$ Flexural and Shear Strength

Operating Rating

$$RF = \frac{\varphi R_n - (1.3D + S)}{1.3L(1+I)}$$ Flexural and Shear Strength

$$RF = \frac{0.9 f^*_y - (F_d + F_P + F_S)}{F_1}$$ Prestressing Steel Tension

where:

RF = Rating factor
f'_c = Concrete compressive strength (psi)

f_y = Specified yield strength of reinforcement (psi)
F_d = Unfactored dead load stress
F_p = Unfactored stress due to prestress force after all losses
F_s = Unfactored stress due to secondary prestress forces
F_l = Unfactored live load stress including impact
φR_n = Normal strength of section satisfying the ductility limitations of Article 9.18 and Article 9.20 of the AASHTO Standard Specifications. Both moment, φM_n , and shear, φV_n , should be evaluated.
D = Unfactored dead load moment or shear
S = Unfactored prestress secondary moment or shear
L = Unfactored live load moment or shear
f^*_y = Prestressing steel yield stress
I = Impact factor
φ = 1.0 for precast member flexural strength reduction factor
φ = 0.95 for post-tensioned member flexural strength reduction factor
φ = 0.90 for precast or post-tension member shear strength reduction factor
φ = 0.90 for reinforced concrete member flexural strength reduction
φ = 0.85 for reinforced concrete member shear strength reduction

In the rating equations, effects of dead load, prestress force, and secondary prestress forces are subtracted from the allowable stress or capacity. The actual effect of each load relative to the allowable stress or capacity should be considered in the rating equations through using appropriate signs.

6B.5.3.3.1 Pre-tensioned Concrete Bridges

The requirements of Article 6A.5.14.1 of these guidelines shall apply.

6B.5.3.3.2 Post-tensioned Concrete Bridges

The requirements of Article 6A.5.14.2 of these guidelines shall apply.

6B.6 LOADING

6B.6.1 Dead Load: D

The requirements of Article 6A.2.2.1 of these guidelines shall apply.

APPENDIX - RATING REPORT

Bridge Load Rating Summary Report

ADOT Infrastructure Delivery and Operations

Arizona Department of Transportation
Bridge Group | Bridge Management Section

I. General Information

Structure # (N8):		STR Name:		Owner (N22):	
Route (N5d):		Location (N9):		Agency (A229):	
Mile Post (N11):		Road Name:		Maint. (N21):	
District (N2):		Feature Under:		Year Built (N27):	
County (N3):		Other:		Year Recon. (N106):	

II. Rating Data

Dsgn Load (N31):		Deck / Slab Thickness:		Str Type (N43):	
Foundation Type:		Deck Concrete Strength:		Str. Length (N49):	
Bridge Rail Type:		Deck Reinforcing Steel:		Br Width O-O (N52):	
AC Overlay:		Prestress Strands / Struct. Steel:		Span Config:	

NBI Ratings	Inventory				Operating			
Rating Vehicle and Method	Inv. Rtg (Facto	Inv Rtg (Ton)	Location from Beginning of Str. (Feet)	Limit State	Opr. Rating (Factor)	Opr Rtg (Ton)	Location from Beginning of Str (Feet)	Limit State
HS20;LFR								
HL-93;LRFR								

Other Ratings	Operating Load Factor Rating Only		
Legal, NRL, SHV, EV, Permit, ETC; LFR	NRL (80k; 8 axles):	Posting Load, SU4 (54k):	FAST Act EV3 (86k; 3 axles):
	AASHTO Type 3 (50k):	Posting Load, SU5 (62k):	FAST Act EV2 (57.5k; 2 axles):
	AASHTO Type 3-3 (80k):	Posting Load, SU6 (69.5k):	
	AASHTO Type 3 S2 (72k):	Posing Load, SU7 (77.5k):	

III. Computer Program

Software:		Data Base File:		Structure Model ID:	

IV. Inspection Data

Inspected By:		**Inspection Date:**	
Deck (N58):		Waterway (N71):	
Superstructure (N59):		Rdwy Approach (N72):	
Substructure (N60):		ADT (N29):	
Culvert (N62):		% Truck (N109):	
Scour Crit Rtg (N113)		Deck Area in SQFT (A225):	

VI. Rater Info | P.E. Seal

Model By:	
QC By:	
QA By:	
Date of Rating:	

PE SEAL

V. Comments

Updated 6/26/2019