CHAPTER 7
BRIDGE LOAD RATING GUIDELINES

7.1 POLICY

7.1.1 Purpose

This chapter establishes a policy to be used by MassDOT and Consultant Rating Engineers in determining the safe load carrying capacity of newly built and existing bridges. The development of a bridge load rating requires engineering judgment and the implementation of sound engineering principles that are commonly accepted in the field of bridge engineering.

Load rating for bridges shall be performed using the same methodology used for its design. The majority of existing bridges in the Commonwealth of Massachusetts were designed using the Allowable Stress Design (ASD) method. In general, the Central Artery bridges were designed using the Load Factor Design (LFD) method and more recently all bridges have been designed using the Load and Resistance Factor Design (LRFD) method. It is the responsibility of the Rating Engineer to determine the method that will be used for development of the load rating.

Load ratings are performed to evaluate and determine substandard bridges requiring posting, and to provide a means of determining the bridges requiring rehabilitation or replacement. Additionally, FHWA requires reporting of bridge load ratings on an annual basis.

Massachusetts General Laws require the reporting of the Gross Tonnage for statutory vehicles as defined in the sections that follow and therefore, all rating reports shall include ratings for these vehicles.

7.1.2 Rating Specifications

All bridges shall be rated in accordance with the provisions of the current AASHTO *Manual for Bridge Evaluation (MBE)*, including all interims except where modified by this Bridge Manual.

The *MBE* is divided into two parts. Part A of the *MBE* incorporates provisions specific to the LRFR methodology, whereas Part B provides rating criteria and procedures for the Allowable Stress and Load Factor methods of evaluation.

In the articles that follow a designation of “A” or “B” is used to differentiate between the LRFR methodology and the Allowable Stress/Load Factor methodology, respectively.

7.1.3 Definitions

For the purpose of these guidelines, the following definitions shall be used:

MBE – current edition of the AASHTO Manual for Bridge Evaluation including all Interims

MS18 – metric equivalent of the HS20

7.1.4 Qualifications

All bridges shall be rated by a Professional Engineer, registered in Massachusetts, or by a MassDOT Engineer under the direction of the State Bridge Engineer. Engineers performing the analysis shall be knowledgeable in Bridge Design and familiar with the relevant AASHTO specifications.

7.1.5 Field Inspection

The Rating Engineer shall field verify what is contained on the latest Construction Drawings, latest inspection reports, and prior bridge rating reports. If during the verification, the Rating Engineer finds a changed condition that is not noted or documented sufficiently on the latest inspection report, the Rating Engineer shall notify the State Bridge Engineer, and shall obtain documented measurements of the changed condition prior to incorporating the findings into the Rating Report.

7.1.6 Load Rating Software

7.1.6.1 MassDOT currently utilizes AASHTOWare™ Bridge Rating software (formerly known as Virtis) as the standard software for load rating purposes. The assignment letter will provide the Rating Engineer with the required version of AASHTOWare™ Bridge Rating, which is presently used by the Bridge Section. It is the Rating Engineer's responsibility to ensure that ratings are being performed with the correct release.

Where the Rating Engineer determines and the MassDOT State Bridge Engineer concurs that a structure cannot be properly analyzed using the AASHTOWare™ Bridge Rating load rating software, an alternate approved computer program shall be utilized.

7.1.6.2 MassDOT has a current list of acceptable software that may be used to perform ratings that cannot be performed using AASHTOWare™ Bridge Rating. This list of acceptable software including the acceptable version and/or release will be provided with the Rating Engineer's assignment letter.

7.1.6.3 Rating Engineers working for firms that do not have licensed copies of the required software may perform the load rating(s), with prior approval, by utilizing one of the guest computers located in the Bridge Section office in Room 6430 of the State Transportation Building.

7.1.7 Units

7.1.7.1 All bridge ratings shall be performed using U.S. Customary units. If the bridge was designed and detailed using metric units, the bridge geometry and section properties shall be converted using exact conversion factors and the rating calculations shall be prepared using U.S. Customary units.

7.1.7.2B In accordance with requirements of the December 1995 FHWA NBIS Coding Guide an Inventory and Operating Rating shall be obtained for the HS20 vehicle using the Load Factor Method. The gross tonnage is reported on the Summary Sheet of the rating report for Item 64 and Item 66. Since MassDOT reports these Items in metric units the gross tonnage results from the rating calculations performed in U.S. Customary units shall be converted to metric units. The HS20 truck gross tonnage shall be converted to a MS18 gross tonnage using a conversion factor of 0.9, instead of

the exact conversion of 0.907185 metric tons per U.S. short ton. The resulting MS18 metric ton ratings shall be specified on the Summary Sheet in the spaces provided for Item 64 and Item 66.

7.2 GENERAL LOAD RATING REQUIREMENTS

7.2.1A Bridge Projects Designed using LRFD

Ratings for bridges designed using LRFD shall be based on the construction drawings, as-built conditions and the latest bridge inspection reports. The ratings shall be performed in accordance with Part A of the *MBE*.

7.2.1B Bridge Projects Designed using ASD/LFD

Ratings for bridges designed using ASD/LFD shall be based on the construction drawings, prior rating reports, and the latest bridge inspection reports. For bridges that have not been rated previously, ratings shall be provided using as-built member properties and the reported and field verified section losses.

7.2.2 Elements Requiring Load Rating

7.2.2.1 Stringer/girder bridges will require ratings for the primary elements. By default, AASHTOWare™ Bridge Rating performs analyses at each 1/10th points along the girder span length (L). In addition, the Rating Engineer should specify a minimum number of "points of interest" along the girder length as well. These points of interest include, but are not limited to the following:

a. 0.45L for simple span bridges
b. 0.375L and 0.75L for continuous span bridges
c. Location of change(s) in the girder cross section
d. Theoretical (not actual) cover plate cut-off locations
e. Field splice locations
f. Locations of measurable section loss
g. Locations where there are reinforcement discontinuities in the concrete girders
h. Distance H/2 from the centerline of bearings of the prestressed precast concrete beams (where H is the beam depth)
i. Hold down points for draped strands in precast prestressed concrete beams

7.2.2.2 For girder/floorbeam/stringer bridges and girder/floorbeam bridges all elements shall be rated at locations similar to those outlined in 7.2.2.1 above.

7.2.2.3 For truss bridges all chords, diagonals, floorbeams, stringers, bracing, and gusset plates require load ratings. Floorbeams and stringers shall be rated for flexure and shear and changes in section properties shall be investigated.

7.2.2.4 For arches, at a minimum, the crown, springlines and quarter points shall be rated.

7.2.2.5 Bridge Decks - Reinforced concrete decks and exodermic bridge decks supported by girders or floorbeams do not require load ratings unless their condition warrants investigation. Typically MassDOT will specify whether the deck needs to be rated in the assignment letter.

However, if the Rating Engineer feels that the deck should be rated, based upon condition, he/she shall notify MassDOT as soon as possible.

In the event the deck needs to be rated, the Rating Engineer shall check punching shear under wheel loads, as recommended in AASHTO *MBE* Article C6.1.5.1.

Timber decks require a load rating.

Metal grid decks do not require a load rating, but purlins supporting the metal grid decking shall be rated.

7.2.2.6 For bridges which require posting, the Rating Engineer shall also consider all alternate load paths if this shall produce a higher overall bridge rating.

7.2.3 Dead Loads

7.2.3.1 If a material unit weight is not known, Table 3.5.1-1 of the AASHTO Bridge Design Specifications shall be used for guidance.

7.2.3.2 For stringer bridges, dead loads and superimposed dead loads shall be distributed based on provisions of Subsection 3.5.3 of this Bridge Manual. The wearing surface shall be distributed equally to all beams in the cross section.

7.2.3.3 For adjacent beam prestressed deck and box beam systems with a composite concrete slab, dead loads and superimposed dead loads shall be distributed based on the provisions of Paragraph 3.5.3.4 of this Bridge Manual.

7.2.3.4B When analyzing adjacent prestressed deck and box beam systems, without a composite concrete slab and with intact functioning shear keys, the superimposed dead loads shall be distributed to each beam in proportion to its tributary moment of inertia according to the formula provided in Paragraph 3.8.2.2 of this Bridge Manual.

When the shear keys have failed, the Rating Engineer shall distribute the dead loads consistent with the way the bridge is performing, assuming no transfer of load across the failed keys.

7.2.3.5B For adjacent prestressed deck and box beam systems without a composite concrete slab and/or a special sidewalk beam with sidewalk utility bay 60% of the barrier weight shall be applied to the special sidewalk beam or exterior beam and 40% to the adjacent beam system as described in Paragraph 7.2.3.4B. The wearing surface shall be distributed equally to all beams in the adjacent beam system.

7.2.3.6B For concrete slab bridges, the distribution of superimposed dead loads should be determined after careful review of the plans.

If the slab has consistent reinforcing throughout the cross section, the superimposed dead loads (safety curb, sidewalk, and bridge barrier) shall be distributed equally across the entire bridge cross section. If a portion of the slab supporting the sidewalk/bridge barrier or safety curb has an increased section or increased reinforcing, 60% of the superimposed dead loads should be carried by this

portion of the slab and the remaining 40% percent of superimposed dead load should be carried by the remainder of the slab.

For concrete slab bridges the wearing surface shall be distributed to the entire bridge cross section.

7.2.3.7 For all bridge types where the distribution of superimposed dead loads produces rating factors that require the bridge to be posted, the bridge shall be investigated with equal distribution of superimposed dead loads to all load carrying members. The method of distribution that produces the higher rating shall govern.

7.2.4 Live Loads

7.2.4.1A **HL-93 Design Load** is the LRFD Design Live Load as per Appendix C6A of the *MBE*.

Statutory or Legal Loads are defined as the following:

H20 truck	Two Axle	20 Tons
Type 3 truck	Three Axle	25 Tons
Type 3S2 truck	Five Axle	36 Tons

Posting Vehicles are the trucks whose load ratings are used when a bridge is posted. MassDOT currently uses the following posting trucks for posting purposes at Inventory Level:

H20 truck	Two Axle	20 Tons
Type 3 truck	Three Axle	25 Tons
Type 3S2 truck	Five Axle	36 Tons

7.2.4.1B **Statutory or Legal Loads are defined as the following:**

H20 truck	Two Axle	20 Tons
Type 3 truck	Three Axle	25 Tons
Type 3S2 truck	Five Axle	36 Tons
HS20 truck	Three Axle	36 Tons

Posting Vehicles are the trucks whose load ratings are used when a bridge is posted. MassDOT currently uses the following posting trucks for posting purposes at Inventory Level:

H20 truck	Two Axle	20 Tons
Type 3 truck	Three Axle	25 Tons
Type 3S2 truck	Five Axle	36 Tons

7.2.4.2A Bridges shall be rated for Inventory and Operating Level with the HL-93 design live load, as defined by Part A of the *MBE*. The resulting rating factors for roadway beams shall be specified on the Summary of Bridge Rating sheet in the spaces provided for Item 64 and Item 66. Sidewalk beam rating factors shall not be reported.

These bridges shall also be rated for the statutory vehicles outlined above. The ratings and the corresponding gross tonnage for each vehicle shall be reported at both the Inventory and Operating Level. The Inventory Level shall be obtained by multiplying the load factor (γ_L) for live load found in Table 6A.4.4.2.3a-1 by 1.3. The load factor used shall take into account the ADTT as found on the latest SI&A form.

7.2.4.2B Bridges shall be rated based on the method used for design. For most bridges the ratings will be performed using Allowable Stress Methods. There are several existing bridges designed and constructed during the Central Artery timeframe that were designed using Load Factor Method. These bridges shall be rated using Load Factor Method.

The MS18 gross tonnage for roadway beams, as specified in Paragraph 7.1.7.2B shall be specified on the summary sheet in the spaces provided for Item 64 and Item 66. Sidewalk beam gross tonnage shall not be reported.

Both Inventory and Operating Ratings shall be calculated for the statutory vehicles outlined above and the HS20 vehicle. In general, lane loadings shall not be used for the H20 and HS20 vehicles when the span length is less than 200 feet. However, if a component of a structure is rated for the H vehicle, and the rating is determined to be 12 tons or less, the component must also be rated using the lane loading.

For spans greater than 200 feet in length all vehicles other than the H20 and HS20 vehicles shall be spaced with a clear distance between them to simulate a train of vehicles in one lane and a single vehicle load shall be applied in the adjacent lane(s). The truck train axle load intensities for vehicles other than the H20 and HS20 vehicles shall be 75% for truck 1, 100% for truck 2, and 75% for trucks 3 and 4 for each repeated 4-truck train (*AASHTO Standard Specifications for Highway Bridges, Appendix B*). Truck train loading shall be used in all spans of continuous span bridges where at least one span is greater than 200 feet in length.

7.2.4.3A Live load distribution factors for interior and exterior beams shall be calculated in accordance with Chapter 3 of this Bridge Manual and Section 4 of the latest edition of the *AASHTO LRFD Bridge Design Specifications* including all interims. Skew correction factors shall be included.

7.2.4.3B Live load distribution factors for both interior and exterior beams shall be calculated in accordance with Chapter 3 of the *AASHTO Standard Specifications for Highway Bridges.*

7.2.4.4A Dynamic Load Allowance shall apply to all trucks used in the development of the load rating. Reductions of the Dynamic Load Allowance shall not be permitted.

The Dynamic Load Allowance for concrete arches, rigid frames or slabs that have cover greater than 12 inches, shall be calculated in accordance with the *AASHTO LRFD Bridge Design Specifications,* Section 3.6.2.2.

7.2.4.4B The live load impact factor shall apply to all trucks used in the development of the load rating. Reduction of the live load impact factor shall not be permitted in determining the safe load carrying capacity of the structure.

7.2.4.5 Sidewalks with curb heights greater than or equal to 12 inches shall be considered non-mountable. If a bridge has a non-mountable sidewalk that has a width of 6 feet or greater, then the girder supporting the sidewalk shall be rated at the Operating Level for special snow removal equipment using the appropriate load factor, where applicable.

The snow removal equipment shall be assumed to have 2 axles with 2 wheels per axle. The total weight of the snow removal equipment shall be 4 tons (unfactored), divided equally between the 4 wheels, with each wheel load evenly distributed over a tire contact area that is 8 inches wide and 3 inches long. The wheelbase shall be 4 feet and the wheel lines shall be 5 feet apart. The outer wheel line shall be located no closer than 12 inches from the face of railing. The Operating Rating of the supporting members shall be reported in the Breakdown of Bridge Rating and omitted from the Summary Sheet.

7.2.4.6 Sidewalks with curb heights less than 12 inches in height shall be considered mountable. The beams supporting a mountable sidewalk, mountable median, or mountable safety walk with a width greater than 2 feet measured from the face of the bridge rail to the curb line shall be rated by placing a wheel line 2 feet from the face of the bridge rail. This rating shall be performed at the Operating Level. The Inventory Rating shall be calculated with the wheel line located 2 feet from the face of the curb.

7.2.4.7 Pedestrian Load will generally not be included in ratings, unless, based on engineering judgment, its application will produce the maximum anticipated loading. For structural members supporting both sidewalk loads and vehicular traffic, the probability is low for full loading on both the sidewalk and bridge; therefore only Operating Ratings need to be performed. This rating shall be reported in the Breakdown of Bridge Rating and omitted from the Summary Sheet.

7.2.5 Special Instructions for Load Ratings

7.2.5.1 Any request for clarification of or deviation from these guidelines must be submitted in writing (FAX is acceptable) to the State Bridge Engineer. Written responses will be provided.

7.2.5.2A Condition Factors of the *MBE* Article 6A.4.2.3 shall not be used in the calculations of the structural capacity. The structural capacity of the section being investigated shall be based on the field conditions.

7.2.5.3A System Factors of the *MBE* Article 6A.4.2.4 shall be included in the capacity calculations of the non-redundant structure for the section being investigated. Redundant secondary members within a non-redundant structure shall not have their capacities reduced by the same system factor. For example, a bridge comprised of two girders, floorbeams, and stringers shall use a system factor of 0.85 for the girders, 1.0 for the floorbeams, if they are spaced less than or equal to 12 feet, and 1.0 for stringers (refer to Chapter 3, Paragraph 3.6.1.6 above).

7.2.5.4 In general, substructure elements, except steel, timber, and pile bent structures, shall not be rated unless, in the opinion of the Rating Engineer, this shall influence the rating of the bridge. The *MBE* states in part, “Careful attention should be given to all elements of the substructure for evidence of instability which affects the load-carrying capacity of a bridge. Evaluation of the conditions of a bridge’s substructure shall in many cases be a matter of sound engineering judgment”. The report shall contain a statement noting the Rating Engineer’s judgment with regards to the substructure.

7.2.5.5 Engineering judgment alone shall not be accepted as a valid method for rating superstructure elements. For structures with unknown structural detail and lack of Construction Drawings, detailed field measurements, non-destructive testing, and a material testing program shall be performed.

For such situations a program of material sampling and testing shall be developed and submitted to the State Bridge Engineer for approval prior to performing the testing. All material sampling and testing shall be performed in accordance with the latest ASTM and AASHTO Standards.

7.2.5.6 Structures without the necessary details, such as concrete slabs with unknown reinforcing size and spacing and with difficult access in order to take the samples as required by Paragraph 7.2.5.5 above, the Rating Engineer shall contact the Bridge Section for guidance.

7.2.5.7 If an exterior beam or beam supporting a raised median rates below statutory levels, whereas the interior beam does not require posting, the Rating Engineer shall consider the possibility that composite action may exist when a beam is sufficiently embedded in concrete or that an exterior beam may act compositely with a concrete barrier. The restraining moment effects caused by fixity, overhangs, or continuity shall be considered.

7.2.5.8B All timber structures shall be rated using the Allowable Stress Design methodology. Where the actual species and grade of lumber are unknown, the Rating Engineer shall determine the species and grade by field observation and/or testing. Live load impact shall not be considered when rating timber structures.

The Allowable Inventory Stresses for various timber species and grades are shown in the *AASHTO Standard Specifications for Highway Bridges*. The values used for Allowable Operating Unit Stresses shall be equal to 1.33 times the values determined for the Allowable Inventory Unit Stresses.

7.2.5.9 AASHTOWare™ Bridge Rating can only model parabolic and linear varying web depths for reinforced concrete T-beam superstructures. If a beam's web depth varies along a circular curve, the concrete T-beams can only be modeled in AASHTOWare™ Bridge Rating using cross sections and cross sectional ranges with linear varying web depths.

7.2.5.10 Unless there is a mix formula or design strength given on the plans, concrete for superstructures shall be assumed to have an f'_c equal to 2000 psi for structures built prior to 1931; 3000 psi for structures built between 1931 and 1984; and 4000 psi for structures built after 1984. If a mix proportion is given on the plans, the compressive strengths shall be taken from the 1916 Joint Committee Report as shown in the following Table.

Mix	1:1:2	1:1½ :3	1:2:4	1:2½ :5	1:3:6
f'_c	3000 psi	2500psi	2000 psi	1600 psi	1300 psi

The Allowable Inventory and Operating Stresses may be obtained based on the f'c as shown in Table 6B.5.2.4.1-1 of the *AASHTO MBE*.

7.2.6 Special Instructions for Load Ratings of Precast Prestressed Concrete Members including Adjacent Precast Prestressed Concrete Beams

7.2.6.1 Unless there is physical evidence that the grouted keyway(s) between adjacent precast prestressed concrete beams are not transferring shear, all loads applied to the adjacent beam bridge cross section shall be distributed assuming the beams function together as a unit.

7.2.6.2B The Allowable Tensile Stress at Inventory Stress Levels in the pre-compressed tensile zone for serviceability ratings of precast prestressed concrete members shall be $6\sqrt{f'c}$ psi, as per the *MBE*, Article 6B.5.3.3. The Allowable Compressive Stress at Inventory Stress Levels for prestressed concrete members shall be calculated using the formulas presented in the *MBE*, Article 6B.5.3.3. The formulas for the prestressing steel Allowable Tension Stress rating presented in this Article need not normally be checked for either the Inventory or Operating Stress Levels. The only situation these rating values might control a rating would be in the unlikely case of very lightly prestressed members. All Allowable Tensile Stress values and Allowable Compressive Stress values used in the preparation of the rating report must be clearly stated in the Rating Analysis Assumptions and Criteria section of the rating report.

7.2.6.3B The *MBE* provides one set of rating factor formulas for the rating of prestressed concrete members that consider both strength and serviceability together. Therefore, when calculating either Load Factor or Allowable Stress Ratings of prestressed concrete members, the flexural and shear strength rating factors for both Inventory and Operating Levels shall be obtained using these formulas as specified in Article 6B.5.3.3 of the *MBE*. The rating factor formulas make no provisions for serviceability for Operating Ratings and thus serviceability ratings values need not be calculated.

7.2.6.4B For prestressed girders where the nominal moment capacity is less than $1.2M_{cr}$, the nominal capacity shall be reduced by "*k*". The value "*k*" shall be calculated as per the *MBE*, Article 6B.5.3.3.

7.2.7 Special Instructions for Load Ratings of Arches

7.2.7.1 The *MBE* Article 6A.9.1 states that unreinforced masonry arches should be evaluated by the Allowable Stress Method. An acceptable method of analysis is outlined below.

7.2.7.2B The arch shall be modeled using STAAD as a series of prismatic two-nodded beam elements, with the loads applied at each node or as linearly varying loads to each member. A minimum of 10 straight beam elements or 1 straight beam element per 4 feet of clear span, whichever results in the most members, shall be used. Each member shall be of equal horizontal length. The node locations shall correspond to the mid-depth points of the arch segments. The arch geometry used in the analysis shall be determined using either a parabolic, circular, elliptical, or fifth order polynomial curve that achieves the best fit with the actual arch. Field measurement and confirmation of the arch geometry is critical. Assuming an arbitrary geometry is not acceptable since it may result in inaccurate results.

7.2.7.3B Vertical dead loads shall be calculated along horizontal length of each member and shall be applied as linearly varying loads to each member. The height of fill shall be computed from the extrados to the bottom of the wearing surface.

7.2.7.4B The dead load of sidewalks, wearing surfaces, railings, curbs, and spandrel walls shall be computed and equally distributed across the width of the arch. In some cases, the spandrel wall can function as an independent member capable of supporting its self-weight and perhaps a portion of the arch. However, the ability of the spandrel walls to support itself and a portion of the arch is uncertain and shall be neglected in the analysis.

7.2.7.5B The horizontal earth pressure loads shall be calculated assuming a lateral earth pressure coefficient of 0.25. The loads shall be computed along the vertical heights of each member and shall be applied as linearly varying loads to each member.

7.2.7.6B Live load effects, in the form of pressure applied at the wearing surface over the tire contact area for the given wheel loads, shall be computed and distributed in the longitudinal and transverse directions in accordance with the *AASHTO Standard Specifications for Highway* Bridges, Article 6.4. Live load impact shall be calculated in accordance with the *AASHTO Standard Specifications for Highway Bridges,* Article 3.8.2.3.

7.2.7.7B The *MBE* states that environmental loads, in combination with dead and live load effects, shall be included at the Operating Level. Load ratings of stone masonry arches need not consider thermal effects. Load ratings of concrete arches with spans greater than 100 feet shall consider thermal loading at the Operating Level.

7.2.7.8B Unit loads shall be applied to each node in the model to generate influence coefficient tables and lines for moment, shear, and axial load at given nodes. Extreme care shall be exercised to ensure that proper sign convention is maintained. From these influence lines, the maximum moment and corresponding shear and axial loads shall be calculated. As a minimum, influence lines shall be developed at the springlines, crown, quarter points, and at points where significant changes in section properties occur.

7.2.7.9B Live loads shall be positioned in such a way so as to maximize the moment at each joint. It may be helpful to superimpose a transparent wheel load pressure umbrella over a scaled longitudinal section that depicts the wearing surface and arch extrados. The objective is to load those members so that live load moment shall be maximized at joints of interest.

7.2.7.10B In the load rating of stone masonry arches, the maximum eccentricity shall be calculated in order to determine the critical joint locations. The eccentricities shall be calculated by dividing the combined dead and live load moments by the combined dead and live load thrusts.

7.2.7.11B In the load rating of stone masonry arches, the concept of a "kern" or middle third section is used to determine whether any portion of the masonry is in tension. The kern points are located above and below the neutral axis of the arch at a distance r^2/c, where “r” is the radius of gyration and “c” is the distance from the neutral axis to the extreme fiber.

In cases where the combined dead and live load thrust falls outside the kern points, resulting in tension in the masonry, a pressure wedge analysis shall be used to calculate the maximum compressive stress. The portion of the arch masonry in tension shall be effectively ignored by redistributing the pressure over a smaller depth.

If the eccentricity (e) of the combined thrust is located below the bottom kern point, the maximum compressive stress shall be determined as follows:

f_t = 0 (no tension assumed at top of masonry)
f_b = (P/A)(d/c) = (P/A)(d/(d/2)) = 2P/A

Where:

A = 3(d/2-e)(Unit Width)
d = Depth of Arch Section
e = Combined Moment/Combined Thrust

If the eccentricity (e) of the combined thrust is located above the top kern point, the maximum compressive stress shall be similarly determined as follows:

f_t = (P/A)(d/c) = (P/A)(d/(d/2)) = 2P/A
f_b = 0 (no tension assumed at bottom of masonry)

If the eccentricity (e) of the combined thrust is located between the kern points, the maximum compressive stress shall be determined as follows:

f_b or f_t= (P/A)(1 + 6e/d)

Where:

A = Cross sectional area
d = Depth of Arch Section

7.2.7.12B The Inventory Allowable Compressive Stresses for stone masonry shall be determined in accordance with Article 6B.5.2.6 of the *MBE*. Professional judgment based upon field observations and testing is pivotal to the proper determination of Inventory Allowable Compressive Stresses for stone masonry. Based upon the Rating Engineer's judgment, Allowable Compressive Stresses may be lowered for low quality masonry, or raised, if justified by testing of samples taken from the bridge. Ratings for stone masonry arches shall only be provided at the Inventory Stress Level.

7.2.7.13B The combined axial load and moment capacities of reinforced concrete arches shall be determined in accordance with Article 8.15 of the *AASHTO Standard Specifications for Highway Bridges*. Interaction diagrams for combined flexural and axial load capacities shall be produced. Inventory Capacities shall be obtained by using 35% of the capacities determined in accordance with Article 8.16.4 of the *AASHTO Standard Specifications for Highway Bridges.* Operating Capacities shall be obtained by using 50% of the capacities determined in accordance with this Article.

7.2.7.14 While load rating reinforced concrete arches, especially pre-engineered arches or frames, the Rating Engineer shall be aware that the design may have incorporated the soil/arch interaction to reduce the forces in the arch. This soil/arch interaction shall be considered in the development of the rating report.

7.2.8 Special Instructions for Corroded Steel Stringer/Girder Web Load Ratings

7.2.8.1 Corrosion of steel stringer/girder webs due to exposure to deicing chemicals is a very common problem that must be addressed in load ratings. This deterioration is typically located below leaking deck joints and consists of reduced web thicknesses with irregularly shaped web holes in advanced cases. This may result in web crippling or web buckling. When web section losses equal or exceed an average of 1/8", the simplified methods presented below for computing the reduced capacity of the section shall be used to establish load ratings.

7.2.8.2 The web crippling capacity (F_{crip}) for rolled beams shall be calculated only at inventory level as follows:

$$F_{crip} = F_{cr} * t_w * L_{eff}$$

Where:

F_{cr} = the allowable stress for web crippling = 0.75 * F_y

t_w = the average thickness of the deteriorated web above the bearing

L_{eff} = the effective length = $L_{eff} = N + k$

Where:

N = the bearing length

k = distance from outer face of flange to web toe of fillet (per AISC)

7.2.8.3 The web buckling capacity (F_{buc}) shall be calculated using the following AASHTO LRFD derived resistances divided by defined factors of safety at inventory and operating levels. For rolled beams, the effective column section of the web consists a strip of web extended not more than $9*t_w$ (t_w is the average thickness of the deteriorated web) on each side of the centerline of bearing (b $=18*t_w$ and h = t_w). For plate girders, the effective column section shall consist of all stiffener elements, plus a strip of web extended not more than $9*t_w$ (t_w is the average thickness of the deteriorated web) on each side of the centerline of bearing. The calculation shall be performed as follows:

$$F_{buc} = F_{cr} * A_g$$

Where:

$$A_g = bh = 18t_w^2$$

F_{cr} = column critical buckling stress determined as a function of the column slenderness factor λ:

If $\lambda < 2.25$, then $F_{cr} = 0.66^{\lambda} F_y$

If $\lambda > 2.25$, then $F_{cr} = \frac{0.88}{\lambda} F_y$

Where:

$$\lambda = \left(\frac{kl}{r\pi}\right)^2 \frac{F_y}{E}$$

r = radius of gyration about the plane of buckling (in)

$$r = \sqrt{\frac{I}{A}} \text{ With } I = \frac{bh^3}{12} = \frac{3t_w^4}{2} \text{ and } A = bh = 18t_w^2$$

k = 0.75 (effective length factor – Article 6.10.11.2.4a LRFD)
l = unbraced length = web depth – end diaphragm height, when diaphragm is present (in)
E = modulus of elasticity of steel (ksi)
Fy = minimum yield strength (ksi)

Inventory: $F_{buc}^{INV}(ASD) = \frac{F_{buc}(LRFD)}{F.S.}$

Where: F.S. = 1.70 – To accommodate members designed using ASD

Operating: $F_{buc}^{OPER}(ASD) = F_{buc}^{INV}(ASD) * \frac{0.75}{0.55}$

7.2.8.4 The corroded web rating shall be determined using the governing capacity of the web crippling and web buckling checks as follows:

Capacity = Min [F_{crip}, F_{buc}]

Rating Factor:

$$RF = \frac{Capacity - DL_{shear}}{(L+I)_{shear}}$$

7.2.9 Guidelines for Recommendations

The Rating Engineer may make general or specific recommendations to address a structural deficiency or to improve the load carrying capacity of the bridge. Such recommendations shall be based on sound engineering judgment and the results of the rating analysis. The Rating Engineer must examine all ramifications of such recommendations so that any recommendation included in the rating report is feasible, safe and shall not adversely affect the structure or its long-term performance and maintainability.

If the Rating Engineer feels that the situation requires immediate action they are obligated to inform the State Bridge Engineer as soon as possible and not wait for the report to be completed and submitted.

The Rating Engineer is cautioned against making unrealistic or impractical recommendations just for the sake of making a recommendation. Any specific recommendation that shall alter the bridge's load carrying capacity shall include rating calculations, located in Appendix C, that shall indicate the revised rating if the recommendation is implemented.

7.3 REPORT SUBMITTAL REQUIREMENTS

7.3.1 Submittal Media

7.3.1.1 Electronic Media. The entire report shall be submitted as Adobe Acrobat format (PDF) files on a compact disk (CD). The CD shall be contained in a Jewell Case. Both the disk label and the Jewell Case cover shall be color coded as follows: red if any rating is 6 tons or less, yellow if more than 6 tons but less than statutory and green for statutory or greater. In addition, both the disk label and Jewell Case cover shall have a typed title block that includes the following information:

1. Name of the Consulting Firm
2. Bridge Number, BIN Number
3. Facility Carried / Feature Intersected
4. Name of software and version of software used

The names of Facility Carried / Feature Intersected must be exactly the same as those given on the SI&A. The generic Feature and/or Facility Codes (i.e. WATER, HWY, RR, etc.) should be omitted, but the Interstate (I-), US Route (US) and State Route (ST) code along with the route number, followed by the local street names (if any) in parentheses, shall be provided. The local street names shall be fully spelled out (e.g. N WSHNGTN ST on the SI&A shall be spelled out as North Washington Street). If the same stretch of road has several numbered routes associated with it, then all of the routes shall be provided separated by a slash (/) starting with the Interstate then the US Route then the State Route and followed by the local street name (if any) in parenthesis. The following are examples of the proper identification of the bridge with some common Facility Carried/Feature Intersected:

- *ST 19 (WALES ROAD) OVER MILL BROOK*
- *ST 20A (PLAINFIELD STREET) OVER I-91*
- *US 202 (GRANBY ROAD) OVER ST 116 (NEWTON STREET)*
- *I-95/US 1/ST 3 OVER WEST STREET*

The files on the CD shall be organized in the following three folders:

1. COMPUTER INPUT FILES: all AASHTOWare™ Bridge Rating or other MassDOT approved rating analysis software input files that were used to produce the rating recommendations
2. RATING REPORT: the Rating Report itself formatted as specified in Section 7.5
3. BRIDGE PLANS: all plans of the bridge that were used by the Rating Engineer in the preparation of the Rating Report

7.3.1.2 Hardcopy Media. Those sections of the report that are noted in Section 7.5 as **HARDCOPY** shall be printed on 8½" x 11" paper and shall be GBC bound with clear plastic front and back covers and color coded Report covers.

7.3.2 Report Distribution

Two CD's and two copies of the GBC bound report shall be submitted to the MassDOT Bridge Section: 1 set for the Bridge Section and 1 set for the District.

7.4 CALCULATIONS AND INPUT FILE FORMAT

7.4.1 Hand Calculations

7.4.1.1. All submitted hand calculations shall include either sketches or copies of the necessary sheets or details from the construction drawings to support the calculations being prepared. All hand calculations including all details along with relevant notes and code references so that every step of the calculations can be easily followed, in a logical order, legible and prepared on 8.5" x 11" paper.

7.4.1.2 Calculations using spreadsheets and other computer calculation aids (e.g. MathCad) shall be also formatted and presented as hand calculations. These computer aided calculations should be presented in a logical order along with relevant notes and code references so that every step of the calculations can be easily followed.

7.4.2 AASHTOWare™ Bridge Rating Input File Submission

7.4.2.1B The Rating Engineer shall prepare the AASHTOWare™ Bridge Rating file in a manner that will allow MassDOT to analyze the structure using the LRFR method at a later date.

7.4.2.2 AASHTOWare™ Bridge Rating shall be used to rate every unique beam element of the structure in order to determine the controlling live load capacity of the structure. The bridge shall be modeled as a Girder System, wherever possible. Links shall be used to define identical girders within a girder system. However, the following member types shall be modeled as described below:

1. When the structure is a concrete slab bridge it shall be modeled as a Girder Line;

2. When the exterior beam acts composite with a sidewalk or a safety curb. This particular member shall be modeled as a Girder Line and the remaining portion of the structure shall be modeled as a Girder System;

7.4.2.3 The file naming convention shall be consistent with the examples provided with the MassDOT prepared AASHTOWare™ Bridge Rating user example guides. The following Massachusetts specific example of a Town Line bridge is provided:

> Bridge No. D-02-033=P-15-015, BIN = BG1, DANA-PRESCSOTT, MAIN STREET / SWIFT RIVER shall be identified without any blank spaces using the following UPPER CASE characters:
>
> | | |
> |---|---|
> | Bridge ID (unlimited digits): | D-02-033=P-15-015(BG1) |
> | NBI Structure ID (NBI Item 8, 15 digits): | D02033BG1DOTNBI |

Name (same as Bridge ID):	D-02-033=P-15-015(BG1)
Description (unlimited digits):	4 SPAN CONTINUOUS COMPOSITE MULTIPLE STEEL STRINGER (Modify as required.)

Where:

The first 13 characters (22 if town line bridge, as shown in the example) reflect the structure's Bridge Number, including hyphens, equal sign, and parentheses, and the characters within the parentheses represent the structure's BIN.

For submission purposes, the file shall be exported with the extension .XML:

D-02-033=P-15-015(BG1).XML

7.4.2.4 All relevant information from the structure SI&A sheet shall be transcribed verbatim into the appropriate fields in the AASHTOWare™ Bridge Rating file's Bridge Workspace Window.

7.4.2.5 Calculations for all loads and distribution factors shall be clearly shown within the rating and summarized in a table.

7.4.2.6 The non-composite dead load for composite structures in excess of that of the beam and reinforced concrete slab shall be calculated and stated in a table. Non-composite loads may include, but not be limited to, diaphragms, utilities and utility supports, and sign supports.

7.4.2.7 All information pertaining to the beam layout and cross section should be included in tables.

7.4.2.8 Each girder shall have the results of the analysis summarized in Rating Results Summary Reports. The first report shall determine the lowest rating value (analyzed by generating values at 1/10th points and at user defined points of interest) and the other reports, if necessary, shall determine the lowest rating value at each point of interest (generated by selecting the user defined points of interest button under the member alternatives description, engine tab, properties button).

7.4.2.9A All AASHTOWare™ Bridge Rating files shall include the HL-93 design live load and all three statutory vehicles (H20, Type 3 and Type 3S2) used in the rating analysis.

7.4.2.9B All AASHTOWare™ Bridge Rating files shall include the four statutory vehicles (H20, Type 3, Type 3S2 and HS-20) used in the rating analysis.

7.4.2.10 The AASHTOWare™ Bridge Rating output files shall include the following:

1. AASHTOWare™ Bridge Rating produced sketches of the framing plan, structure cross section, and girder details for steel stringer structures;
2. AASHTOWare™ Bridge Rating produced sketches of the framing plan, structure cross section, girder details, and strand locations at midspan and support locations for precast prestressed concrete structures;

3. AASHTOWare™ Bridge Rating produced sketches of the framing plan, structure cross section, and girders cross section with the reinforcement for reinforced concrete slab, T-beam and I-beam structures;
4. AASHTOWare™ Bridge Rating produced Rating Results Summary Reports for all members and points of interest;

7.4.2.11 The same submission requirements shall apply when an alternate approved computer program is utilized. For example, if STAAD or STRUDL are used, sketches showing legible joint and member numbers shall be included.

7.4.3 Check of Calculations Submission

All rating calculations shall be reviewed with a check of the methods, assumptions, load distributions and AASHTOWare™ Bridge Rating or other approved computer software input files in addition to a check of the actual calculations. The Standard Statement of Concurrence with the calculations shall be included in the Rating Report with the date and signature of the Reviewer. The standard statement of concurrence shall be as follows:

> "I HEREBY STATE THAT I HAVE CHECKED THE METHODS, ASSUMPTIONS, LOAD DISTRIBUTION, COMPUTER INPUT FILE(S) AND ALL CALCULATIONS FOR THIS RATING REPORT FOR BRIDGE NO. A-12-345 (ABC). BY SIGNING BELOW, I CONFIRM THAT I AGREE WITH ALL METHODS, ASSUMPTIONS, LOAD DISTRIBUTIONS, AND CALCULATIONS CONTAINED IN THIS RATING REPORT."

The Reviewer shall be a Professional Engineer registered in the Commonwealth of Massachusetts.

7.5 RATING REPORT

7.5.1 Preparation and Format

The entire Rating Report shall be prepared as an Adobe Acrobat format (PDF) file. The PDF file pages shall be sized as 8½" x 11" sheets. The font shall be Times New Romans with a minimum size 11. The PDF file shall also have a front and back cover that shall be color coded as follows: red if any rating is 6 tons or less, yellow if more than 6 tons but less than statutory and green for statutory or greater. All pages that require a P.E. stamp shall be scanned after the stamp is affixed and signed.

The entire PDF file of the Rating Report shall be bookmarked so that the reader can navigate to each individual section directly without having to scroll through the entire file. The Appendices containing calculations or computer output shall be further bookmarked to match the index of the calculations or by each computer output (e.g., Beam #1, etc.) so that the reader can navigate to a particular calculation or output of interest.

In addition to the CD, those sections of the report that are noted **HARDCOPY** shall be printed on 8½" x 11" sheets and shall be GBC bound with clear plastic front and back covers. The lettering of the Bridge Number shall be such as to permit easy recognition. Covers with cutouts, which may get torn in filing cabinets, and pages greater than 8½" x 11" in size shall not be used. The Report covers shall be color coded as specified above.

The Facility Carried / Feature Intersected listed on the Rating Report cover and elsewhere in the report must be the same as those given on the SI&A. Omit the generic Feature Facility Codes (i.e. WATER, HWY, RR, etc.), however include the Interstate, US and State Route numbers, and fully spell out any contracted names (e.g. *N WSHNGTN ST* on the SI&A should be spelled out as *North Washington Street*). For numbered routes, the route number shall always be first followed by the street name.

7.5.2 Report Organization

The Rating Report PDF file shall consist of the following sections. Those sections marked **HARDCOPY** shall also be included in the printed GBC bound report:

1. REPORT COVER (HARDCOPY – CARD STOCK, minimum 65 lb.)
- 1.1. P.E. Stamp with signature of the Engineer shall be placed here.
- 1.2. Color coded background and formatted as shown in Figure 7.1

2. TITLE SHEET (HARDCOPY)
- 2.1. A copy of the Report Cover formatted as shown in Figure 7.1 and printed on plain white paper and containing the P.E. Stamp with the signature of the Engineer.

3. INDEX (HARDCOPY)
- 3.1. Index of sections outlined with page numbers.

4. SUMMARY OF BRIDGE RATING (HARDCOPY)
- 4.1. P.E. Stamp with signature of the Engineer shall be placed here.
- 4.2. Tabular listing of the controlling rating values from the Rating Report. Item 66 shall not be lower than Item 64.
- 4.3. Formatted as shown in Figure 7.2A or 7.2B for all structures.

5. BREAKDOWN OF BRIDGE RATING (HARDCOPY – printed double sided)
- 5.1. Tabular listing of all bridge elements that must be rated to determine the rating of the bridge and at all critical locations as described in Subsection 7.2.2. All ratings below statutory should be highlighted. The controlling rating cell shall be shaded with the appropriate color and the text shall be bold. For legibility, the font color for green ("Spring" crayon color used for the shading in the figures) and red shading should be white. All of the boxes in the rating breakdown table should be filled in. Elements that do not require a rating should be noted as N/A.
- 5.2. Formatted as shown in Figures 7.3A, 7.4A, 7.5A or 73.B, 7.4B, 7.5B.

6. LOCATION MAP (HARDCOPY)
- 6.1. The location map shall be in color and provide sufficient landmarks and adjacent highway information to allow the user to find the bridge in the field without additional information. Satellite or aerial photographs are not acceptable substitutes.

7. DESCRIPTION OF BRIDGE (HARDCOPY)
- 7.1. Formatted as shown in Figure 7.6

8. RATING ANALYSIS ASSUMPTIONS AND CRITERIA (HARDCOPY)

8.1. Description of all methods, assumptions, allowable stresses, and strengths used to determine the rating of the structure, including computer programs, with version or release numbers utilized.

8.2. Statement of the applicability of the substructure to the rating.

9. EVALUATION OF RATING AND RECOMMENDATIONS (HARDCOPY)

9.1. Summary of controlling elements of the structure and recommendations to either improve or maintain the condition of the structure as described in Subsection 7.2.9.

10. AVAILABLE PLANS AND INSPECTION REPORTS (HARDCOPY)

10.1. Listing of all plans, latest inspection report(s) used and their sources that were available to the rating engineer for the purpose of preparing the Rating Report.

11. TRUCK LOADINGS (HARDCOPY)

11.1. Standard diagrams of H20, Type 3, Type 3S2, and HL-93 or HS20 Vehicles showing axle weights and spacing as shown in Figures 7.7A, 7.8A or 7.7B.

12. APPENDIX A - INSPECTION REPORTS (HARDCOPY)

12.1. Inspection Reports including structure inventory and appraisal (SI&A), structures inspection field report and field notes. The first sheet shall be the latest SI&A sheet. Inspection Reports must be the latest available Routine and Special Member at the time the Rating Report is submitted and shall include color reproductions of all inspection report photos.

13. APPENDIX B - PHOTOS (HARDCOPY)

13.1. An abundant number of color photographs of the structure, each no smaller than 3" by 5", including both elevation views, views of both approaches, framing views (if it varies, one of each type) and sufficient critical member photos shall be provided to adequately display the current condition of the structure. An index of all photos shall precede the photos.

14. APPENDIX C - COMPUTATIONS

14.1. The Standard Statement of Concurrence of the independent reviewer (see Subsection 7.4.3) **(HARDCOPY)**

14.2. Tabular summary of all non-composite dead loads, composite dead loads, and live load distribution factors, etc., per beam. **(HARDCOPY)**

14.3. All hand calculations and computer aided calculations prepared as specified in Subsection 7.4.1 along with an index.

15. APPENDIX D - COMPUTER INPUT AND OUTPUT

15.1. Copies of all input and output summary pages, including software generated sketches from computer programs used in rating the structure shall be submitted sized for printing on 8½" x 11" sheets. **(HARDCOPY)**

15.2. A summary sheet of all rating factors and rating values for each structure's particular elements shall be created and placed in front of each output of each particular element.

16. APPENDIX E - OLD RATING REPORT REFERENCE (HARDCOPY)

16.1 Copies of Sections 2, 4, 6, 7, 8, 9 and 10, as identified above, from the previous rating report shall be included in this Appendix for reference. If the previous Rating Report does not have all of these sections as numbered above, then the Rating Engineer shall provide those pages that best fit the description of these sections.

7.6 AVAILABLE PLANS

7.6.1.1 Copies of all plans that were made available to the Rating Engineer and used in the preparation of the Rating Report shall be included in this folder. If the plans were provided in file formats other than PDF, the Rating Engineer shall convert them to PDF format prior to inclusion in this folder. Preferably, each sheet in the plan set shall be an individual file.

7.6.1.2 Organization. Each set of plans shall be placed in a separate folder. The name of the folder shall be the date the plans were advertised for construction, or if this is not available, then the latest date provided on the plans. These individual folders shall be placed in the main BRIDGE PLANS folder on the CD.

BRIDGE RATING

Prepared For

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

DANA-PRESCOTT

MAIN STREET

OVER

SWIFT RIVER

BRIDGE NO. D-02-033=P-15-015(BG1)

STRUCTURE NO. D02033-BG1-DOT-NBI

DATE OF INSPECTION
DATE OF RATING

PREPARED BY

"Consultant Name & Address"
"P.E. Stamp with Signature"

FIGURE 7.1

SUMMARY OF BRIDGE RATING

TOWN/CITY: DANA-PRESCOTT BRIDGE NO.: D-02-033=P-15-015

CARRIES: MAIN STREET OVER: SWIFT RIVER

STRUCTURE NO. D02033-BG1-DOT-NBI BIN NO.: BG1

RATINGS (TONS)

LRFR RATINGS FOR LOAD POSTING PURPOSES LOAD RATINGS IN ENGLISH TONS		
VEHICLE TYPE	INVENTORY	OPERATING
H20	48.6	63.2
TYPE 3	48.8	63.4
TYPE 3S2	54.0	70.2

THE LOAD AND RESISTANCE RATING FACTORS PROVIDED IN COMPLIANCE WITH THE FHWA NBIS CODING GUIDE	
INVENTORY	OPERATING
ITEM 66	ITEM 64
4.8	6.2

Consultant P.E. Stamp

A posting recommendation has been made based on the results of this Rating Report. This recommendation is contained in the "Memorandum to the NBIS File" for this bridge, dated _____.

_____

State Bridge Engineer Date

FIGURE 7.2A

SUMMARY OF BRIDGE RATING

TOWN/CITY: DANA-PRESCOTT BRIDGE NO.: D-02-033=P-15-015

CARRIES: MAIN STREET OVER: SWIFT RIVER

STRUCTURE NO. D02033-BG1-DOT-NBI BIN NO.: BG1

RATINGS (TONS)

ALLOWABLE STRESS RATINGS FOR LOAD POSTING PURPOSES LOAD RATINGS IN ENGLISH TONS		
VEHICLE TYPE	INVENTORY	OPERATING
H20	32.4	72.2
TYPE 3	32.5	73.3
TYPE 3S2	36.0	81.4
HS20	32.8	73.8

MS18 LOAD FACTOR RATING IN METRIC TONS PROVIDED IN COMPLIANCE WITH DECEMBER 1995 FHWA NBIS CODING GUIDE			
INVENTORY		OPERATING	
ITEM 66	MS Equivalent	ITEM 64	MS Equivalent
46.5	MS25.8	78.1	MS43.4

A posting recommendation has been made based on the results of this Rating Report. This recommendation is contained in the "Memorandum to the NBIS File" for this bridge, dated _____.

Consultant P.E. Stamp

_____

State Bridge Engineer Date

FIGURE 7.2B

BREAKDOWN OF BRIDGE RATING

TOWN/CITY: DANA-PRESCOTT BRIDGE NO.: D-02-033=P-15-015

CARRIES: MAIN STREET OVER: SWIFT RIVER

STRUCTURE NO. D02033-BG1-DOT-NBI BIN NO.: BG1

BRIDGE ELEMENT	INVENTORY RATING BY LRFR METHOD			OPERATING RATING BY LRFR METHOD		
	H20	TYPE 3	TYPE 3S2	H20	TYPE 3	TYPE 3S2
EXTERIOR BEAMS: MIDSPAN	55.5	60.0	65.9	72.2	78.0	85.6
EXTERIOR BEAMS: BOTTOM PLATE TRANSITION AT X = 20’-0 1/4”	59.1	56.7	63.8	76.8	73.7	82.9
EXTERIOR BEAMS: BOTTOM PLATE AND TOP PLATE TRANSITION AT X = 30’6 1/4”	53.7	56.3	63.8	69.8	73.1	82.9
INTERIOR BEAMS: MIDSPAN	55.2	57.8	65.4	71.8	75.1	85.0
INTERIOR BEAMS: BOTTOM PLATE TRANSITION AT X = 21’-3 1/4”	50.4	**48.8**	**54.0**	65.5	**63.4**	**70.2**
INTERIOR BEAMS: WEB PLATE TRANSITION AT X = 29’-0 1/4”	54.9	57.8	65.4	71.4	75.1	85.0
INTERIOR BEAMS: BOTTOM PLATE AND TOP PLATE TRANSITION AT X = 32’-0 1/4”	**48.6**	50.3	56.7	**63.2**	65.3	73.7

FIGURE 7.3A

BREAKDOWN OF BRIDGE RATING

TOWN/CITY: DANA-PRESCOTT BRIDGE NO.: D-02-033=P-15-015

CARRIES: MAIN STREET OVER: SWIFT RIVER

STRUCTURE NO. D02033-BG1-DOT-NBI BIN NO.: BG1

BRIDGE ELEMENT	INVENTORY RATING BY WORKING STRESS METHOD				OPERATING RATING BY WORKING STRESS METHOD			
	H20	TYPE 3	TYPE 3S2	HS20	H20	TYPE 3	TYPE 3S2	HS20
EXTERIOR BEAMS: MIDSPAN	37.0	40.0	43.9	40.0	81.8	85.8	97.2	88.2
EXTERIOR BEAMS: BOTTOM PLATE TRANSITION AT X = 20'-0 1/4"	39.4	37.8	42.5	38.5	87.2	83.5	93.6	85.0
EXTERIOR BEAMS: BOTTOM PLATE AND TOP PLATE TRANSITION AT X = 30'6 1/4"	35.8	37.5	42.5	38.5	79.8	83.8	94.3	85.7
INTERIOR BEAMS: MIDSPAN	36.8	38.5	43.6	39.6	78.2	81.8	92.9	84.2
INTERIOR BEAMS: BOTTOM PLATE TRANSITION AT X -= 21'-3 1/4"	33.6	32.5	36.0	32.8	76.0	73.3	81.4	73.8
INTERIOR BEAMS: WEB PLATE TRANSITION AT X = 29'-0 1/4"	36.6	38.5	43.6	39.2	77.4	81.3	91.8	82.8
INTERIOR BEAMS: BOTTOM PLATE AND TOP PLATE TRANSITION AT X = 32'-0 1/4"	32.4	33.5	37.8	34.2	72.2	75.0	84.2	76.7

FIGURE 7.3B

BREAKDOWN OF BRIDGE RATING

TOWN/CITY: DANA-PRESCOTT BRIDGE NO.: D-02-033=P-15-015

CARRIES: MAIN STREET OVER: SWIFT RIVER

STRUCTURE NO. D02033-BG1-DOT-NBI BIN NO.: BG1

BRIDGE COMPONENT	INVENTORY LRFR RATING FACTORS		OPERATING LRFR RATING FACTORS	
	HL-93 TRUCK & LANE LOAD	HL-93 TANDEM & LANE LOAD	HL-93 TRUCK & LANE LOAD	HL-93 TANDEM & LANE LOAD
Exterior Beam at .5L	8.2	**4.8**	10.6	**6.2**
First Interior Beam @ .5L	**7.6**	4.9	**9.9**	6.4
Interior Beam @ .5L	7.9	5.1	10.2	6.6

FIGURE 7.4A

BREAKDOWN OF BRIDGE RATING

TOWN/CITY: DANA-PRESCOTT BRIDGE NO.: D-02-033=P-15-015

CARRIES: MAIN STREET OVER: SWIFT RIVER

STRUCTURE NO. D02033-BG1-DOT-NBI BIN NO.: BG1

BRIDGE ELEMENT	INVENTORY RATING BY LOAD FACTOR METHOD (METRIC TONS)		OPERATING RATING BY LOAD FACTOR METHOD (METRIC TONS)	
	MS18	MS (EQUIV.)	MS18	MS (EQUIV.)
Exterior Beam at .5L	55.4	MS30.8	83.3	MS46.3
First Interior Beam @ .5L	**46.5**	**MS25.8**	**78.1**	**MS43.4**
Interior Beam @ .5L	47.6	MS26.5	79.7	MS44.3

FIGURE 7.4B

BREAKDOWN OF BRIDGE RATING

TOWN/CITY: DANA-PRESCOTT BRIDGE NO.: D-02-033=P-15-015

CARRIES: MAIN STREET OVER: SWIFT RIVER

STRUCTURE NO. D02033-BG1-DOT-NBI BIN NO.: BG1

BRIDGE ELEMENT	INVENTORY LRFR RATING (ENGLISH TONS)			OPERATING LRFR RATING (ENGLISH TONS)		
	H20	TYPE 3	TYPE 3S2	H20	TYPE 3	TYPE 3S2
Interior Beam – Type A Serviceability – Concrete Tension @ 0.50L	54.6	65.3	103.7	N/A	N/A	N/A
Interior Beam - Type A Flexural Strength – 0.5L	39.5	47.4	75.0	51.3	61.6	97.5
Interior Beam – #5 - Serviceability - Concrete Tension @ 0.50*L	37.2	44.7	70.8	N/A	N/A	N/A
Interior Beam – #5 – Flexural Strength @ 0.50*L	28.2	33.9	53.6	36.7	44.1	69.6
Interior Beam – #6 – Serviceability -Concrete Tension @ 0.50*L	30.6	36.5	57.8	N/A	N/A	N/A
Interior Beam – #6 - Flexural Strength @ 0.50*L	**23.7**	**28.5**	**45.2**	**30.8**	**37.1**	**58.7**

Figure 7.5A
(PRESTRESSED CONCRETE EXAMPLE)

BREAKDOWN OF BRIDGE RATING

TOWN/CITY: DANA-PRESCOTT BRIDGE NO.: D-02-033=P-15-015

CARRIES: MAIN STREET OVER: SWIFT RIVER

STRUCTURE NO. D02033-BG1-DOT-NBI BIN NO.: BG1

BRIDGE ELEMENT	INVENTORY RATING (ENGLISH TONS)				OPERATING RATING (ENGLISH TONS)			
	H20	TYPE 3	TYPE 3S2	HS20	H20	TYPE 3	TYPE 3S2	HS20
Interior Beam – Type A Serviceability – Concrete Tension @ 0.50L	36.4	43.5	69.1	48.2	N/A	N/A	N/A	N/A
Interior Beam - Type A Flexural Strength – 0.5L	26.3	31.6	50.0	34.9	44.0	52.7	83.4	58.3
Interior Beam – #5 - Serviceability - Concrete Tension @ 0.50*L	24.8	29.8	47.2	32.8	N/A	N/A	N/A	N/A
Interior Beam – #5 – Flexural Strength @ 0.50*L	18.8	22.6	35.7	24.9	31.4	37.7	59.6	41.6
Interior Beam – #6 – Serviceability - Concrete Tension @ 0.50*L	20.4	24.3	38.5	27.0	N/A	N/A	N/A	N/A
Interior Beam – #6 - Flexural Strength @ 0.50*L	**15.8**	**19.0**	**30.1**	**21.0**	**26.5**	**31.7**	**50.2**	**37.8**

FIGURE 7.5B
(PRESTRESSED CONCRETE EXAMPLE)

DESCRIPTION OF BRIDGE

DANA-PRESCOTT MAIN STREET / SWIFT RIVER BRIDGE NO. D-02-033=P-15-015

Date of Construction:	2009
Original Design Loading:	HL-93
Posted Limit:	None
Bridge Type:	Plate girders with composite reinforced concrete deck
Skew:	40°-16'-2"
Spans:	1 simple span, 131'-0"
Width of Bridge Deck:	48'-6" out-to-out
Roadway Width:	40'-0" curb-to-curb
Roadway Surface:	3" bituminous concrete
Curbs:	Concrete curb both sides
Sidewalk/Walkway/Median:	1 – 5'-6" sidewalk, 1 – 19.5" safety curb
Bridge Railing:	S3-TL4 metal bridge rail
Approach Railing:	Type SS highway guard (all four corners)
Superstructure:	6 plate girders @ 8-6" spacing with 8" thick composite reinforced concrete deck
Modifications to Original Superstructure:	None
Utilities:	None
Substructure:	Two stub type abutments with adjoining gravity U-wingwalls
Modifications to Original Substructure:	None

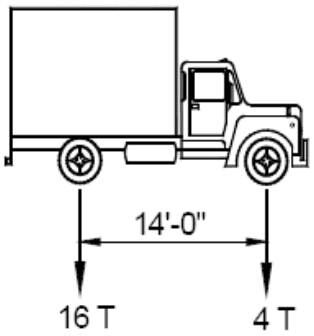
FIGURE 7.6

LOADINGS USED FOR BRIDGE RATING

DANA-PRESCOTT MAIN STREET / SWIFT RIVER BRIDGE NO. D-02-033=P-15-015

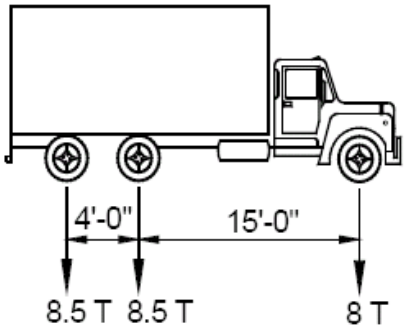
H20 VEHICLE

TOTAL WEIGHT
20 TONS



TYPE 3 VEHICLE

TOTAL WEIGHT
25 TONS



TYPE 3S2 VEHICLE

TOTAL WEIGHT
36 TONS

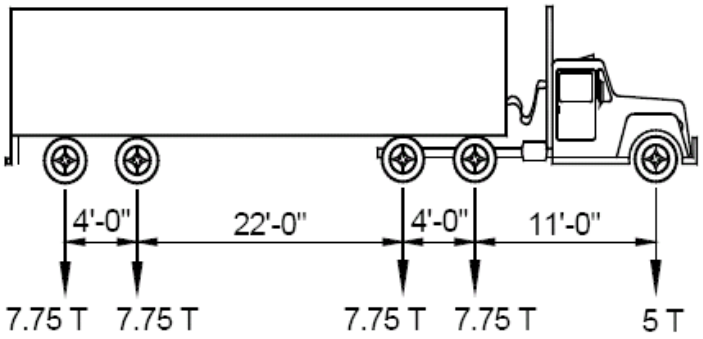


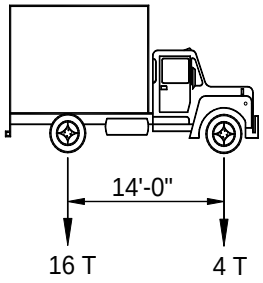
FIGURE 7.7A

LOADINGS USED FOR BRIDGE RATING

ANYCITY=ANYTOWN MAIN STREET / BIG RIVER BRIDGE NO. A-12-345=A-67-890

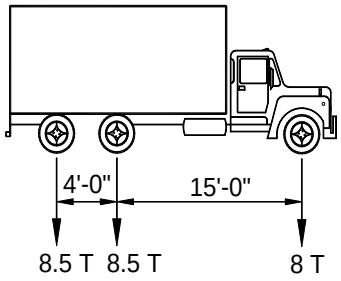
H20 VEHICLE

TOTAL WEIGHT
20 TONS



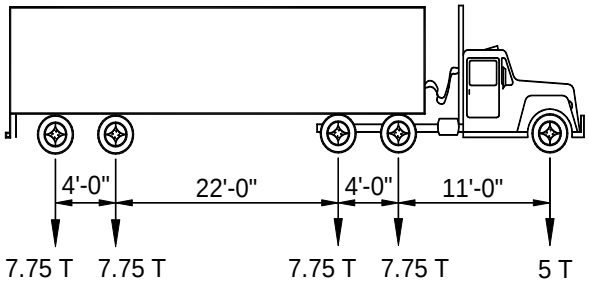
TYPE 3 VEHICLE

TOTAL WEIGHT
25 TONS



TYPE 3S2 VEHICLE

TOTAL WEIGHT
36 TONS



HS20 VEHICLE

TOTAL WEIGHT
36 TONS

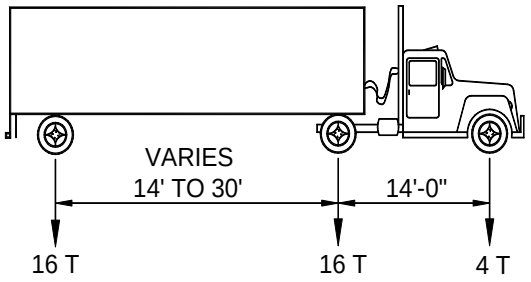
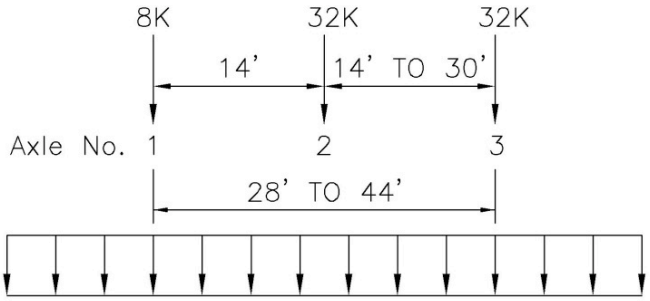


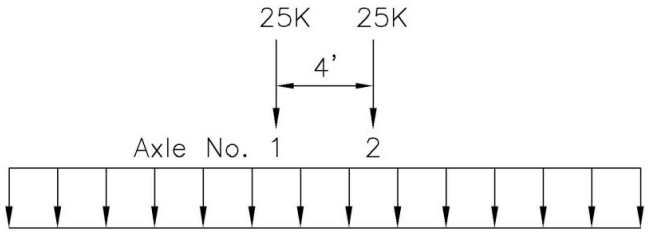
FIGURE 7.7B

HL-93 LOADING

Indicated Concentrations are Axle Loads in Kips



HL-93 Truck = 72 Kips (36 Tons)
HL-93 Lane Load = 0.64 klf



HL-93 Tandem = 50 Kips (25 tons)
HL-93 Lane Load = 0.64 klf

Additional Load Model for Negative Moment and Interior Reaction
(Reduce all Loads to 90%)
Design Lane Load = 0.64 klf

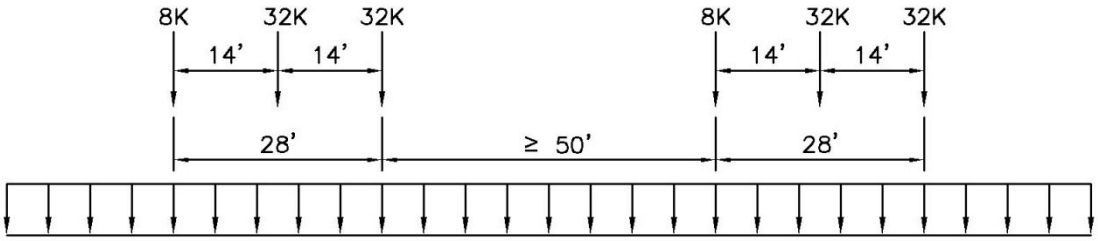


FIGURE 7.8A