NEW JERSEY TURNPIKE AUTHORITY
GARDEN STATE PARKWAY
NEW JERSEY TURNPIKE

LOAD RATING MANUAL

LRFR METHODOLOGY

Version 9.6

December 2020

PREPARED BY

HNTB

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SUMMARY OF VERSION 9.6 REVISIONS (DECEMBER 2020)

The NJTA LRFR Load Rating Manual, LRFR Methodology, Version 9.5, October 2019 has been updated to Version 9.6 in December 2020. The major changes to the Manual are as follows:

- Updated Section 2.2a (Qualifications and Responsibilities) regarding the discontinuation of NHI's 2-day LRFR refresher courses
- Updated Section 2.4 to specify dead load distribution for the outside three roadway stringers since this information was previously removed from the Authority's Design Manual
- Clarified Section 3.1.3 (Truck Traffic Conditions at Bridge Site) by reordering the existing instructions and adding a table explaining when to use various ADTT sources
- Updated Figures 4.2-3a and 4.2-3b (InspectTech LRSS for Typical Structures) based on updated versions of the Load Rating Summary and Load Rating Member Summary IT forms
- Updated Section 4.3 (Quality Control and Quality Assurance Review of Load Ratings) regarding the new QCF-3 Consultant Load Rating Checklist
- Updated Section 4.4 (Requirements for Load Rating of New or Rehabilitated Structures) to require the Design Engineer to perform both As-Designed and As-Built load ratings
- Removed Figure 4.4 (BrR Section Loss Forms); see Appendix A5 for the new section loss documentation procedure
- Added Questions #24 and #25 (Appendix A2) regarding adding the NJ Type 3S2 vehicle to the BRASS-Girder vehicle library and rating update needs for slab structures, respectively
- Added new Appendix A5 (Section Loss Workbook) which includes detailed guidance on the new Section Loss Workbook (SLW) procedure

Please review the entire Load Rating Manual for additional revisions not listed above but included as part of the Version 9.6 revisions.

SUMMARY OF VERSION 9.5 REVISIONS (OCTOBER 2019)

The NJTA LRFR Load Rating Manual, LRFR Methodology, Version 9.4, October 2018 has been updated to Version 9.5 in October 2019. The major changes to the Manual are as follows:

- Updated Section 2.6 (Reporting LRFR Values to the NBI) to specify the Authority's policy regarding reporting load ratings based on limit state
- Added new Section 2.7 (Engineering Judgment Rating) regarding engineering judgment ratings
- Updated Section 3.1.2 (Bridge Inspection for Load Rating) to highlight the importance of identifying steel beam corrosion near bearing areas when performing inspections; also provided guidance regarding prestressed concrete beams with exposed strands or cosmetic spall repairs
- Added new Figure 1 to Section 3.2.2 which includes the HL-93 design vehicle schematics
- Updated Sections 4.1 (Load Rating Report) and 4.2 (Load Rating Summary Sheets) to clarify proper usage of the load rating summary sheet (InspectTech vs Excel) and summary of updates
- Updated Section 4.1.4 (Interpretation of Rating Results and Low Ratings) to include discussion of member-by-member condition factor application
- Updated Section 4.4 (Requirements for Load Rating of New or Rehabilitated Structures) by adding an updated rating factor table which clarifies the contents of the table and recommended notes
- Updated Section 5.6.1 (Live Load Distribution) regarding load ratings for culverts under significant fill (> 8 feet)
- Updated Appendix A1 (AASHTOWare BrR Guidelines for LRFR Ratings) regarding the analysis engine options in Version 6.8.3
- Added Question #23 (Appendix A2) relating to the application of the condition factor in the load rating

Please review the entire Load Rating Manual for additional revisions not listed above but included as part of the Version 9.5 revisions.

SUMMARY OF VERSION 9.4 REVISIONS (OCTOBER 2018)

The NJTA LRFR Load Rating Manual, LRFR Methodology, Version 9.3, September 2017 has been updated to Version 9.4 in October 2018. The major changes to the Manual are as follows:

- Updated Section 2.1.2 (Existing Bridges) regarding the Summary of Updates, and also clarified the expected deliverable when performing load rating updates
- Figures 4.2-1, 4.2-2, and 4.3 have been updated
- Added new Section 3.2.7 (Legal Load Rating for Emergency Vehicles), added new Figure 3.2.7, and modified Section 4.1.4 regarding emergency vehicle load ratings
- Updated Section 3.5.2 (Concrete Bridges) and added Question #21 (Appendix A2) relating to the Service III limit state check when performing legal load ratings of prestressed concrete beams
- Updated Section 4.2 (Load Rating Summary Sheet) to identify the recent creation of InspectTech forms to be used for input of load rating data, as well as automatic generation of the load rating summary sheet (by InspectTech)
- Updated Section 4.4 (Requirements for Load Rating of New or Rehabilitated Structures) to require the use of 33% dynamic load allowance for all vehicles when performing a design rating
- Added new Appendix A4 (Emergency Vehicle Ratings) which includes detailed guidance for performing Emergency Vehicle ratings using BrR
- Made minor revisions and enhancements to all three appendices (A1, A2, A3)

Please review the entire Load Rating Manual for additional revisions not listed above but included as part of the Version 9.4 revisions.

SUMMARY OF VERSION 9.3 REVISIONS (SEPTEMBER 2017)

The NJTA LRFR Load Rating Manual, LRFR Methodology, Version 9.2, December 2016 has been updated to Version 9.3 in September 2017. These updates include, but are not limited to, the following changes to the Manual:

- Added reference to the required section loss sheets in Section 2.1.3 (Member Deterioration), Section 3.1.2 (Bridge Inspection for Load Rating), and Section 4.1 (Load Rating Report), and also mentioned the optional BrR Section Loss Forms available for use
- Added Figure 4.4 which shows the BrR Section Loss Forms
- Clarified the proper date to be used when copying and reusing previously created load rating summary sheets in bridge inspection reports in Section 4.1.1 (Load Rating Report Deliverables)
- Added discussion in Sections 3.2.2 (Design Load Rating for HL-93 Loading) and 4.4 (Requirements of Load Rating for New or Rehabilitated Structures) regarding As-Designed ratings and the new requirement for these ratings to also include Authority-specific design vehicles as specified in the NJTA Design Manual (Structures Design)
- Added specific direction regarding file naming for As-Designed load ratings in Section 4.1.2 (File Naming)
- Made minor revisions and enhancements to all three appendices (A1, A2, A3)

Please review the entire Load Rating Manual for revisions not listed above but included as part of the Version 9.3 revisions.

SECTION 1 INTRODUCTION AND GENERAL OVERVIEW

1.1 Introduction

Bridge load rating is the determination of the live load carrying capacity of a newly designed or existing bridge. Load ratings are typically determined by analytical methods based on information taken from bridge plans supplemented by information gathered from field inspections or field testing. Knowledge of the capacity of each bridge to carry loads is critical for several reasons, including (but not limited to) the following:

- To determine which structures, have substandard load capacities that may require posting or other remedial action.
- To assist in the most effective use of available resources for rehabilitation or replacement.
- To assist in the overload permit review process.
- To satisfy FHWA requirements for submitting load ratings. The NBIS (Title 23, Code of Federal Regulations, Section 650.313 (c)), requires that load ratings be in accordance with the latest AASHTO Manual. The results are used in conjunction with other bridge inventory and inspection information to determine the Federal Bridge Sufficiency Rating.

1.2 Purpose of this Document

This document has primarily been based upon the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Bridge Evaluation*, Third Edition, including 2019 Interims, hereinafter referred to as the MBE. This document provides guidance to engineers for performing and submitting load rating calculations using the Load and Resistance Factor (LRFR) methodology. The procedures stated in this document are to provide guidelines that will result in consistent and reproducible load rating inputs and deliverables. This document serves as a supplement to the AASHTO MBE and deals primarily with New Jersey Turnpike Authority (NJTA) specific load rating requirements, interpretations, and policy decisions. While this Manual is intended to provide bridge load rating policy for work done by or for the NJTA, it does not preclude justifiable exceptions, subject to the approval of the NJTA. This Manual is a living document in that changes will be issued as warranted because of changes in policy, loadings, or evaluation criteria.

1.3 Load and Resistance Factor Rating Methodology

Load and Resistance Factor Rating is consistent with the LRFD Specifications in using a reliability-based limit states philosophy and extends the provisions of the LRFD Specifications to the areas of inspection, load rating, posting and permit rules, fatigue evaluation, and load testing of existing bridges. The LRFR methodology has been developed to provide uniform reliability in bridge load ratings, load postings and permit decisions. The LRFR procedures provide live load factors for load rating that have been calibrated to provide a uniform and acceptable level of reliability.

SECTION 2 GENERAL LOAD RATING REQUIREMENTS

2.1 Load Rating Requirements

2.1.1 New or Reconstructed Bridges

Load ratings by the LRFR method, for the live load models defined in Section 3.2 of this document, are required for all new and replacement bridges, and for all rehabilitation and repair designs involving a substantial structural alteration. LRFR load rating calculations shall be performed as part of the design process and reflect the bridge's As-Built or As-Rehabilitated condition. When ratings are initially performed in conjunction with the preparation of design drawings, the As-Designed load rating results shall be shown on the structural drawings following the structural notes for all new, replaced and rehabilitated bridge projects in accordance with Section 4.4 of this document. Load rating shall not include the future wearing surface as a dead load because it is not part of the as-built condition. The Load Rating Summary Sheet and all electronic files for use in future re-analyses shall be created by the Design Engineer and provided to the NJTA in accordance with the requirements of Section 2.4 of this document. Input files shall be created using AASHTOWare's Bridge Rating Software (BrR) (See Appendix A1 for current version) unless the structure cannot be modeled using BrR, such as complex curved girder structures or other unique structure types.

It is also required that the live load distribution factors used in the design and initial load rating for structures not originally designed using line girder methodology and which cannot be modeled using BrR be noted on the structural drawings.

Ratings performed using the latest version of BrR shall utilize the most current version of the LRFD specifications (See Appendix A1). If rating results based on the latest version of BrR differ from those based on the LRFD specifications at the time of original design, with approval of the Authority, ratings using BrR and the LRFD design specifications may be used.

2.1.2 Existing Bridges

The engineer shall assess the bridge after each inspection to see if a re-analysis is required. Load ratings are typically updated if there is a change in condition or loading of the structure or when the structure is being rehabilitated or replaced. For all bridges previously rated using load and resistance factor methodology, the biennial bridge inspection consultant shall adhere to the requirements identified in Appendix A3 (Load Rating Updates of Existing Structures Previously Rated using LRFR Methodology) for load rating updates.

In general terms, a re-rating would usually be necessary if any of the following have occurred since the last load rating was completed:

- The primary member general condition rating has changed
- Dead load has changed due to resurfacing or other non-structural alterations
- Section properties of controlling or non-controlling members have changed due to deterioration, rehabilitation, re-decking or other alterations
- Damage due to vessel or vehicular hits
- Cracking in primary members
- Losses at critical connections
- Significant changes in truck traffic volume used for selecting the live load factor
- Rating specification changes
- An increase in the surface roughness rating (worsened rideability)
- Review of previous load ratings reveals significant errors or inaccuracies

If a structure is found to require load rating updates per Appendix A3, the load rating consultant shall first contact the Authority Liaison prior to commencing with load rating updates. Load rating updates should not be commenced without prior approval from the Authority.

When approved, all existing bridge load rating updates shall be performed using LRFR in accordance with the requirements of this Manual and the MBE. During these updates, the consultant shall review the previous load rating calculations and bridge model files to ensure accuracy. Once updates are performed, the consultant performing these updates shall be fully responsible for the correctness of the complete load rating submission. Refer to Section 3.1.5 for proper span and member numbering during load rating updates.

It is also recommended to include previous load rating report documents in an appendix within the load rating report pdf, for quick access and clarity between previous work and current updates. If the previous consultant's working files are updated (i.e., Excel), some method of identification should be used to allow for clear identification of each firm's work.

For load rating updates of previously load rated structures, a Summary of Updates shall be created, which lists all updates made to the load rating calculations and/or load rating software files. The field titled "Primary Reason(s) for Load Rating Updates" shall be completed by listing one (or more) of the seven bulleted items on the first page of Appendix A3. This summary shall be included in the load rating report immediately following the Load Rating Summary Sheet, it shall clearly identify all changes made to the load rating since the previous load rating (See Example, Figure 4.3), and it shall be prepared in accordance with Section 4.3 of this Manual. Each time load rating updates are performed for a given bridge, a separate Summary of Updates sheet should be created which includes only those updates performed. The Summary of Updates sheet shall also be dated.

2.1.3 Member Deterioration

Load ratings or load rating updates should consider both As-Built and As-Inspected conditions during the analysis. Often, there is no significant deterioration which would affect the ratings, in which case the As-Built member section would be the same as the As-Inspected member section.

For cases where there is member deterioration, it shall be considered in the load rating for the As-Inspected condition (See Section 3.1.2). Refer to Appendix A1 for specific modeling directions and requirements regarding As-Inspected ratings using BrR. Member deterioration that could have an effect on the load rating shall be documented in accordance with the Authority's Section Loss Workbook procedure. Refer to Appendix A5 for specific directions and requirements regarding the Section Loss Workbook procedure. Note that the load rating engineer is expected to use the existing load rating files for all re-rating efforts. All modifications and corrections to the existing files, if any, shall be listed on the Summary of Updates sheet, as discussed in Sections 2.1.2 and 4.1.1. In addition, performance of load rating updates shall also be noted on the Load Rating Summary Sheet (See Section 4.2). The required section loss documentation, as discussed in Section 4.1, shall also be utilized and included in the load rating report.

2.2 Qualifications and Responsibilities

The engineering expertise necessary to properly evaluate a bridge varies widely with the complexity of the bridge. Evaluation in accordance with the MBE shall be performed and checked by suitably qualified engineers in the type of bridges being load rated. At a minimum, the load rating team shall consist of a Load Rating Engineer (LRE) and a Load Rating Reviewer (LRR). The LRE is responsible for performing load ratings in accordance with this manual, as well as the AASHTO LRFD Bridge Design Specifications (current version) and Manual for Bridge Evaluation (current version), as needed. The LRR is responsible for independently checking the load rating calculations using sound engineering judgment, and signing, dating and sealing the Load Rating Summary Sheet. Assistance in performing the load ratings may be provided by engineers other than the LRE or LRR, however, all load rating work shall be reviewed by the LRR. It is expected that the LRE and LRR will have a working knowledge of the LRFD Specifications. Specific qualifications for the LRE and LRR are as follows:

a. The LRE and LRR shall each (1) possess a minimum of five years of bridge design and/or load rating experience; (2) demonstrate a working knowledge of LRFD Specifications and the NJTA Load Rating Manual; (3) have successfully completed NHI Course No. 130092 Load and Resistance Factor Rating of Highway Bridges (4 days); and (4) successfully complete NHI Course No. 130092 (4 days) every five years following the initial 4 day course.
b. The LRR shall be a Licensed Professional Engineer registered in the State of New Jersey, and shall sign, date, and seal the Load Rating Summary Sheet, as shown in Section 4.2 of this Manual.

The above noted qualifications apply to all load ratings being created or updated under bridge inspection assignments, and also apply to design assignments involving new construction or bridge rehabilitation.

The Authority's Load Rating Representative shall possess the same qualifications as specified for the Load Rating Reviewer.

2.3 Elements to be Load Rated

Load rating will include analysis of the following items:

- All elements defined as "primary members"
- Capacity of gusset plates and connection elements for non-redundant steel truss bridges
- Other connections of non-redundant systems (e.g., floorbeam connections, pin and hanger assemblies)
- Non-redundant steel pier caps
- Other substructure elements on an as-needed basis, as directed by the Authority

For ratings performed using AASHTOWare's Bridge Rating (BrR) software, the entire bridge superstructure shall be rated as a girder system which includes rating of all girders.

2.4 Analysis Methods and Rating Software

Where applicable, bridges shall be rated in accordance with the LRFD live load distribution factors. Where LRFD distribution methods are not applicable, refined methods of analysis should be considered. Refined methods of analysis are also justified where needed to avoid load restrictions. Refined analysis shall not be undertaken without the prior approval of the NJTA.

Standard analysis tools applicable to the NJTA bridge inventory can maximize efficiency, provide consistency, and also facilitate future revisions of load ratings by different parties. To this end, NJTA has specified BrR (See Appendix A for current version) as the primary load rating software to be used. During initial rating of a bridge, if it is capable of being defined within the parameters of the BrR software, it must be rated using BrR. Please refer to Appendix A of this document for guidelines regarding creation of the BrR .xml file, reference to past questions raised during the load rating process, as well as corresponding answers to these questions. This Appendix should be reviewed prior to performing any load ratings.

Structures that cannot be modeled in BrR shall be analyzed using BRASS-Girder (LRFD), STAAD, GTStrudl, CSiBridge, Descus, MDX, or PCAColumn and load rated in accordance with the requirements of this Manual. See the following list for clarification regarding the selection of proper load rating software for various structure types.

<u>Superstructure Type and Required Load Rating Software</u>

- Multi-stringer / multi-girder (steel or concrete) – BrR
- Reinforced Concrete Beams – BrR
- Reinforced Concrete Slabs – BrR
- Prestressed Concrete I-beams or Box Beams – BrR
- Girder / Floorbeam / Stringer Systems – Stringers (BrR), Floorbeams (BrR or BRASS), Girders (BrR or BRASS)
- Curved Girders – BrR, Descus, MDX, or Influence Lines from Original Design
- Transverse Steel I-Girders – BRASS
- Transverse Steel Box Girders – Spreadsheet Tool

- Reinforced Concrete Box Culverts (with or without a bottom slab) – BrR

Unique, complex structures which cannot be modeled as noted above shall be modeled using CSiBridge, STAAD, GTStrudl, or other approved software. The load rating engineer shall utilize one of these programs to model the structure and obtain the required live load and dead load effects. Actual LRFR rating calculations must be performed via a spreadsheet tool (Microsoft Excel required). This spreadsheet tool should be clearly documented to facilitate future updates if the condition of the structure changes due to section losses, structural modifications, rehabilitations, etc. Below is a list of possible unique, complex structures:

Unique, Complex Structure Types (to be load rated using CSiBridge, STAAD, GTStrudl, SAP, or other approved software)

- Trusses
- Post-Tensioned members (steel and concrete)
- Other

The following structure types currently do not need to be rated using LRFR methodology:

- Pedestrian Bridges
- Structures Carrying Rail Traffic

Approval shall first be obtained from NJTA prior to moving forward with the use of any type of rating software when initially load rating and modeling the structure. A copy of the computer models, load rating documentation, and referenced plans shall be submitted to NJTA (See Section 4.1). When performing load rating updates, bridge models shall not be remodeled or recreated using other approved software unless approved by NJTA.

The top ½ inch of the concrete deck slab thickness shall be considered as dead load only. Curbs, parapets, railings, sidewalks, and safetywalks, if placed after the slab has cured, shall be divided between the outside three roadway stringers in the ratio of 50 percent to the outside stringer, 35 percent to the first interior stringer, and 15 percent to the second interior stringer. Where there is an open joint in a split median barrier, the dead load of the median barrier or raised median shall be distributed in the same manner as for outside roadway stringers.

2.5 Curved Girder Rating

The LRFR provisions of MBE Article 6A.6 apply to components of straight or horizontally curved I-girder bridges and straight or horizontally curved single or multiple closed-box or tub girder bridges. Recent improvements to BrR have added the capability to analyze and load rate basic curved girder structures. Existing structures capable of being load rated using BrR shall be modeled and load rated using BrR.

Existing structures which cannot currently be modeled using BrR shall be analyzed using refined methods of analysis. A 2D grid analysis would be an acceptable approach in most cases for curved girder ratings. A 3D FEM analysis may be considered for curved girders with tight radius, severe skews, or irregular framing. Load ratings of curved girder structures and cross bracing/diaphragms using finite element-based software should consider the software used during design, and, whenever possible, should also utilize that same software for load ratings. This recommendation is based on differences in the method of solution of various software packages which can lead to differences in load distribution throughout the structure.

2.6 Reporting LRFR Ratings to the NBI

All load rating data shall be reported to the NBI by the Authority's Bridge Inspection Program Technical Manager (HNTB) in accordance with the below information.

All Authority load ratings shall typically be reported to the NBI in accordance with load and resistance factor methodology. For LRFR methodology, the load rating data shall be reported to the FHWA as a Rating Factor multiplied by a factor of 100, for Structural Inventory and Appraisal (SI&A) Items 31, 63, 64, 65 and 66, using the HL-93 loadings. See the New Jersey Department of Transportation (NJDOT) Memorandum regarding Fields for Load Rating and Revised LRFR Implementation, dated January 13, 2017 for additional clarification and guidance.

For cases where load and resistance factor legal load ratings are found to be less than 1.00 for one or more State legal loads, and the structure was also designed using methodology other than LRFD, load factor ratings shall be reported to the NBI.

For cases where load and resistance factor ratings for the Service limit state are found to be less than 1.00 for one or more State legal loads, but ratings for the Strength limit state are found to be greater than 1.00 for all State legal loads, the Strength limit state ratings shall be reported. This reporting method of disregarding the low Service limit state ratings and reporting Strength limit state ratings should only be used after following the guidance outlined in Section 4.1.4 (Interpretation of Rating Results and Low Ratings) and exhausting all possible options for accurately increasing the load ratings.

2.7 Engineering Judgment Rating

Engineering Judgment (EJ) load ratings may be required when necessary bridge information or details are unavailable. When EJ load ratings are determined to be required, it is acceptable to use the New Jersey Department of Transportation's (NJDOT) latest guidance titled "Load Capacity Ratings through Engineering Judgment" (dated February 27, 2019). The Authority does not have an Agency-specific procedure regarding the performance of EJ load ratings. The performance of such ratings must be approved by the Authority prior to commencing with the rating.

SECTION 3 LOAD AND RESISTANCE FACTOR RATING GUIDELINES

3.1 Data Collection for LRFR Load Rating

3.1.1 Review of Existing Bridge Plans and Documents

As-Built plans are the contract design plans which have been modified as-required to reflect changes made during construction. As-Built plans are used to determine loads, bridge geometry, and section and material properties. Shop drawings are also useful sources of information about the bridge and are especially important when performing load ratings of prestressed concrete beams. For these member types, shop drawings should be obtained and used to verify the beam strand pattern and geometry. Other appropriate bridge history records, testing reports, or repair or rehabilitation plans shall be reviewed to determine their impact on the load carrying capacity of the structure.

3.1.2 Bridge Inspection for Load Rating

Bridges being investigated for load capacity must be inspected for condition as per the latest edition of the AASHTO MBE and the FHWA Bridge Inspector's Reference Manual. Bridge inspections are conducted to determine the physical and functional condition of the bridge and to form the basis for the evaluation and load rating of the bridge. The inspector shall verify the accuracy of existing plans or sketches in lieu of plans with field measurements. It is especially important to measure and document items that may affect the load capacity, such as dead loads and section deterioration or damage. Only sound material shall be considered in determining the nominal resistance of the deteriorated section.

Section losses shall be measured during the field inspection, not estimated by visual observations. The area, thickness, and location of section loss (within the beam cross section, and along the length of span) shall be documented. Calipers or D-meter readings shall be taken to document the remaining section. These findings have a significant influence on the section property calculations and the member resistance used for load rating.

All member deterioration that could have an effect on the load rating shall be documented in accordance with the Authority's Section Loss Workbook procedure. Specifically, a standardized Section Loss Table shall be completed which documents member deterioration as well as rating and repair recommendation decision-making. Refer to Appendix A5 for specific directions and requirements regarding the Section Loss Workbook procedure.

Based on recent inspection findings, special consideration shall be given to steel girders that exhibit significant base of web and/or bottom flange corrosion near supports, especially for rolled beams or locations with a history of cracking. Even though corrosion or cracking may not have a significant effect on the flexural or shear ratings, the web may be susceptible to collapse when subjected to substantial levels of corrosion. Closer review and/or supplemental analysis of the beam end and bearing may be warranted based on the level of corrosion and cracking.

Prestressed concrete beams which exhibit exposed prestressing strands shall be treated as follows when performing As-Inspected load ratings:

- All exposed strands located within the span (not including the "joint side" of the beam) shall be discounted when determining member capacity (regardless of condition)

Exceptions to the above guidance may occur on a case-by-case basis but should only be utilized following Authority approval.

It is also important to understand the details of any prestressed concrete beam repairs and apply them as necessary to the load rating model and associated files. For instance, cosmetic spall repairs (i.e., patches) to locations exhibiting exposed, corroded, or severed prestressing strands do not improve the superstructure condition nor overall beam capacity, and should not lead to increases in member ratings. In these cases, corroded or severed prestressing strands should continue to be reflected in the load rating model, load rating report, and section loss records.

All section loss measurements which are considered in the As-Inspected ratings shall be properly documented and included in the load rating report (See Section 4.1 for details).

Where present, utilities, attachments, depth of fill, and thickness of wearing surface shall be field verified at the time of inspection. Wearing surface thicknesses are also highly variable. Multiple measurements at curbs shall be used to determine an average wearing surface thickness. If available, wearing surface thickness determined via ground penetrating radar should be considered for use in the load rating. The load factor for DW at the strength limit state may be taken as 1.25 when the wearing surface thickness has been field measured.

3.1.3 Truck Traffic Conditions at Bridge Site

LRFR live load factors appropriate for use with legal loads are defined based upon current Average Daily Truck Traffic (ADTT) for the bridge site. See Table 1 below for a summary of ADTT sources.

For structures that carry the New Jersey Turnpike, ADTT values by class of vehicles between Turnpike interchanges are given in Table 1A and Table 1B and have been determined based upon the Authority's daily tolling records. The truck class number also denotes the number of axles. Trucks belonging to Classes 3 thru 6 are included in the total ADTT count for a site. Milepost ranges between interchanges and other points of interest have been added for ease of use. For structure numbers that serve as the boundary between interchanges and therefore are included within two rows of Table 1A or 1B, the maximum ADTT shall be used.

Tables 1A and 1B consisted of data from 2008 when first prepared as part of the earliest versions of the Authority's Load Rating Manual. Since that time, the tables have been updated annually to reflect any observed increases in truck traffic. When the truck traffic has decreased or remained the same, the existing data has been conservatively maintained in Tables 1A and 1B. Sections of the Turnpike roadway that have seen increases in total ADTT in 2019 have been shown in ***BOLD***. All load rating updates and load ratings of new construction for structures that carry the outer roadway along the New Jersey Turnpike shall utilize the data shown in Table 1A and 1B. It should be noted that prior versions of the Load Rating Manual (Versions 8 and prior) required an average increase of 1% per year be used to compute ADTT values for subsequent years. Thus, load rating updates utilizing later versions of the load rating manual may lead to a reduction in total ADTT.

For bridges located along the Newark Bay - Hudson County Extension (MP N0.16A to N7.93W) and the Pearl Harbor Memorial Turnpike Extension (MP P0.00 to P5.59E/W), consider "Northbound" per Tables 1A and 1B to be carrying eastbound traffic, and "Southbound" to be carrying westbound traffic.

Specific traffic data for structures located within interchange areas of the New Jersey Turnpike is not included in Tables 1A or 1B. As a conservative approach, the total ADTT as shown in Tables 1A or 1B may be used for load rating of these structures. However, if low legal load ratings are obtained, the load rating engineer should review the traffic patterns and consider possible reductions in the ADTT such that low legal load ratings can be eliminated. Any reductions made to the ADTT should be clearly documented within the load rating report.

ADTT for New Jersey Turnpike structures located north of mile points E117.60 or W114.00 is not included in Tables 1A or 1B, and also is not typically available using NJDOT's Straight Line Diagrams. For these structures, an ADTT value of 5000 shall be used unless a more accurate ADTT can be determined. Where legal load rating factors are less than 1.00 in this zone and where structures consist of multiple superstructure units separated by longitudinal joints in the deck, consideration may be given to reducing the ADTT used in the load rating to better represent the maximum ADTT experienced by any one superstructure unit. All assumptions and ADTT modifications should be clearly documented within the load rating report.

Inner roadway structures located along the New Jersey Turnpike and which routinely carry vehicular traffic only shall utilize an ADTT of 1000. This ADTT value considers the periodic closures of the outer roadway, which shifts all traffic (including trucks) to the inner roadway.

Structures that carry the Garden State Parkway, regardless of location, shall be assumed to carry truck traffic. Traffic data obtained for the Garden State Parkway in 2019 shows that one-way ADTT does not exceed 1000. Thus, all structures carrying Garden State Parkway mainline traffic shall utilize an ADTT of 1000.

For structures which do not directly carry New Jersey Turnpike or Garden State Parkway mainline traffic (local roads over, etc.), the ADTT values for these structures shall be computed manually. Calculations should utilize the most current SI&A data via the NJTA InspectTech website and shall also reference data from the NJDOT Straight Line Diagrams to verify accuracy.

Table 1: Summary of ADTT Sources

Roadway	ADTT Source
Turnpike Mainline Roadway (NS/SN, NSO/SNO, NSE/SNE, NSW/SNW)	Tables 1A & 1B
Turnpike Inner Roadway (NSI/SNI)	1000
NBHCE (MP N0.16A to N7.93W)	Tables 1A & 1B
PHMTE (MP P0.00 to P5.59E/W)	Tables 1A & 1B
Turnpike Interchange Areas	Tables 1A & 1B
Turnpike North of MP E117.60 or W114.00	5000*
Parkway Mainline Roadway	1000
Local Roads Over the Turnpike and Parkway	SI&A Data, NJDOT Straight Line Diagrams

*Unless a more accurate ADTT can be determined

Note that the following tables list ADTT values for the New Jersey Turnpike roadway only.

Table 1A: Annual Average Daily Truck Traffic between Interchanges by Class

NJ TURNPIKE NORTHBOUND (2019 ADTT Updates in BOLD)						
MP Between Interchanges	Link	Class 3	Class 4	Class 5	Class 6	Trucks Classes 3 thru 6
3.5-12.86	1-2	141	215	2441	41	2838
12.86-26.13	2-3	193	233	2556	42	3024
26.13-34.49	3-4	295	278	2796	47	3416
34.49-44.05	4-5	389	366	3253	58	4066
44.05- 51.00	5-JCT	408	413	3420	63	4304
51.00-P3.00	JCT-6	***299***	***395***	***2462***	***167***	***3323***
P0.00	BRIDGE	***398***	***482***	***3092***	***172***	***4143***
51.00-53.28	JCT-7	596	666	4825	106	6193
53.28-60.51	7-7A	656	717	5573	110	7056
60.51-67.57	7A-8	803	845	6527	116	8291
67.57-73.89	8-8A	799	834	6531	118	8282
73.89-83.42	8A-9	865	937	7090	126	9018
83.42-88.09	9-10	986	1034	7487	129	9636
88.09-90.99	10-11	1025	1005	6828	90	8948
90.99-95.92	11-12	1487	1313	7403	467	10669
95.92-99.35	12-13	1757	1407	8261	501	11927
99.35-101.53	13-13A	2095	1558	9091	552	13297
101.53-104.82	13A-14	1590	1365	8382	150	11487
104.82-N3.53	14-14A	489	237	1657	68	2452
N3.53-N5.56	14A-14B	199	70	300	3	572
N5.56-N5.90	14B-14C	208	41	145	2	396
104.82-105.5	14-SMB	1802	1521	8387	162	11872
105.5-106.89	SMB-15E	1086	697	3055	91	4929
106.89-E109	15E-JE	***1006***	***646***	***2907***	***101***	***4659***
E109-E110.80	JE-15X	***1115***	***716***	***3070***	***104***	***5006***
E110.80-E112.58	15X-16E	***831***	***562***	***2473***	***81***	***3947***
E112.58-E112.95	16E-17	0	0	0	0	0
E112.95-E117.6	17-18E	***575***	***500***	***2270***	***70***	***3414***
105.5-W107	SMB-JW	916	879	5477	121	7393
W107-W108.79	JW-15W	1210	1041	6495	136	8882
W108.79-W112.72	15W-16W	935	884	5953	128	7900
W112.72-W114.0	16W-18W	640	684	4847	115	6286
See Note 1	15W-JE	103	63	128	2	297
See Note 2	15E-JW	294	162	1018	15	1489

Legend:
JCT: Junction between Pennsylvania Extension and Mainline of NJ Turnpike
SMB: Southern Mixing Bowl (MP 105 - 106)
JE: Junction with Eastern Alignment
JW: Junction with Western Alignment

Notes:
1. Location includes from the 15W Interchange to the junction with the Eastern Alignment.
2. Location includes from the 15E Interchange to the junction with the Western Alignment.

Table 1B: Annual Average Daily Truck Traffic between Interchanges by Class

NJ TURNPIKE SOUTHBOUND (2019 ADTT Updates in *BOLD*)						
MP Between Interchanges	Link	Class 3	Class 4	Class 5	Class 6	Trucks Classes 3 thru 6
3.5-12.86	1-2	143	242	2392	42	2819
12.86-26.13	2-3	178	296	2568	45	3087
26.13-34.49	3-4	240	413	2914	51	3618
34.49-44.05	4-5	308	529	3431	61	4329
44.05- 51.00	5-JCT	329	580	3608	63	4580
51.00-P3.00	JCT-6	***377***	***343***	***2205***	***90***	***3015***
P0.00	BRIDGE	***377***	***343***	***2205***	***90***	***3015***
51.00-53.28	JCT-7	***1083***	***865***	***4893***	***250***	***7091***
53.28-60.51	7-7A	***1146***	***1007***	***5888***	***244***	***8284***
60.51-67.57	7A-8	***1311***	***1165***	***6504***	***247***	***9228***
67.57-73.89	8-8A	***1296***	***1148***	***6456***	***245***	***9145***
73.89-83.42	8A-9	***1399***	***1286***	***7327***	***265***	***10278***
83.42-88.09	9-10	***1524***	***1449***	***7814***	***269***	***11056***
88.09-90.99	10-11	***1317***	***1232***	***7466***	***224***	***10240***
90.99-95.92	11-12	1335	1524	8405	287	11551
95.92-99.35	12-13	1566	1757	9111	286	12719
99.35-101.53	13-13A	1851	1796	9837	315	13800
101.53-104.82	13A-14	1383	1561	8344	148	11436
104.82-N3.53	14-14A	466	226	1794	65	2552
N3.53-N5.56	14A-14B	281	226	414	3	924
N5.56-N5.90	14B-14C	296	200	264	2	762
104.82-105.5	14-SMB	1834	1834	8436	258	12362
105.5-106.89	SMB-15E	907	918	3469	115	5409
106.89-E109	15E-JE	780	934	3138	107	4959
E109-E110.80	JE-15X	948	1034	3415	113	5510
E110.80-E112.58	15X-16E	822	964	3199	109	5095
E112.58-E112.95	16E-17	157	198	363	4	722
E112.95-E117.6	17-18E	348	465	2246	64	3122
105.5-W107	SMB-JW	755	874	5309	99	7037
W107-W108.79	JW-15W	1208	1109	6019	159	8495
W108.79-W112.72	15W-16W	858	930	6088	112	7988
W112.72-W114.0	16W-18W	588	733	4995	94	6410
See Note 1	15W-JE	158	91	258	5	512
See Note 2	15E-JW	299	155	1155	15	1624

Legend:
JCT: Junction between Pennsylvania Extension and Mainline of NJ Turnpike
SMB: Southern Mixing Bowl (MP 105 - 106)
JE: Junction with Eastern Alignment
JW: Junction with Western Alignment

Notes:
1. Location includes from the 15W Interchange to the junction with the Eastern Alignment.
2. Location includes from the 15E Interchange to the junction with the Western Alignment.

3.1.4 Surface Roughness Rating

An LRFD dynamic load allowance of 33% reflects conservative conditions that may prevail under certain distressed approach and bridge deck conditions. For load rating of legal loads for bridges with less severe approach and deck surface conditions, the dynamic load allowance (IM) may be decreased based on field observations in accordance with MBE Table C6A.4.4.3-1 (See Section 3.2.6). Inspection shall carefully note these and other surface discontinuities to benefit from a reduced dynamic load allowance.

Surface Roughness for load rating purposes is defined as follows:

Table 2. Surface Roughness Rating

Surface Roughness Rating	Description
1 = Smooth	Smooth riding surface at the approaches, bridge deck, and expansion joints.
2 = Average	Minor surface deviations or depressions.
3 = Poor	Significant deviations in the riding surface at the approaches, bridge deck surface (patchwork), and expansion joints

Bridge Inspection Forms currently have similar guidelines for inspectors on how to assign a rating for this item.

3.1.5 Span and Member Numbering

In many instances, span and member numbering can differ between the design drawings and the bridge inspection report, leading to possible errors and confusion. For this reason, span and member numbering during load ratings should reflect the numbering shown in the latest bridge inspection report for the subject structure. The Authority typically numbers spans and members from south to north or west to east, though there may be exceptions to this rule in areas where the alignment of the roadway is not in a north-south or east-west direction (interchange ramps, Y-shaped structures, and complex structures).

When performing load rating updates in accordance with Appendix A3, the load rating engineer shall review the most recent bridge inspection report to ensure that the load ratings utilize the same span and member numbering as the bridge inspection report. If the numbering does not agree with the bridge inspection report numbering, the span and/or member numbering should be revised to agree with the bridge inspection report. However, load rating updates should typically not be performed solely to address incorrect member numbering.

In cases where the load rating program does not allow the renaming or renumbering of members (MDX, etc.), a note shall be placed on the load rating summary sheet which describes the member numbering used, as well as how it differs from the inspection report numbering.

3.2 Live Loads and Load Factors

3.2.1 Overview of LRFR Load Rating Process for NJTA Bridges

Live loads to be used in the rating of bridges are selected based upon the purpose and intended use of the rating results. Live load models outlined below shall be evaluated for the Strength and Service limit states in accordance with Table 3. The Fatigue Limit state shall be evaluated during a load rating analysis when directed by the Authority.

Each bridge shall be load rated for the following live load models:

1) **Design load rating** is a first-level rating performed for all bridges (including bridges designed using the Standard Specifications) using the HL-93 loading at the Inventory (Design) and Operating levels (See Figure 1, Section 3.2.2).
2) **Legal load rating for routine commercial traffic**: Rate for the NJ state legal loads: Type 3, Type 3-S2, Type 3-3. Legal lane loads given in Figure 2 (Section 3.2.3) are to be used for spans greater than 200 ft and for negative moment areas. Note that the NJTA Type 3S2 (See Figure 2a) varies from the standard gross vehicle weight of a standard AASHTO legal load.
3) **Legal load rating for specialized hauling vehicles**: Rate for AASHTO Specialized Hauling Vehicles (SHV) SU4, SU5, SU6, and SU7 given in Figure 3 (Section 3.2.4).
4) **Legal load rating for emergency vehicles**: Rate for emergency vehicles EV2 and EV3 given in Figure 4 (Section 3.2.7).
5) Load Rating for overweight permits may be performed when required following the provisions of Section 3.2.5.

Table 3. LRFR Limit States

Bridge Type	Limit State	Design	State Legal	Legal SHV	Legal EV
		HL-93	Type 3, Type 3S2, Type 3-3 LTLL	SU4, SU5, SU6, SU7	EV2 & EV3
Steel	Strength I	●	●	●	●
	Service II	●	●	●	●
	Fatigue	●			
Reinforced Concrete	Strength I	●	●	●	●
Prestressed Concrete	Strength I	●	●	●	●
	Service III	●	●	●	●

Note: Bullets indicate applicable limit states

Annual Permits and Trip Permits may be authorized for vehicles exceeding the legal limit, as specified in the NJTA permit regulations. Load rating for overweight permits shall be in accordance with Section 3.2.5.

3.2.2 Design Load Rating for HL-93 Loading

The design-load rating (or HL-93 rating) assesses the performance of existing bridges utilizing the LRFD HL-93 design loading and design standards with dimensions and properties for the bridge in its present condition. It is a measure of the performance of existing bridges to new bridge design standards contained in the LRFD Specifications. The design-load rating produces Inventory and Operating level rating factors for the HL-93 loading. The evaluation live-load factors for the Strength I limit state shall be taken as given in MBE Table MBE 6A.4.3.2.2-1.

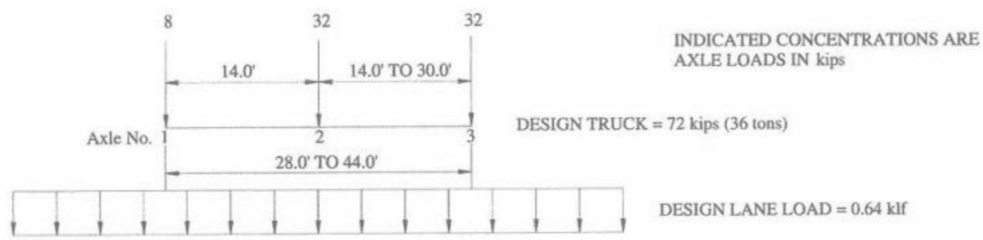
Modifications to the design loading per the NJTA Design Manual, Structures Design, Section 3.2.2 for use in the design of new or rehabilitated structures shall not be considered during As-Built or As-Inspected load rating analyses. However, modified design loads shall be included when performing As-Designed load ratings. For all load ratings, the standard design loading as specified in the LRFD Specifications and Figure 1 shall be considered and included on the load rating summary sheet (for uniform means of comparison for all bridges).

Table MBE 6A.4.3.2.2-1 Load Factors for Design Load: γ_L

Evaluation Level	Load Factor
Inventory	1.75
Operating	1.35

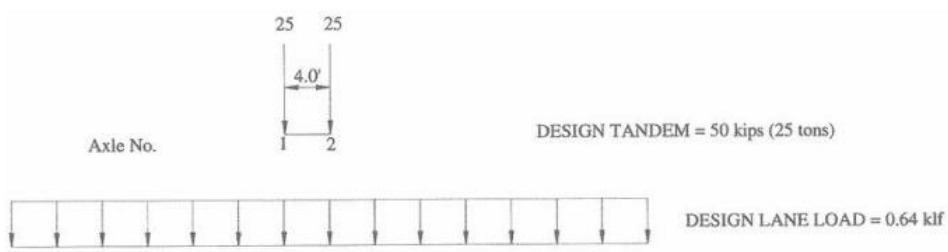
The dynamic load allowance specified in the LRFD Specifications for new bridge design (LRFD Article 3.6.2) shall apply. For design load rating, regardless of the riding surface condition or the span length, always use 33% for the dynamic load allowance (IM).

a) HL-93 Truck + Design Lane Load



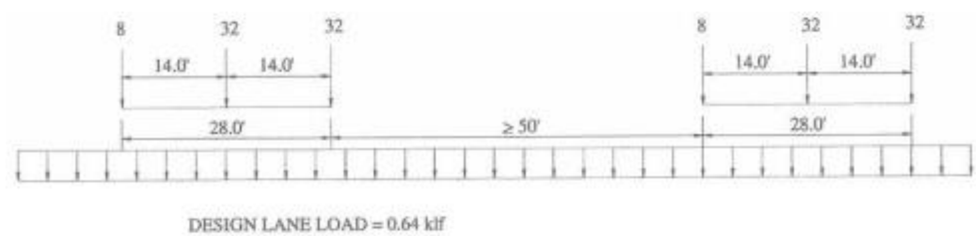
MBE Appendix C6A, Figure C6A-1

b) HL-93 Tandem + Design Lane Load



MBE Appendix C6A, Figure C6A-1

c) 90% HL-93 Design Load – Apply for negative moment and interior reaction (reduce all loads to 90%)



MBE Appendix C6A, Figure C6A-1

Figure 1 – Design Load Models

3.2.3 Legal Load Rating for Routine Commercial Traffic

In LRFR, load ratings for legal loads determine a single safe load capacity of a bridge. The previously existing distinction of Operating and Inventory level ratings is no longer maintained when performing load ratings for legal loads.

The live load to be used in the LRFR rating for routine commercial traffic shall be any of the State legal loads shown in Table 3.

It is unnecessary to place more than one vehicle in a lane for spans less than 200 ft. because the LRFR live load factors provided have been modeled for this possibility (no lane load to be used). For negative moments and for span lengths greater than 200 ft., critical load effects shall be obtained by lane-type legal load models given in MBE APPENDIX D6A**,** also shown in Figure 2 below.

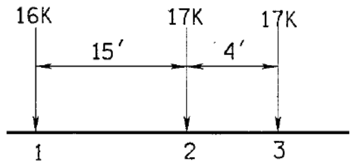
The live-load factors for legal loads for the Strength I limit state shall be taken as given in Table MBE 6A.4.4.2.3a-1.

Table MBE 6A.4.4.2.3a.-1 Live-Load Factors, γ_L for NJ Legal Loads

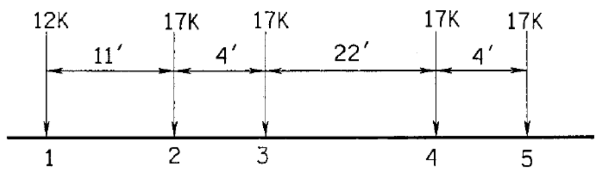
Traffic Volume (One direction)	Load Factor for Type 3, Type 3S2, Type 3-3 and lane loads
Unknown	1.45
ADTT ≥ 5000	1.45
ADTT ≤ 1000	1.30

Note: A linear interpolation is permitted for other ADTT values

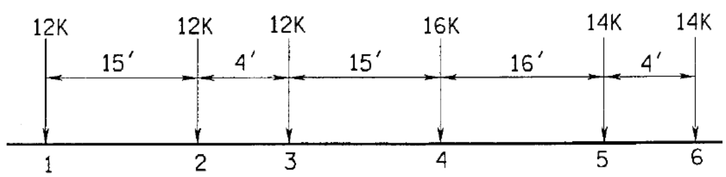
a) Truck Type Legal Loads (Type 3S2 modified by NJTA)



TYPE 3 TRUCK (SP-2 LOADING) - 5Ø KIPS

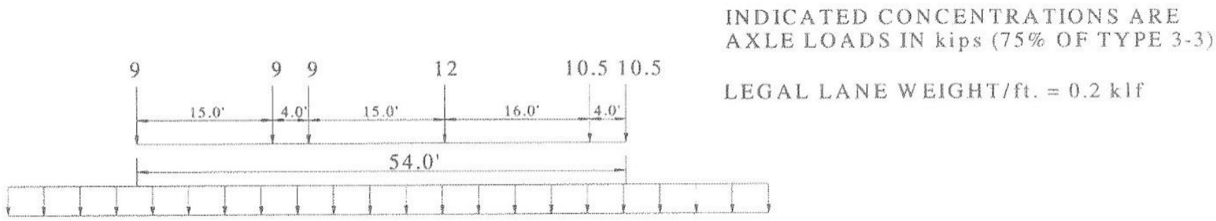


TYPE 3S2 TRUCK (SP-3 LOADING) - 8Ø KIPS



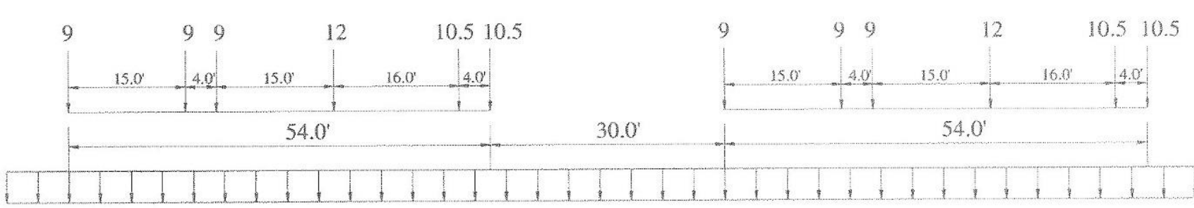
TYPE 3-3 TRUCK (SP-4 LOADING) -8Ø KIPS

b) Lane-Type Legal Load Model—Apply for spans greater than 200 ft. and all load effects.



MBE APPENDIX D6A, Figure D6A-4

c) Lane-Type Legal Load Model—Apply for negative moment and interior reaction for all span lengths.



MBE APPENDIX D6A, Figure D6A-5

Figure 2 - Legal Load Models

3.2.4 Legal Load Rating for Specialized Hauling Vehicles

In recent years, the trucking industry has introduced single unit Specialized Hauling Vehicles (SHV) with closely-spaced multiple axles that make it possible for these short wheelbase trucks to carry the maximum load of up to 80,000 lbs and still meet Federal Bridge Formula B and the axle weight limits. Because of the higher load effects of these vehicles, especially on short span bridges, AASHTO has adopted an additional rating live load model and four additional single unit trucks as legal loads. The four single unit posting trucks SU4, SU5, SU6 and SU7 shown in Figure 3 model the short wheelbase multi-axle SHVs that are becoming increasingly common in New Jersey.

The live-load factors for the SHV legal loads for the Strength I limit state shall be taken as given in Table MBE 6A.4.4.2.3b-1. These load factors are identical to those for Routine Commercial Traffic in Section 3.2.3.

Table MBE 6A.4.4.2.3b.-1 Live-Load Factors, γ_L
for Specialized Hauling Vehicles

Traffic Volume (One direction)	Load Factor for SU4, SU5, SU6 and SU7
Unknown	1.45
ADTT ≥ 5000	1.45
ADTT ≤ 1000	1.30

Note: A linear interpolation is permitted for other ADTT values.

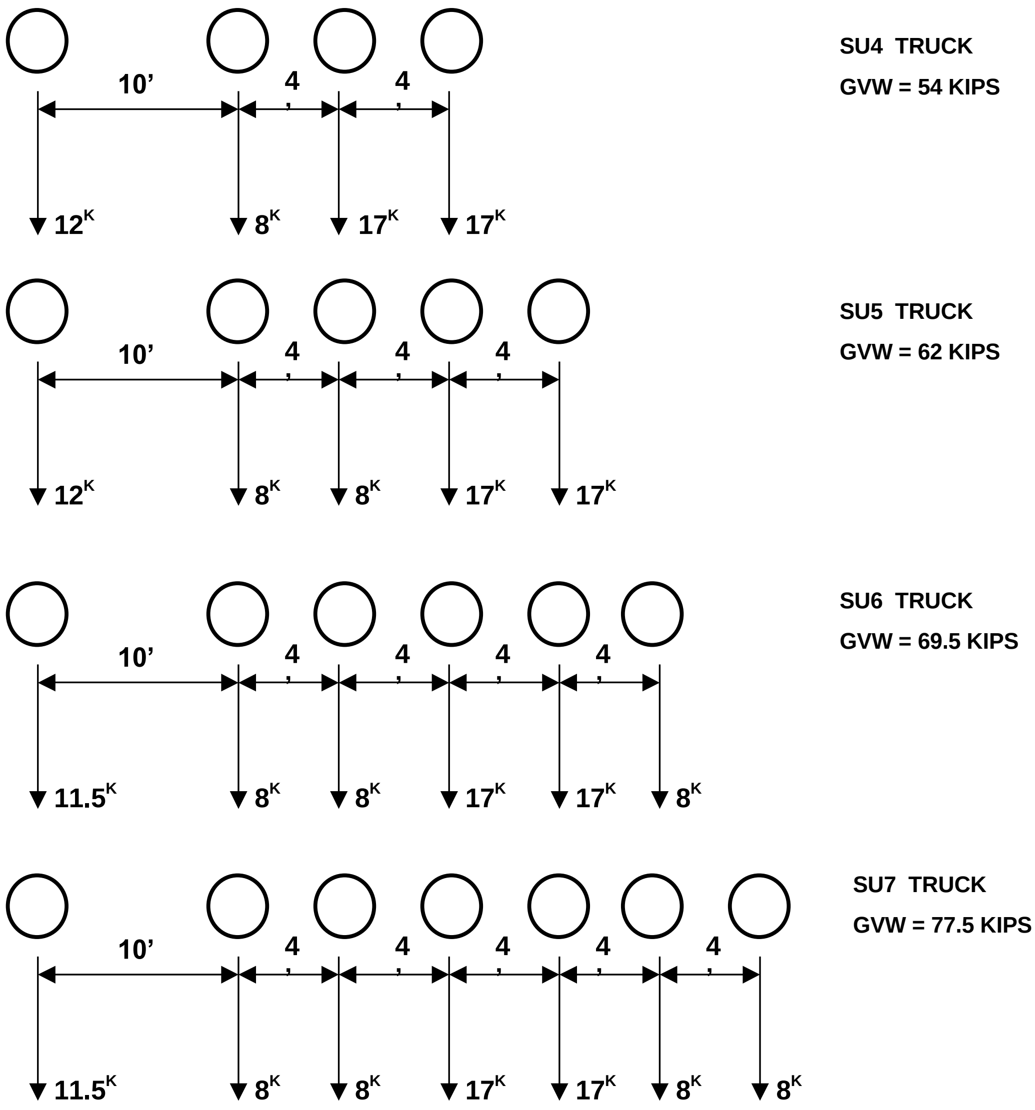


Figure 3 - AASHTO Legal Loads for SHV

3.2.5 Load Rating for Overweight Permits

Annual Permits and Trip Permits may be authorized for vehicles exceeding the legal limit, as specified in the NJTA permit regulations.

Trip permit analysis shall be performed for a single lane loading utilizing the LRFD single-lane distribution factor. This is used because these permit loads are infrequent and are likely the only heavy loads on the structure during the crossing. When the one-lane LRFD distribution factor is used, it should be noted that the built-in multiple presence factor of 1.2 should be divided out of equations located in AASHTO LRFD Tables 4.6.2.2.2b-1, 4.6.2.2.2d-1, 4.6.2.2.3a-1, and 4.6.2.2.3b-1 when considering one lane loaded. However, if distribution factors are calculated by the lever rule for the single lane case, the resulting value should be used as-is, without multiplying with the multiple presence factor. The permit vehicle shall be placed laterally on the bridge, within the striped lanes, to produce maximum stresses in the critical member under consideration.

3.2.5.1 Strength Evaluation

The LRFR live-load factors for annual and trip permits for the Strength limit state shall be taken as given in Table MBE 6A.4.5.4.2a-1. The trip permit load factors are applicable to all gross weights and all ADTT values.

Table MBE 6A.4.5.4.2a-1—Permit Load Factors: γ_L

Permit Type	Frequency	Loading Condition	*DF*[a]	*ADTT* (one direction)	Load Factor by Permit Weight Ratio[b]		
					GVW / AL < 2.0 (kip/ft)	2.0 < GVW/AL < 3.0 (kip/ft)	GVW/AL > 3.0 (kip/ft)
Routine or Annual	Unlimited Crossings	Mix with traffic (other vehicles may be on the bridge)	Two or more lanes	>5000	1.40	1.35	1.30
				=1000	1.35	1.25	1.20
				<100	1.30	1.20	1.15
					All Weights		
Special or Limited Crossing	Single-Trip	Escorted with no other vehicles on the bridge	One lane	N/A	1.10		
	Single Trip	Mix with traffic (other vehicles may be on the bridge)	One Lane	All ADTTs	1.20		
	Multiple-Trips (less than 100 crossings	Mix with traffic (other vehicles may be on the bridge)	One lane	All ADTTs	1.40		

[a] *DF* = LRFD distribution factor. When one-lane distribution factor is used, the built-in multiple presence factor should be divided out.

[b] Permit Weight Ratio = GVW/AL;. GVW = Gross Vehicle Weight; AL = Front axle to rear axle length; Use only axles on the bridge.

3.2.5.2 Serviceability Evaluation

LRFR Service limit states checks for permit load ratings should be performed using the limit states and load factors given in Table 5.

Table 5. LRFR Service Limit States and Load Factors for Permit Loads

Bridge Type	Limit State	Dead Load	Dead Load	Permit Load
		DC	DW	LL
Steel	Service II	1.00	1.00	1.00
Reinforced Concrete	Service I	1.00	1.00	1.00
Prestressed Concrete	Service I	1.00	1.00	1.00

- A SERVICE I load combination for reinforced concrete components and prestressed concrete components has been introduced in LRFR to check for possible inelastic deformations in the reinforcing steel during heavy overload crossings (MBE 6A.5.4.2.2b). This check shall be applied to overload checks and sets a limiting criterion of 0.9Fy in the extreme tension reinforcement. Limiting steel stress to 0.9 F_y is intended to ensure that there is elastic behavior and that cracks that develop during the passage of overweight vehicles will close once the vehicle is removed. It also ensures that there is reserve ductility in the member.

- Steel structures shall satisfy the overload permanent deflection check under the SERVICE II load combination for permit ratings using load factors as given in Table 5. Maximum steel stress is limited to 95% and 80% of the yield stress for composite and non-composite compact girders respectively.

3.2.5.3 Floorbeam Load Rating

Load rating of floorbeams for permit loads shall be carried out by placing live loads in positions and combinations that maximize floorbeam load effects. A permit vehicle is placed in any one lane only. When the one-lane loaded condition is evaluated using the permit load it is not necessary to include the 1.2 multiple presence factor in the analysis. When live loads are placed in more than one lane, the lanes other than the permit load lane shall be loaded with legal loads with applicable reductions for multiple presence.

3.2.6 Reduced Dynamic Load Allowance for Rating

For legal and permit load rating of longitudinal members having spans greater than 40 ft. with less severe approach and deck surface conditions, the Dynamic Load Allowance (IM) may be decreased from the LRFD design value of 33%, as given below in Table 6, for the Strength and Service limit states. Dynamic load allowance shall be applied to the vehicles and not the lane loads. Regardless of riding surface condition, always use 33% for longitudinal members with spans 40 ft or less and for all transverse members. Also, as specified in Section 4.4, always use 33% dynamic load allowance for all members and vehicles when performing load ratings associated with new design or rehabilitation. Selection of IM shall be in accordance with the requirements of Section 3.1.4 and the Surface Roughness rating noted in the inspection report. State or document what value of IM was used for the load rating on the Load Rating Summary Sheet. If a permit vehicle proceeds at a crawl speed under escorted conditions, no more than 10 miles per hour, then the impact can be assumed to be 0%.

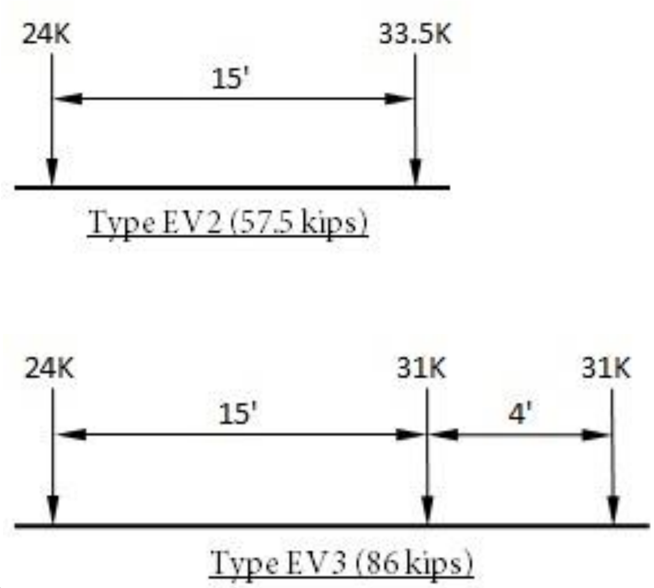
Table 6 Dynamic Load Allowance for Rating: IM.

Riding Surface Rating	IM
1	10%
2	20%
3	33%

3.2.7 Legal Load Rating for Emergency Vehicles

In accordance with the FHWA Memorandum dated November 3, 2016 (Load Rating for the FAST Act's Emergency Vehicles), Emergency Vehicle load ratings will be required for Interstate bridges and bridges within reasonable access to the Interstate as soon as December 31st, 2019. In response to this memorandum, the Authority now requires the inclusion of Emergency Vehicles EV2 and EV3 for all bridge load ratings.

See Figure 4 for the axle configuration and weights of these vehicles.



a)

b)

Figure 4 – Emergency Vehicle Models

The FHWA Memorandum indicates that, "…if necessary, when combined with other unrestricted legal loads for rating purposes, the emergency vehicle needs only to be considered in a single lane of one direction of a bridge". In other words, the memo allows for a refined analysis using a single lane EV loading in combination with other unrestricted legal loads. This type of advanced analysis is difficult to perform using the most versatile of the Authority's approved load rating programs (BrR) and was not found to result in significant improvements to the computed rating factors. For these reasons, EV2 and EV3 ratings shall be performed utilizing these vehicles as routine legal loads, considering typical single-lane and multi-lane loading scenarios, and shall not include other unrestricted legal loads as an adjacent vehicle during analysis.

A live load factor of 1.3 shall be utilized (LRFR methodology), and the emergency vehicles shall be considered as legal loads for the purposes of the load rating calculations and analysis. A live load factor of 1.3 is also recommended in the memo when performing load factor ratings (LFR).

See Appendix A4 for detailed instructions on how to perform EV ratings using AASHTOWare's Bridge Rating (BrR) software.

3.3 Resistance Factors and Resistance Modifiers for the Strength Limit States

3.3.1 Resistance Factor: ϕ

For Strength Limit States, member capacity is given as:

$$C = \phi_c \ \phi_s \ \phi \ R_n$$

Where:

ϕ_c = Condition Factor

ϕ_s = System Factor

ϕ = LRFD Resistance Factor

Where, the following lower limit shall apply:

$\phi_c \ \phi_s \ \geq \ 0.85$

Resistance factor ϕ has the same value for new design and for load rating. Resistance factors, ϕ, shall be taken as specified in the LRFD Specifications for new construction. A reduction factor based on member condition, Condition Factor ϕ_c, is applied to the resistance of degraded members. An increased reliability index is maintained for deteriorated and non-redundant bridges by using condition and system factors in the load rating equation.

3.3.2 Condition Factor: ϕ_c

The 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. Current NJTA policy is to set this factor equal to the values presented in Table MBE 6A.4.2.3-1.

Table MBE 6A.4.2.3-1 Condition Factor: ϕ_c

Superstructure Condition Rating (SI & A Item 59)	Equivalent Member Structural Condition	ϕ_c
6 or higher	Good or Satisfactory	1.00
5	Fair	0.95
4 or lower	Poor	0.85

The Condition Factor ϕ_c does not account for section loss but is used in addition to section loss. However, if section properties are obtained accurately, by actual field measurement of losses rather than by an estimated percentage of losses, the values specified for ϕ_c in Table MBE 6A.4.2.3-1 may be increased by 0.05 ($\phi_c \leq 1.0$). Increasing of the condition factor should be performed only when the following have been satisfied, to maintain consistency:

1. Section properties are obtained accurately, via field measurements.
2. Ratings are first computed using the actual ϕ_c value (< 1.00) and result in legal load rating factors less than 1.00.
3. The Authority Liaison has been contacted and has given approval regarding the use of an increased condition factor.

This type of scenario would most commonly be encountered when dealing with steel beams exhibiting section loss. On the other hand, a concrete member may receive a low condition rating due to heavy cracking and spalling or due to the deterioration of the concrete. Such deterioration of concrete components may not necessarily reduce their calculated flexural resistance, but it is appropriate to apply the reduced condition factor in the LRFR load rating analysis. If there are also losses in the reinforcing steel of this member, they shall be measured and accounted for in the load rating. It is appropriate to also apply the reduced condition factor in the LRFR load rating analysis, even when the as-inspected section properties are used in the load rating as this reduction by itself does not fully account for the impaired resistance of the concrete component. Also refer to Section 3.1.2 (Bridge Inspection for Load Rating) for additional guidance regarding incorporation of bridge conditions into the load rating.

3.3.3 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 member capacities reduced, and, accordingly, will have lower ratings. The aim of the system factor is to provide reserve capacity for safety of the traveling public. Current NJTA policy is to use the system factors provided in Table MBE 6A.4.2.4-1 when load rating for flexural and axial effects for steel members and non-segmental concrete members. The system factor is set equal to 1.0 when checking shear. Subsystems that have redundant members shall not be penalized if the overall system is non-redundant (i.e. multi stringer deck framing members on a two-girder or truss bridge). The system factor is used with all live load models.

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

Superstructure 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
All Other Girder Bridges and Slab Bridges	1.00
Floorbeams with Spacing >12ft. and Non-Continuous Stringers	0.85
Redundant Stringer Subsystems Between Floorbeams	1.00

Definitions

Floorbeam – A horizontal flexural member located transversely to the bridge alignment.
Stringer – A longitudinal beam supporting the bridge deck.
Girder – A large flexural member, usually built-up, which is the main or primary support for the structure, and which usually receives load from floorbeams, stringers, or in some cases directly from the deck.

3.4 Resistance Factors and Resistance Modifiers for the Service Limit States

For all non-strength limit states, $\varphi = 1.0$, $\phi_C = 1.0$, $\phi_S = 1.0$

3.5 Service & Fatigue Limit States for Load Rating

3.5.1 General Overview

Service and fatigue limit states to be evaluated during a load rating analysis shall be as given below in Table 7. Fatigue limit states shall be evaluated during a load rating analysis only when directed by the Authority.

Table 7 LRFR Service and Fatigue Limit States and Load Factors

Bridge Type	Limit State	Dead Load	Dead Load	Design Load		Legal Load
				Inventory	Operating	
		DC	DW	LL	LL	LL
Steel	Service II	1.00	1.00	1.30	1.00	1.30
	Fatigue	0.00	0.00	0.75	NA	NA
Prestressed Concrete	Service III	1.00	1.00	0.80	NA	1.00

NA = Not applicable

3.5.2 Concrete Bridges

- For prestressed concrete bridges, LRFR provides a limit state check for cracking of concrete (SERVICE III) by limiting concrete tensile stresses under service loads. The SERVICE III check shall be performed during design load ratings of prestressed concrete bridges as required by MBE Table 6A.4.2.2-1. Legal load ratings need not routinely perform this SERVICE III check (listed as “optional” in MBE Table 6A.4.2.2-1). However, in cases where prestressed beams exhibit tensile cracks or other signs of distress, this SERVICE III check should be performed. If performed, it shall be clearly documented in the load rating report. An allowable tension stress in the precompressed tensile zone of $0.19\sqrt{f'_c}$. in prestressed concrete members with bonded reinforcement shall be utilized when performing the design load check at the Inventory level and at the legal load rating level, if deemed necessary.

3.5.3 Steel Bridges

- Steel structures shall satisfy the overload permanent deflection check under the SERVICE II load combination for design and legal load ratings using load factors as given in Table 7. Maximum steel stress is limited to 95% and 80% of the yield stress for composite and non-composite compact girders respectively.
- In situations where fatigue-prone details are present (Category C or lower) and when directed by the Authority, a Fatigue limit state rating factor for infinite fatigue life shall be computed. If directed by NJTA, bridge details that fail the infinite-life check can be subject to the finite-life fatigue evaluation using evaluation procedures given in MBE Section 7.

SECTION 4 LOAD RATING DELIVERABLES

4.1 Load Rating Report

Load rating calculations and documentation shall be incorporated into a comprehensive report to facilitate updating of the information and calculations in the future. The load rating shall be completely documented in writing including all background information such as field inspection reports, material and load test data, all supporting computations, referenced drawings, and a clear statement of all assumptions used in calculating the load rating. The drawings included in the load rating report shall include all drawings that were referenced during the load rating, including the general notes, framing plans, cross sections, beam details, as well as any other unique details. When section losses are present and a Section Loss Table is created as part of the Section Loss Workbook (SLW) procedure (see Appendix A5), a Section Loss Load Rating Form (SLLRF), generated from the Section Loss Table, shall be included in the load rating report to document deterioration that could have an effect on the load rating. Sketches shall also continue to be provided in concert with the SLW procedure to document member section losses incorporated in the analysis and shall utilize section loss forms located on the InspectTech website. The SLW procedure and beam elevation sketches are currently accessible via the HELP / DOCUMENTATION menu within InspectTech. Inspection reports, testing reports, and articles referenced as part of the load rating shall be documented. When refined methods of analysis or load testing are used, the load rating report shall include live load distribution factors for all rated members, determined through such methods. For more complex structures where computer models are used in the analysis, a copy of the computer models with documentation shall be made and submitted to NJTA. For new, replaced or rehabilitated bridges designed using LRFD, the LRFR As-Designed load ratings shall be computed at the time of design and shown on the structural drawings following the structural notes (See Section 4.4).

4.1.1 Load Rating Report Deliverables

The following list details the required components of the load rating report, to be submitted via uploading to the InspectTech (IT) website for NJTA (https://njta-it.bentley.com), and placed within the "Load Ratings" section for the applicable bridge inspection report. The following listed info shall be provided in pdf format:

- Load Rating Summary Sheet(s)
- Summary of Updates (required for rating updates only)
- Supplemental Load Rating Calculations
- Additional Calculations for Unique Structures (if needed)
- Section Loss Load Rating Form (if needed)
- Section Loss Documentation Sketches (Elevation Views) (if needed)
- Reference Drawings

When uploading files to the InspectTech(IT) website, each file shall be assigned a "file date". For all load rating files, this date should reflect the date of the signed and sealed load rating summary sheet(s). Further, when copying a load rating summary sheet in IT from a prior bridge inspection report for inclusion in a current bridge inspection report, this process should be followed and the load rating summary sheet date assigned within IT should match the initial date on the load rating summary sheet.

The load rating consultant shall make every effort to contain the above documents in ONE pdf file for ease of future use and reference. At a minimum, the pdf shall include bookmarks for the following sections of the load rating report:

- Load Rating Summary Sheet(s)
- Summary of Updates (required for rating updates only)
- Cross Section(s)
- Framing Plan(s)
- Section Loss Information

- Load Rating Calculations
- Any Unique Calculations Specific to the Structure

It is understood that some of the more complex structures will require multiple pdf files. All pdf files shall be created using no higher than "Standard" settings. Pdf files shall be created directly from the native program (Word, Excel) whenever possible, and scanned images shall be limited to those which cannot be created in this fashion. Examples of pages which must be scanned will likely be the Load Rating Summary Sheet(s) (due to signature) and any additional calculations done by hand. In addition to this load rating report, the following working files shall be submitted via uploading to the InspectTech website:

- Load Rating Summary Sheet(s) (if generated using Excel; See Section 4.2)
- Summary of Updates (Excel; combine with LRSS in one Excel file if LRSS is generated using Excel)
- Supplemental Load Rating Calculations (Excel)
- Additional Calculations for Unique Structures (Excel or other – if utilized)
- BrR file (.xml) or other load rating software files (CSiBridge, BRASS, STAAD, MDX, etc.)
- Section Loss Table (Excel – if utilized)
- Section Loss Documentation Sketches (Elevation Views and Cross Sections)(if utilized)

For complex structures which are load rated using CSiBridge, BRASS, STAAD, MDX, or other similar software packages, numerous individual computer program files are often generated. In cases such as this, working files shall be uploaded to InspectTech in one zip folder.

These working files are intended to aid in future load rating updates. Refer to Section 2.1.2 for additional guidance when performing load rating updates of existing bridges. Note that Microsoft Excel has been specified as the required program for computing supplemental load rating calculations and preparing the Summary of Updates. The Load Rating Summary Sheet(s) is now completely generated utilizing InspectTech forms, except for rare cases in which Microsoft Excel shall still be used (See Section 4.2). See Section 4.2 regarding creation of multiple load rating summary sheets. If multiple sheets are created using Excel, they should be contained in one Excel file. If an alternate program would like to be used, prior approval must first be obtained from NJTA.

As required via the Authority's annual bridge inspection contracts (Turnpike and Garden State Parkway Group Inspections) when performing initial load ratings or load rating updates, the bridge inspection consultant shall also update the Authority's overall listing of load ratings, which is currently maintained in spreadsheet format. The Authority's Liaison and/or the Authority's Load Rating Representative will provide the file to be updated following completion of the bridge inspection and load ratings.

Upon completion of any load rating assignment, all load rating files for each structure rated shall be submitted to the Authority via CD or DVD. The files shall be named as outlined below such that all files can be clearly identified.

4.1.2 File Naming

All file names should be given descriptive names and should include the BRIDGE ID number (See Appendix A). The following details the required naming convention for the load rating deliverables, along with examples for each. Logical clarifiers shall be appended to these recommended names in cases where multiple files are needed.

1. Load Rating Summary Sheet – The summary sheet working Excel file name shall begin with MP and shall be directly followed by the milepost number of the structure, a space, then LOAD RATING SUMMARY SHEET. If the summary sheet is generated using Excel (See Section 4.2), it shall also contain the SUMMARY OF UPDATES data on a separate worksheet. When the summary sheet is created within InspectTech, the summary of updates data shall be a stand-alone file (See #2 below). PDFs of the signed and sealed summary sheets used in the bridge inspection reports shall also utilize this same naming convention.

   Ex. For NJ Turnpike Structure located at MP 23.12, the summary sheet file shall be named "MP23.12 Load Rating Summary Sheet.xls".

2. Summary of Updates – The summary of updates working Excel file name shall begin with MP and shall be directly followed by the milepost number of the structure, a space, then SUMMARY OF UPDATES. This file shall solely contain the summary of updates data when the load rating summary sheet is created within InspectTech.

   Ex. For NJ Turnpike Structure located at MP 23.12, the summary of updates file shall be named "MP23.12 Summary of Updates.xls".

3. Supplemental Load Rating Calculations – The load rating calculations working Excel file shall begin with MP and shall be directly followed by the milepost number of the structure, a space, then SUPPLEMENTAL CALCS. Multiple files can be specified by adding incremental numeric values at the end of this file name (i.e., 1, 2, 3, etc.).

   Ex. For NJ Turnpike Structure located at MP 23.12, the load rating calculations file shall be named "MP23.12 Supplemental Calcs.xls".

4. Additional Calculations for Unique Structures – The additional load rating calculations working Excel file (if needed) shall begin with MP and shall be directly followed by the milepost number of the structure, a space, then ADDITIONAL CALCS. Multiple files can be specified by adding incremental numeric values at the end of this file name (i.e., 1, 2, 3, etc.).

   Ex. For NJ Turnpike Structure located at MP 23.12, the additional load rating calculations file shall be named "MP23.12 Additional Calcs.xls".

5. BrR File – The BrR working file shall begin with MP and shall be directly followed by the milepost number of the structure. Other program file names should be similarly named.

   Ex. For NJ Turnpike Structure located at MP 23.12, the BrR file shall be named "MP23.12.xml".

6. Load Rating Report (pdf version) – The Final Load Rating Report shall begin with MP and shall be directly followed by the milepost number of the structure, a space, then LRFR LOAD RATING REPORT.

Ex. For NJ Turnpike Structure located at MP 23.12, the final load rating report shall be named "MP23.12 LRFR Load Rating Report.pdf".

7. Section Loss Table – The Section Loss Table working Excel file shall begin with MP and shall be directly followed by the milepost number of the structure, a space, then SECTION LOSS TABLE.

   Ex. For NJ Turnpike Structure located at MP 23.12, the Section Loss Table file shall be named "MP23.12 Section Loss Table.xlsm".

As-Designed ratings should utilize the above noted file naming conventions and should append "(As-Designed)" to all load rating files. See Section 4.4 for additional details regarding As-Designed ratings.

4.1.3 InspectTech – Plan Uploading and Load Rating Input

Upon completion of the load rating, the consultant shall input the required load rating data directly into a master load rating summary table provided by the Authority and maintained by the Authority's Load Rating Representative.

In addition to the input of required load rating data into this table, all relevant plans should also be uploaded to the "drawings" location within InspectTech if they have not been previously uploaded. The term "relevant" refers to any drawing specific to the structure in question, regardless of whether it was referenced during the load rating process. This includes but is not limited to original design drawings, original contract drawings, and structure rehabilitation drawings. Note that this is in addition to including the referenced drawings in the Load Rating Report pdf.

Please confirm with the Authority Liaison the appropriate method to use for submitting the load rating data and relevant plans prior to start of work.

4.1.4 Interpretation of Rating Results and Low Ratings

Load ratings are performed to ensure bridge safety, to comply with federal regulations, to assist with determining needs for bridge replacement or rehabilitation, to determine needs for posting, and to assist with the processing of overload permits. For these reasons, it is important that accurate load rating results are reported to the bridge owner.

In cases where load ratings for legal loads (not including Emergency Vehicles EV2 and EV3) fall below the required 1.00 rating factor, the load rating engineer shall review the ratings to ensure that overly conservative assumptions have not led to overly conservative rating results. If applicable, ensure that any dynamic load allowance reductions based on the riding surface have been incorporated into the analysis. In cases where fascia members exhibit low ratings, consider reducing the travelway (and live load effects) in accordance with MBE Section 6A.2.3.2. If a reduced condition factor has been applied to all members of a given structure, but only select members exhibit that reduced condition rating (and φ_c factor), the condition factor can be adjusted on a member-by-member basis (See Appendix A2, Question 23). The Authority should be notified immediately if rating results continue to yield rating factors less than 1.00 for legal loads. If this is the case, Load Factor ratings (LFR) may be requested. Also reference Section 2.6 regarding reporting of load rating data to the NBI in cases where low ratings are determined.

4.2 Load Rating Summary Sheets

After the structure has been load rated, the NJTA Bridge Load Rating Summary Sheet(s) shall be prepared and utilized as the first sheet for the load rating report.

Beginning in 2018, bridge inspection consultants shall utilize newly created forms within InspectTech to automatically generate the standard load rating summary sheet(s). Reference to the Excel-based load rating summary sheets remains in this document since an initial means for presenting and recording As-Designed ratings is needed, prior to officially updating the SI&A data. Design engineers will likely not have access to InspectTech, thus requiring the Excel-based approach to create As-Designed load rating summary sheets.

Note that the Load Rating Engineer should indicate the controlling member numbers on the Load Rating Summary Sheet, and also indicate the controlling span when multiple spans have been rated. For simple structures comprised of one superstructure type only, a single load rating summary sheet is sufficient. However, for more complex structures which contain varying member types (concrete girders, steel girders, floorbeams, stringers, transverse box girders, connections, trusses, etc.), a separate load rating summary sheet shall be created for each member type load rated.

When multiple analysis engines are available from within AASHTOWare's Bridge Rating software (i.e., Version 6.8.4), the analysis engine shall be designated on the summary sheet immediately following the version number (See Appendix A1 for details).

In cases where multiple load rating summary sheets are required, the "Past Inventory Rating (HL93 or HS20)" and "Past Operating Rating (HL93 or HS20)" data should reflect the member type shown. If previous ratings were not performed for the specific member type, "N/A" should be entered. For all load rating summary sheets, the "Past Inventory Rating (HL93 or HS20)" and "Past Operating Rating (HL93 or HS20)" data should include in parentheses the member and span which previously controlled (See below for an example).

Past Inventory Rating (HL93):	0.720 (S2(S22), Span 4)
Past Operating Rating (HL93):	0.933 (S2(S22), Span 4)

If load rating updates or corrections to the load rating calculations or load rating program files have been performed, the appropriate check box shall be selected when completing the load rating summary sheet.

Input fields for rating factors shall not be left blank. In rare cases where rating factors are not required for specific vehicles (i.e., LTLL ratings for single spans), input "N/A" for not applicable.

Also note that the format required for the load rating summary sheet of culverts differs from typical structures (See Figure 4.2-2 for Excel-based load rating summary sheet templates). There are also unique culvert load rating summary sheet forms available for use within InspectTech (See Figures 4.2-4a and 4.2-4b for InspectTech-generated summary sheet templates).

If load factor ratings are performed as briefly discussed in Section 4.1.4, a separate LFR load rating summary sheet should also be created. Unique LFR load rating summary sheet forms are also available for use within InspectTech. If necessary, contact your Authority Liaison or the Authority's Load Rating Representative for a sample Excel-based LFR load rating summary sheet. Both the LRFR and LFR load rating summary sheets should be included in the load rating report, but only the load rating summary sheet which contains the results reported to FHWA should be included in the final bridge inspection report. When possible, the load rating summary sheet included in the bridge inspection report shall be generated entirely using available forms within InspectTech.

NEW JERSEY TURNPIKE AUTHORITY
BRIDGE LOAD RATING SUMMARY

EXISTING BRIDGE DATA

Bridge Number:
Span Type:
Referenced Contract Dwgs:
Design Loading:
Past Inv. Rating (HL93 or HS20):
Past Oper. Rating (HL93 or HS20):
Last Load Rating Date:

Last Inspection Date:
Inspected By (Firm):
Fracture Critical Members (Y/N):

BRIDGE LOAD RATING SUMMARY

Dead Load Data
Overlay Type:
Overlay Depth (in.):
Was Overlay Depth Measured (Y/N):
Weight of Utilities:
Weight of other Non-Structural Attachments:

LRFR Evaluation Factors	As-Built	As-Insp.
Surface Roughness Rating:		
Dyn. Load Allow. (IM - HL-93):		
Dyn. Load Allow. (IM - Legal):		
Condition Factor:		
System Factor:		
ADTT (one way):		

SUPERSTRUCTURE/DECK RATING SUMMARY

Vehicle Type	**Vehicle GVW (kips)**	**Controlling Flexural Rating Factor (Interior) G2**		**Controlling Flexural Rating Factor (Exterior) G1**		**Controlling Shear Rating Factor (Interior) G2**		**Controlling Shear Rating Factor (Exterior) G1**	
		As-Built	As-Insp.	As-Built	As-Insp.	As-Built	As-Insp.	As-Built	As-Insp.
HL-93 (INV)	N/A								
HL-93 (OPR)	N/A								
Type 3	50								
NJ Type 3S2	80								
Type 3-3	80								
Lane-Type LL	N/A								
SU4	54								
SU5	62								
SU6	69.5								
SU7	77.5								
EV2	57.5								
EV3	86								

Notes:
1. Legend: sp = span; G = girder or stringer
2. Rating program used: AASHTOware Bridge Rating, Version ____ – ________ Engine.
3. Lane-Type LL = Lane-Type Legal Load.

QC/QA

Load Rating Engineer (LRE) Name / Firm Name:

Load Rating Reviewer (LRR) Name / Firm Name:

LRR Signature:
Load Rating Date:

☐ Previous LRFR Load Ratings have been Updated and/or Corrected

The load rating report, including all associated calculations and files, are confidential and for the Authority's use only. Any use of this information without the consent of the Authority is strictly prohibited.

LOAD RATING REVIEWER TO SIGN, DATE AND SEAL LOAD RATING SUMMARY SHEET

Figure 4.2-1 - Load Rating Summary Sheet for Typical Structures (Excel)

NEW JERSEY TURNPIKE AUTHORITY
BRIDGE LOAD RATING SUMMARY

EXISTING BRIDGE DATA

Bridge Number:	Last Inspection Date:
Span Type:	Inspected By (Firm):
Referenced Contract Dwgs:	Fracture Critical Members (Y/N):
Design Loading:	
Past Inv. Rating (HL93 or HS20):	
Past Oper. Rating (HL93 or HS20):	
Last Load Rating Date:	

BRIDGE LOAD RATING SUMMARY

Dead Load Data
Overlay Type:
Overlay Depth (in.):
Was Overlay Depth Measured (Y/N):
Weight of Utilities:
Weight of other Non-Structural Attachments:
Depth of Earth Fill (ft):
Earth Fill Type:

LRFR Evaluation Factors	As-Built	As-Insp.
Surface Roughness Rating:		
Dyn. Load Allow. (IM - HL-93):		
Dyn. Load Allow. (IM - Legal):		
Condition Factor:		
System Factor:		
ADTT (one way):		

CULVERT RATING SUMMARY

Vehicle Type	**Vehicle GVW (kips)**	**Controlling Flexure Rating Factor TS Mid**		**Controlling Flexure Rating Factor BS End**		**Controlling Shear Rating Factor Ext Wall**		**Controlling PM Rating Factor Ext Wall**	
		As-Built	As-Insp.	As-Built	As-Insp.	As-Built	As-Insp.	As-Built	As-Insp.
HL-93 (INV)	N/A								
HL-93 (OPR)	N/A								
Type 3	50								
NJ Type 3S2	80								
Type 3-3	80								
SU4	54								
SU5	62								
SU6	69.5								
SU7	77.5								
EV2	57.5								
EV3	86								

Notes:
1. Legend: TS Mid: Top Slab Mid-span, BS end: Bottom Slab End Section, Ext Wall: Exterior Wall, PM: Axial-Flexural
2. Rating program used: AASHTOware Bridge Rating, Version ____ – ________ Engine.

QC/QA

Load Rating Engineer (LRE) Name / Firm Name:

Load Rating Reviewer (LRR) Name / Firm Name:

LRR Signature:

Load Rating Date:

☐ Previous LRFR Load Ratings have been Updated and/or Corrected

The load rating report, including all associated calculations and files, are confidential and for the Authority's use only. Any use of this information without the consent of the Authority is strictly prohibited.

LOAD RATING REVIEWER TO SIGN, DATE AND SEAL LOAD RATING SUMMARY SHEET

Figure 4.2-2 - Load Rating Summary Sheet for Culverts (Excel)

NEW JERSEY TURNPIKE AUTHORITY

BRIDGE LOAD RATING SUMMARY

EXISTING BRIDGE DATA:

BRIDGE NUMBER:

REFERENCED CONTRACT DRAWINGS:

DESIGN LOADING:

LAST INSPECTION DATE:

INSPECTED BY (FIRM):

FRACTURE CRITICAL MEMBER: Y

DEAD LOAD DATA:

OVERLAY TYPE:

OVERLAY DEPTH (IN.):

WAS OVERLAY DEPTH MEASURED (Y/N):

WEIGHT OF UTILITIES:

WEIGHT OF OTHER NON-STRUCTURAL ATTACHMENTS:

LRFR EVALUATION FACTORS:

SURFACE ROUGHNESS RATING (AS-BUILT): 1

SURFACE ROUGHNESS RATING (AS-INSPECTED):

ADTT (ONE WAY) (AS-BUILT):

ADTT (ONE WAY) (AS-INSPECTED):

Version 1.1 February 2020

Figure 4.2-3a - Load Rating Summary Sheet for Typical Structures, Page 1 of 2 (InspectTech)

NEW JERSEY TURNPIKE AUTHORITY

LOAD RATING MEMBER SUMMARY **BRIDGE NUMBER:**

SPAN TYPE: CONDITION WHEN RATED:
PAST INVENTORY RATING: :

PAST OPERATING RATING: :
LAST LOAD RATING DATE:

CONDITION FACTOR (AS BUILT): (AS INSPECTED):
SYSTEM FACTOR:

DYNAMIC LOAD ALLOWANCE (HL-93) (AS-BUILT): (AS-INSPECTED):
DYNAMIC LOAD ALLOWANCE (LEGAL) (AS-BUILT): (AS-INSPECTED):

VEHICLE TYPE	VEHICLE GVW (KIPS)	CONTROLLING FLEXURAL RATING FACTOR (INTERIOR)		CONTROLLING FLEXURAL RATING FACTOR (EXTERIOR)		CONTROLLING SHEAR RATING FACTOR (INTERIOR)		CONTROLLING SHEAR RATING FACTOR (EXTERIOR)	
		AS-BUILT	AS-INSP.	AS-BUILT	AS-INSP.	AS-BUILT	AS-INSP.	AS-BUILT	AS-INSP.
HL-93(INV)	N/A								
HL-93(OPR)	N/A								
TYPE 3	50								
NJ TYPE 3S2	80								
TYPE 3-3	80								
LANE TYPE LL	N/A								
SU4	54								
SU5	62								
SU6	69.5								
SU7	77.5								
EV2	57.5								
EV3	86								

NOTES: 1. Legend: sp = span; G = girder or stringer
2. Rating program used: AASHTOware Bridge Rating, Version ____ – ________ Engine.
3. Lane-Type LL = Lane-Type Legal Load.

QC/QA:
LOAD RATING ENGINEER (LRE) NAME: ______________________
FIRM NAME: ______________________
LOAD RATING REVIEWER (LRR) NAME: ______________________
FIRM NAME: ______________________
LRR SIGNATURE: ______________________
LOAD RATING DATE: ______________________

☐ PREVIOUS LRFR LOAD RATINGS HAVE BEEN UPDATED AND / OR CORRECTED

The load rating report, including all associated calculations and files, are confidential and for the Authority's use only. Any use of this information without the consent of the Authority is strictly prohibited.

Figure 4.2-3b - Load Rating Summary Sheet for Typical Structures, Page 2 of 2 (InspectTech)

NEW JERSEY TURNPIKE AUTHORITY

BRIDGE LOAD RATING SUMMARY

EXISTING BRIDGE DATA:

BRIDGE NUMBER:

REFERENCED CONTRACT DRAWINGS:

DESIGN LOADING:

PAST INVENTORY RATING :

PAST OPERATING RATING :

LAST LOAD RATING DATE:

LAST INSPECTION DATE:

INSPECTED BY (FIRM):

DEAD LOAD DATA:

OVERLAY TYPE:

OVERLAY DEPTH (IN.):

WAS OVERLAY DEPTH MEASURED (Y/N):

WEIGHT OF UTILITIES:

DEPTH OF EARTH FILL (FEET):

EARTH FILL TYPE:

WEIGHT OF OTHER NON-STRUCTURAL ATTACHMENTS:

LRFR EVALUATION FACTORS:

SURFACE ROUGHNESS RATING (AS-BUILT): 1

SURFACE ROUGHNESS RATING (AS-INSPECTED):

ADTT (ONE WAY) (AS-BUILT):

ADTT (ONE WAY) (AS-INSPECTED):

Figure 4.2-4a - Load Rating Summary Sheet for Culverts, Page 1 of 2 (InspectTech)

NEW JERSEY TURNPIKE AUTHORITY

LOAD RATING MEMBER SUMMARY **BRIDGE NUMBER:**

SPAN TYPE:
CONDITION WHEN RATED:
CONDITION FACTOR (AS-BUILT):
CONDITION FACTOR (AS-INSPECTED):
SYSTEM FACTOR:
DYNAMIC LOAD ALLOWANCE (HL-93) (AS-BUILT):
DYNAMIC LOAD ALLOWANCE (HL-93) (AS-INSPECTED):
DYNAMIC LOAD ALLOWANCE (LEGAL) (AS-BUILT):
DYNAMIC LOAD ALLOWANCE (LEGAL) (AS-INSPECTED):

VEHICLE TYPE	VEHICLE GVW (KIPS)	Controlling Flexure Rating Factor TS Mid		Controlling Flexure Rating Factor BS End		Controlling Shear Rating Factor Ext Wall		Controlling PM Rating Factor Ext Wall	
		AS-BUILT	AS-INSP.	AS-BUILT	AS-INSP.	AS-BUILT	AS-INSP.	AS-BUILT	AS-INSP.
HL-93(INV)	N/A								
HL-93(OPR)	N/A								
TYPE 3	50								
NJ TYPE 3S2	80								
TYPE 3-3	80								
LANE TYPE LL	N/A								
SU4	54								
SU5	62								
SU6	69.5								
SU7	77.5								
EV2	57.5								
EV3	86								

NOTES:

1. Legend: TS Mid: Top Slab Mid-span, BS end: Bottom Slab End Section, Ext Wall: Exterior Wall, PM: Axial-Flexural
2. Rating program used: AASHTOware Bridge Rating, Version ____ – ________ Engine.

QC/QA:

LOAD RATING ENGINEER (LRE) NAME: ______________________
FIRM NAME: ______________________
LOAD RATING REVIEWER (LRR) NAME: ______________________
FIRM NAME: ______________________
LRR SIGNATURE: ______________________
LOAD RATING DATE: ______________________

☐ PREVIOUS LRFR LOAD RATINGS HAVE BEEN UPDATED AND / OR CORRECTED

The load rating report, including all associated calculations and files, are confidential and for the Authority's use only. Any use of this information without the consent of the Authority is strictly prohibited.

Figure 4.2-4b - Load Rating Summary Sheet for Culverts, Page 2 of 2 (InspectTech)

Made By: SEC Date: 09/06/2018
Checked By: APM Date: 09/07/2018

NEW JERSEY TURNPIKE AUTHORITY
SUMMARY OF UPDATES

The following summary identifies all updates and/or corrections made to the LRFR load ratings for **Structure MP12.34**:

Primary Reason(s) for Load Rating Updates:
As-Inspected Conditions; Changes to the Surface Roughness Rating

Updates/Corrections to AASHTOware's BrR file:

1. Updated the analysis using AASHTOware's BrR Version 6.8.2.
2. Modified the DW loading on all members to account for additional overlay on the bridge since the last inspection (See the load rating calculations for field measurements and computed wearing surface thickness).
3. Added As-Inspected MEMBER ALTERNATIVES for G2, G3 and G5 to BrR to include section loss (web) identified during the most recent inspection.
4. Modified the impact during the analysis to use a value of 33% for all legal loads due to a worsened riding surface condition observed during the most recent inspection.
5. Removed the live load distribution factors previously input for each member such that BrR will automatically compute the LRFR LLDFs during each analysis event (in accordance with the current NJTA LRFR Load Rating Manual, Appendix A1).

Updates/Corrections to the Supplemental Load Rating Calculations:

1. Computed additional wearing surface dead load on all members based on field measurements.
2. Performed supplemental calculations associated with additional section loss identified in the webs of members G2, G3 and G5.
3. Indicated a revised impact value to be used for legal loads based on a worsened riding surface condition.

Updates/Corrections to the Load Rating Summary Sheet:

1. Revised the overlay depth based on the most recent field inspection findings.
2. The controlling rating factors were updated based on an analysis which incorporates the above noted revisions.
3. The notes were updated to identify BrR Version 6.8.2.3002 as being used for this load rating updates.

Figure 4.3 – Summary of Updates (Example)

4.3 Quality Control and Quality Assurance Review of Load Ratings

Quality control procedures are intended to maintain the quality of the bridge load ratings and are usually performed continuously within the load rating teams/units. The LRE and LRR shall satisfy the requirements of Section 2.2, Qualifications and Responsibilities. Upon completion of the load rating, the initials of the LRR shall be placed on every sheet of the calculations. Failure to do this will be grounds for rejection of the submittal by NJTA.

In accordance with Section 7.e (Load Rating Quality Control) of the Authority's Bridge Inspection Program Quality Management Plan (latest version), upon completion of the load rating review, the LRR shall complete a QCF-3 form (Consultant Load Rating Checklist) to include with the load rating submission.

When computer programs are used, the LRR shall perform independent checks to validate the accuracy of the load rating results generated by the program. The LRR shall verify all input data, verify that the summary of load capacity information accurately reflects the analysis, and be satisfied with the accuracy and suitability of the computer program.

Quality assurance procedures are used to verify the adequacy of the quality control procedures to meet or exceed the standards established by the agency or the consultant performing the load ratings. Quality assurance procedures are usually performed independent of the load rating teams (LRE & LRR) on a sample of their work. Guidance on quality measures for load rating may be found in MBE Article 1.4.

4.4 Requirements for Load Rating of New or Rehabilitated Structures

While most existing bridge load ratings for the Authority have been performed as part of various New Jersey Turnpike and Garden State Parkway Group Bridge Inspections assignments, load ratings shall also be performed by design engineers in association with bridge rehabilitation or bridge design contracts (See the NJTA Design Manual, Structures Design, Section 3.2.1.2).

The Design Engineer shall submit, as a part of the Phase C submission, the complete As-Designed load rating analysis for all new bridges, and for all existing bridges subject to substantial modification. When ratings are performed in conjunction with the preparation of design drawings, the load rating results for all investigated live load models shall be shown on the General Notes sheet for each structure. In cases where primary members are unaffected by the design (partial rehabilitation, selective repairs, etc.), only the controlling ratings for the members affected by the design should be displayed. The analysis notes should clearly state which members are affected by the design and which members control the overall rating of the bridge. See Figure 4.4.1 for a sample rating factor summary table and associated recommended notes, and refer to the current NJTA Design Manual, Structures Design for a complete list of required design vehicles. Live load distribution factors used in the design and rating of structures shall also be noted on the structural drawings for all rating analyses other than line girder analyses. Dynamic Load Allowance should be conservatively assumed to be 33% during design for all vehicles (design, legal load, specialized hauling, and emergency vehicles) to eliminate the need for future load rating updates based on riding surface changes. For unique cases where only wearing surface modifications are performed, and legal load rating factors were previously found to be less than 1.00, a reduced Dynamic Load Allowance value can be considered (See Appendix A3).

For load ratings of rehabilitated structures, the consultant shall review and update (if needed) the previous load rating calculations and bridge model files to ensure accuracy prior to incorporating the rehabilitation. The consultant performing these updates shall be fully responsible for the correctness of the complete load rating submission (See Section 2.1.2).

CONTROLLING MEMBER RATING - INTERIOR STRINGER								
LRFR METHOD LIMIT STATE		DESIGN LOAD RATING (TP-16)		DESIGN LOAD RATING (HL-93)		STATE LEGAL LOAD RATING		
		INVENTORY	OPERATING	INVENTORY	OPERATING	TYPE 3	NJ TYPE 3S2	TYPE 3-3
STRENGTH I	FLEXURE	X.XX						
	SHEAR							
SERVICE								
FATIGUE								

CONTROLLING MEMBER RATING - INTERIOR STRINGER							
LRFR METHOD LIMIT STATE		SPECIALIZED HAULING VEHICLE RATING				EMERGENCY VEHICLE RATING	
		SU4	SU5	SU6	SU7	EV2	EV3
STRENGTH I	FLEXURE	X.XX					
	SHEAR						
SERVICE							
FATIGUE							

CONTROLLING MEMBER RATING - EXTERIOR STRINGER								
LRFR METHOD LIMIT STATE		DESIGN LOAD RATING (TP-16)		DESIGN LOAD RATING (HL-93)		STATE LEGAL LOAD RATING		
		INVENTORY	OPERATING	INVENTORY	OPERATING	TYPE 3	NJ TYPE 3S2	TYPE 3-3
STRENGTH I	FLEXURE	X.XX						
	SHEAR							
SERVICE								
FATIGUE								

CONTROLLING MEMBER RATING - EXTERIOR STRINGER							
LRFR METHOD LIMIT STATE		SPECIALIZED HAULING VEHICLE RATING				EMERGENCY VEHICLE RATING	
		SU4	SU5	SU6	SU7	EV2	EV3
STRENGTH I	FLEXURE	X.XX					
	SHEAR						
SERVICE							
FATIGUE							

(Recommended Notes, to be modified as necessary)

1. Load and resistance factor ratings have been performed using (BrR, Version x.x.x / BRASS Version x.x.x / specify other software).
2. The analysis of the girder to determine dead load and live load effects has been performed based on a (Line Girder Analysis / Finite Element Analysis / Grid Analysis considering the diaphragms to act as primary members).
3. The controlling HL-93 vehicle for the above members is the (Design Truck & Lane / Design Tandem & Lane / 90% of Two Design Trucks & 90% Lane).
4. Modifications via this contract have affected the load ratings for the following members: (Girders xx / Stringers xx / Floorbeams xx / (specify other members))
5. The load ratings shown are the controlling ratings for those members modified via this contract and (do / do not) represent the controlling rating for the entire bridge.
6. The overall controlling members for the entire bridge are (Girder xx / Stringer xx / Floorbeam xx / (specify other member)) (specify Exterior and Interior).

(Refer to Section 3.1.5 and Appendix A1 (Page A5, No. 11) for member numbering guidance, as it relates to Recommended Notes 4 through 6)

Figure 4.4.1 – Sample Rating Factor Table and Recommended Notes

The load rating summary sheet, as shown in Section 4.2, shall be used, but should be modified as follows when preparing the As-Designed load ratings:

- In lieu of the typical As-Built and As-Inspected rating conditions, the Design Engineer shall modify the sheet to identify the rating as an As-Designed rating. This indicates that the rating has been based entirely on the design drawings and has not been built and/or verified in the field via inspection.
- For rehabilitation and repair design, the overall controlling ratings of the bridge should be shown on the summary sheet, including members unaffected by the design.
- For all new bridges or new primary bridge members, the As-Designed superstructure rating summary section should include ratings for all design vehicles, as well as the standard design and legal vehicles specified in this manual for load ratings. Inclusion of all additional design vehicles in the As-Designed load rating analysis is intended to serve as a verification of the design, whereas all design rating factors are expected to be greater than 1.00 at the Inventory Level. Refer to the NJTA Design Manual, Structures Design (current version) for design criteria.

Following completion of construction for a new or rehabilitated bridge, the Design Engineer shall perform an updated load rating to capture any changes made during construction that may affect the previously calculated As-Designed load ratings. These revised load ratings shall be referred to as As-Built load ratings, and they shall be submitted in accordance with Section 4.4 of this manual. As-Built load ratings shall also be submitted in cases where there have been no changes made to the design during construction. In these cases, the As-Built load ratings may be identical to the As-Designed load ratings. Refer to Section 3.2.1.2 of the NJTA Design Manual, Structures Design (current version) for additional details and timing of the As-Built rating submission. The bridge inspection consultant responsible for performing the first biennial inspection following the completion of construction will be tasked with performing the As-Inspected ratings.

Fatigue shall be considered during design and shall be in accordance with the NJTA Design Manual, Structures Design, which references the AASHTO LRFD Bridge Design Specifications (current version), and the necessary design rating factors shall be shown on the drawings. However, Fatigue ratings are not required to be shown on the load rating summary sheet nor included in the LRFR load rating report.

The electronic input file for the load rating summary sheet and all other applicable load rating data shall be created by the Design Engineer and provided to the Authority in accordance with the requirements of Section 4.1.

4.5 Dissemination of Load Rating Results to Other Entities

All load rating files, reports, calculations, and bridge models are solely the property of the New Jersey Turnpike Authority. Further, the load rating results contained in the load rating report are confidential and for the use of the Authority or their consultants who are engaged in active contracts with the Authority. Any use of this information without the consent of the Authority is strictly prohibited.

To obtain access to load rating files, written permission shall be obtained from an Authority representative. Transmission of load rating data to the State as part of the biennial bridge inspection is part of the consultant’s scope of work and is therefore exempt from the above requirement.

SECTION 5 LOAD RATING OF CULVERTS

5.1 Introduction

With the addition of culvert rating capabilities in Virtis Version 6.4 and in subsequent versions of AASHTOWare's Bridge Rating (BrR) software, numerous culverts located throughout the New Jersey Turnpike (Turnpike) and Garden State Parkway (Parkway) roadways can or have been modeled using BrR. Current culverts located throughout both roadways consist of single cell box culverts, multiple cell box culverts, three-sided culverts, and multi-span reinforced concrete arch culverts. The National Bridge Inspection Standards (23 CFR 650.3) generally define bridges as structures with a span length greater than 20 feet. Load ratings of structures with a span length less than 20 feet are not currently required. Other structures which often are less than 20 feet in span length consist of reinforced concrete pipes and corrugated metal pipes. A small number of single span arch culverts exist throughout the length of the two roadways but are not considered bridge structures since the span lengths are less than 20 feet. The LRFR rating guidelines provided herein pertain to various bridge culvert types which are defined as "bridges" in the current NJTA bridge inventory.

5.2 AASHTO MBE Provisions for Culverts

The AASHTO Manual for Bridge Evaluation (MBE) 2013 Interim Revisions initially introduced LRFR provisions specific to the load rating of single and multiple cell reinforced concrete box culverts. Culverts experience loadings that are not applicable to most bridge superstructures, including vertical and horizontal soil loads, and live load surcharge. MBE Article 6A.5.12.1 incorporates LRFR provisions for cast-in-place and precast reinforced concrete box culverts but does not address culvert types such as three-sided culverts and arches. The procedures described herein apply to the LRFR rating of box culverts and three-sided culverts and supplement the MBE provisions.

5.3 BrR Capabilities for Culverts

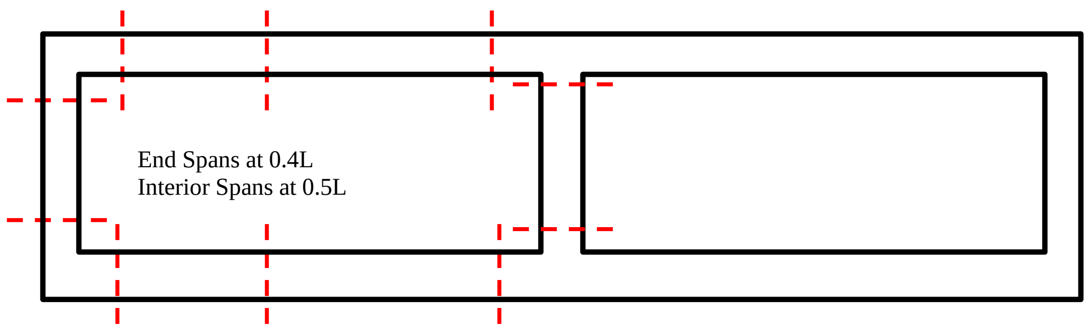
All culvert ratings shall be performed using the most current version of the AASHTOWare Bridge Rating (BrR) software, following the guidelines provided in this section and the Appendices. This program can perform LRFR ratings of single or multi cell box culverts, with or without a bottom slab, in accordance with the MBE (latest edition). This program currently does not have the capability to rate arch shaped culverts. Specific guidance on modeling of reinforced concrete box culverts and three-sided culverts can be found in Appendices A1 and A2.

5.4 Load Rating Requirements

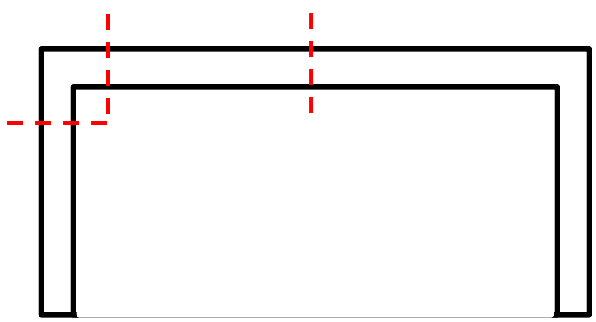
5.4.1 Sections

Culverts shall be evaluated at their critical sections for the force effects. Force demands at several critical sections must be calculated to establish the lowest load rating for a culvert structure. As shown in Figure 5.1, the typical critical sections are shown at the member ends, mid span and at shear critical locations. The load rating engineer shall review the culvert plans and verify that all critical sections have been included in the rating.

(a) Single Cell Box Culverts



(b) Multi Cell Box Culverts



(c)Three-Sided Culverts

Figure 5.1 - Typical Critical Sections for (a) Single Box, (b) Multiple-cell Box and (c) Rigid Frame with Pinned Base Columns

The exterior/interior walls of box culverts are subjected to significant axial loading. Thus, flexural-axial interaction shall be included in the LRFR ratings. Flexure controlled behavior at these locations is assumed when axial demand is less than 10% of the axial resistance. In such cases, the rating factor is governed by flexure.

The top and bottom slabs of multi-cell culverts usually behave as continuous beams where both negative and positive flexure should be evaluated. At the end spans of such culverts the maximum flexure is at a distance of 0.4L from the span end.

For three-sided culverts, if the bottom section of the wall is not detailed to resist moment, the culvert should be evaluated at the top section of the side walls and the top slab sections. If the bottom section of the wall is detailed to resist moment, the rating engineer should evaluate the bottom section of the wall as well.

Shear evaluation of slabs and walls are required and shall be performed at critical shear sections located a distance d_v away from the support. BrR will automatically check this location as part of the load rating analysis. The shear resistance shall be calculated per LRFD 5.7.3.3. For the section, where the simplified procedure in LRFD 5.7.3.4.1 for shear resistance does not apply, the general procedure in LRFD 5.7.3.4.2 shall be followed.

Table 5.1 Critical Sections for Reinforced Concrete Culverts

	Single-Cell Box	**Multi-Cell Box**	**Rigid Frame**
Top Slab End	M, V	M, V	M, V
Top Slab Mid-span	M	M (see Note.1)	M
Bottom Slab End	M, V	M, V	-
Bottom Slab Mid-span	M	M (see Note.1)	-
Ext. Wall Top	V, PM	V, PM	V, PM
Ext. Wall Bottom	V, PM	V, PM	V (see Note.2)
Int. Wall Top	-	V, PM	-
Int. Wall Bottom	-	V, PM	-

Notes

M: Flexure, V: Shear, PM: Axial-Flexure Interaction.

Note 1 At the end span of multi-cell box culverts, the critical moment is located at a distance 0.4L from the span end.

Note 2 Where culverts are not rigidly connected to the footing and do not resist moment. If moment resisting details are present, a PM evaluation is required.

5.4.2 Limit States

Concrete culverts shall be rated for the Strength I limit state for design and legal loads, and for the Strength II limit state for permit loads. The applicable loads and load combinations for the evaluations are specified in Table MBE 6A.5.12.5-1. Maximum and minimum load factors for different loads should be combined to produce the largest load effect. For instance, in some cases the dead load effects may add to the live load effects, in which case maximum dead load factors should conservatively be used. In other cases, the dead load effects on the box culvert may counteract the live load effects, essentially reducing the total force effects. In such cases the minimum dead load factors are used. It should be noted that BrR will automatically perform this comparison and utilize the controlling load factors during analysis.

The service limit state for crack width control need not be checked when load rating reinforced concrete culverts as these structures are subject to high compressive thrust forces.

The optional provision to use the Service I Limit State for Permit Load ratings to check the stresses in the reinforcing bars nearest the extreme tension fiber of the member is not required for culvert ratings.

For culverts with high earth fill depths, it is prudent to also perform an evaluation of the culvert under permanent loads only as the earth-fill depth may have been increased since the original construction (See Section 5.4.3). The Authority Liaison should be contacted prior to performing this type of analysis.

5.4.3 Culvert Load Rating Deliverables

The AASHTO Manual for Bridge Evaluation (MBE) allows live load effects to be neglected in cases where single and multi-span culverts are under significant depths of fill (See Section 5.6.1).

For all bridge culverts with span lengths of 20 feet or greater and live load distribution to the buried structure (See Section 5.6.1), refer to Section 4 for all load rating deliverable requirements.

For all bridge culverts with span lengths of 20 feet or greater, but no live load distribution to the buried structure per Section 5.6.1, the following shall apply when submitting the load rating report and associated files:

- All load rating working files, as specified in Section 4, shall be submitted
- A complete bridge model (using BrR or other software) shall be created, verified, and submitted
- A review and analysis of the structure should be performed, for permanent loads only, to verify that the structure can adequately support all permanent loads (See MBE Section 6A.5.12.10.3a)
- Provided the structure can adequately support all permanent loads, a load rating report should be prepared, utilizing engineering judgment to complete the load rating summary sheet

5.5 LRFR Load Rating Equation for Culverts

For the Strength Limit State, the Rating Factor (RF) per MBE 6A.5.12.4-1 is:

$$RF = \frac{C \pm \gamma_{DC}\, DC \pm \gamma_{DW}\, DW \pm \gamma_{EV}\, EV \pm \gamma_{EH}\, EH \pm \gamma_{ES}\, ES}{\gamma_{LL}(LL + IM) \pm \gamma_{LS}\, LS}$$

$$C = \varphi_C\, \varphi_S\, \varphi\, R_n$$

RF	=	Rating factor
C	=	Capacity
R_n	=	Nominal member resistance (As-Built and As-Inspected)
DC	=	Dead load effect due to structural components and attachments
DW	=	Dead load effect due to wearing surface and utilities
EV	=	Vertical earth pressure
EH	=	Horizontal earth pressure
ES	=	Uniform Earth Surcharge
LL	=	Live load effect
IM	=	Dynamic load allowance
LS	=	Live load surcharge
γ_{DC}	=	LRFD load factor for structural components and attachments
γ_{DW}	=	LRFD load factor for wearing surfaces and utilities
γ_{EV}	=	LRFD load factor for vertical earth pressure
γ_{EH}	=	LRFD load factor for horizontal earth pressure
γ_{ES}	=	LRFD load factor for earth surcharge
γ_{LL}	=	Evaluation live load factor
γ_{LS}	=	LRFD load factor for live load surcharge
φ_c	=	Condition factor
φ_s	=	System factor

φ = LRFD resistance factor

Note that for the evaluation of Earth Pressure loads (EV, EH, ES), the provisions in MBE 6A.5.12.10.2 shall apply.

5.5.1 Condition Factor

Condition factors shall be taken as presented in MBE Table 6A.4.2.3-1.

5.5.2 System Factor

The system factor for Strength limit states for concrete culverts shall be taken as 1.0.

5.5.3 Resistance Factors

Resistance factors for concrete members for the Strength limit state shall be taken as specified in LRFD Design Article 12.5.5, which further references LRFD Table 12.5.5-1.

Table MBE 6A.5.12.5-1 Limit States and Load Factors for Culvert Load Rating

Bridge Type	Limit State	DC		DW		Design Load[1]		Legal Load[2]	Permit[2] Load	LS		EH[3]		EV		ES[4]	
		Max	Min	Max	Min	Inv.	Opr.			Max	Min	Max	Min	Max	Min	Max	Min
		γ_{DC}	γ_{DC}	γ_{DW}	γ_{DW}	γ_{LL}	γ_{LL}	γ_{LL}	γ_{LL}	γ_{LS}	γ_{LS}	γ_{EH}	γ_{EH}	γ_{EV}	γ_{EV}	γ_{ES}	γ_{ES}
Reinforced Concrete Box Culvert	Strength I	1.25	0.90	1.50	0.65	1.75	1.35	2.00	—	Same as LF for Design / Legal loads	0.00	1.35	0.90	1.30	0.90	1.50	0.75
	Strength II	1.25	0.90	1.50	0.65	—	—	—	Table 6A.4.5.4.2a-1	Same as LF for Permit Loads	0.00	1.35	0.90	1.30	0.90	1.50	0.75

Notes:
1 In addition to the load factor, use the 1.2 multiple presence factor for single lane loading.
2 Multiple presence factor is not included and is not required for single lane loading.
3 Use a 50% reduction to EH for rating positive moment in top slabs; need not be combined with the minimum load factor.
4 Use a 50% reduction to ES for rating positive moment in top slabs; need not be combined with the minimum load factor.
Water loads on interior walls are neglected.

5.6 Live Loads and Distributions

5.6.1 Live Load Distribution

For load rating culverts for the HL-93 design load, only the axle loads of the design truck or the design tandem, without the lane load, shall be applied.

For traffic traveling parallel to the span, box culverts shall be load rated for a single loaded lane with the following multiple presence factors:

- Design Load— LRFD single-lane multiple presence factor (1.2) shall be applied to the load.
- Legal Loads — Only the single lane loaded condition needs to be checked for legal load ratings, even when the culvert carries multiple lanes. A single legal load factor of 2.00 is specified for all traffic volumes. Omit the 1.2 single lane multiple presence factor.

Load factors for load rating shall be selected from Table MBE 6A.5.12.5-1.

The distribution of wheel loads for culverts with less than 2.0 ft of fill shall be taken as specified in LRFD Design Article 4.6.2.10. Distribution of wheel loads to culverts with 2.0 ft or more of fill shall be as specified in LRFD Design Article 3.6.1.2.6. For single span culverts with depth of fill more than 8 ft, and for multiple span culverts where the depth of fill exceeds the distance between faces of end walls, the effects of live load may be neglected since the live load will constitute a negligible portion of the overall loading. The Authority Liaison should be contacted prior to performing this type of analysis.

5.6.2 Impact Factor

The dynamic load allowance for culverts shall be taken as given in LRFD Design 3.6.2.2 except that, for slow moving (≤ 10 mph) permit vehicles, the dynamic load allowance shall be taken equal to zero.

5.6.3 Permit Loads

Only the single lane loaded condition needs to be checked for permit load ratings, even when the culvert carries multiple lanes. Culvert permit load ratings shall be based on the Strength II limit state and the permit truck live load factor shall be taken from MBE Table 6A.4.5.4.2a-1.

REFERENCE PUBLICATIONS

1. AASHTO *Manual for Bridge Evaluation,* Third Edition, including 2019 interim revisions.

2. New Jersey Turnpike Authority Design Manual, February 2020.

3. FHWA. 2002. *Bridge Inspector's Reference Manual (BIRM)*, Federal Highway Administration, U.S. Department of Transportation, Washington, DC.

4. AASHTO LRFD *Bridge Design Specifications*, 8^{th} Edition, including all subsequent interim revisions.

5. NCHRP Report 575; *Legal Truck Loads and AASHTO Legal Loads for Posting,* 2006.

6. NCHRP Report 454; *Calibration of Load Factors for LRFR Evaluation,* 2001.

7. NJDOT Bridges and Structures Design Manual, Latest Edition.

APPENDIX A BrR GUIDANCE

APPENDIX A1 AASHTOWare BrR - Guidelines for LRFR Ratings

This Appendix will be utilized to provide more specific BrR load rating guidance, and has been based primarily upon BrR, Version 6.6. This Appendix assumes the reader is familiar with the BrR load rating software. Also, this document is not to be treated as a User's Manual, but instead is intended to provide some useful program notes and specific guidance regarding LRFR load ratings for NJTA. Unless noted as **(OPTIONAL)**, all direction listed below must be utilized when creating the BrR model or performing load ratings. Items in all capital letters refer directly to specific BrR commands, windows, tabs, etc.

BRR CURRENT VERSION

1. The current version of AASHTOWare's Bridge Rating software is version 6.8.4.3002. All load ratings performed for the Authority shall utilize this version, including all applicable Maintenance Releases and Technical Note updates to the software, unless otherwise directed by the Authority. There are now two analysis engine options in this version of the software. See below under "MEMBER ALTERNATIVE DESCRIPTION – SPECS" for further details.

BRR UPDATES, CRITICAL BUGS, ETC.

1. At least one contact from each company performing load ratings should subscribe to the AASHTO BrDR Mailing List. This list is the sole means of communication between AASHTOWare and the user. By subscribing to this mailing list, this ensures that proper notifications will be received when program updates are available (Service Packs), critical errors have been uncovered or corrected, or general BrR information must be distributed. With the recent change in AASHTOWare Bridge Design-Rating (BrDR) Enhancement and Support Contractor from Michael Baker to ProMiles, a new AASHTOWare website has been developed, but the previous self-subscribe mailing list feature has not yet been replicated on the new website. The implementation of a self-subscribe mailing list on the new website is being planned by ProMiles for the end of 2020, at which time the previous mailing list will be reinstituted via migration to the new mailing list. Until that time, all users should reach out to AASHTOWare Support (BrDR@promiles.com) or visit the below new website to maintain up-to-date software knowledge:

   https://www.aashtowarebridge.com

FILE NAMING

1. All BrR files will possess two unique identifiers, a BRIDGE ID and a NBI STRUCTURE ID. The bridge ID should consist of the MP appended to the actual milepost number (and direction, if applicable) of the structure. The NBI STRUCTURE ID should be identical to the NBI Structure ID as noted on the structure's SI&A forms and can be a maximum of 8 characters. Below are two examples:

   Structure at MP 28.0S on the Garden State Parkway:
   BRIDGE ID= MP28.0S
   NBI STRUCTURE ID=360280S

   Structure at MP 23.12 on the New Jersey Turnpike:
   BRIDGE ID = MP23.12
   NBI STRUCTURE ID = M023120

2. The BrR .xml file name should be identical to the above BRIDGE ID.

BRR LIBRARY

1. It should be noted that the existing Type 3S2 vehicle in BrR (72 kips) is not the same as the NJTA Type 3S2 (80 kips) vehicle per this Load Rating Manual and NJTA specifications. Therefore, the load rating engineer should create a new Type 3S2 vehicle in the LIBRARY (recommended name: NJTA Type 3S2). Be sure to select the correct 3S2 vehicle when performing NJTA load ratings.

MEMBER ALTERNATIVE DESCRIPTION – SPECS

This tab has been added as part of BrR version 6.3. See below for specific notes pertaining to its use.

1. For LRFR ratings, the Legacy AASHTO engine should be used for all ratings. The previously available BRASS engine, which was available in Version 6.2, is no longer available directly from BrR. If required, the BRASS load rating engine capabilities can be enabled if the engineering firm or agency possesses a separate BRASS license. Contact AASHTOWare or BRASS (Wyoming DOT) for guidance.

2. There are now two AASHTO engine options: Legacy AASHTO (existing) and AASHTO (new). When importing existing BrR files into Version 6.8.4, the LRFR engine will be automatically set to the Legacy AASHTO engine, thus requiring no additional effort when updating existing load ratings.

3. For all LRFR load ratings, the load rating engineer should select the most current SPEC VERSION. Note that Versions 6.3 and later now allow for both Legal loads and Specialized Hauling Vehicles to be run using the same FACTORS file.

MEMBER ALTERNATIVE DESCRIPTION - CONTROL OPTIONS

The BrR default settings are typically sufficient for load rating purposes, however, the following specific direction should be followed when performing LRFR load ratings using BrR.

1. POINTS OF INTEREST shall be generated at TENTH POINTS, SECTION CHANGE POINTS, AND USER-DEFINED POINTS. If needed, the load rating engineer can also generate points of interest at STIFFENERS.

2. The CONTROL OPTIONS tab within each MEMBER ALTERNATIVE window lists various settings for the different types of analyses and design. For LRFR, one specific control option listed is ALLOW PLASTIC ANALYSIS. This option should be selected for the rating of all steel members, with the exception of built-up riveted members (See MBE Section 6A.6.9.6). This will allow BrR to compute various plastic section properties required for the LRFD compactness checks (AASHTO sec. 6.10.6.2.2) for composite sections in positive flexure.

3. For LRFR for non-composite sections or composite sections in negative flexure, USE APPENDIX A6 FOR FLEXURAL RESISTANCE should be considered under CONTROL OPTIONS. The AASHTO LRFD code, sec. 6.10.6.2.3 does not perform compactness checks and will automatically assume a non-compact section for these member types. By using Appendix A6, additional compactness checks will be performed, and increased flexural resistances will be used if the section is indeed compact. Note that BrR will automatically check several criteria prior to use based on checking this box. It is recommended that Appendix A6 be considered in cases where continuous steel structures are present and are yielding low rating results (**OPTIONAL**).

BrR MODELING

These BrR MODELING notes have generally been provided in order of BrR input and following the BrR tree view from the top down.

1. Average Daily Truck Traffic (ADTT) is required for input, must be based on one-way traffic, and shall be determined based upon Section 3.1.3 of this manual. For analysis, ADTT shall be input in the RECENT text box. BrR will not use any ADTT values input in the DESIGN text box when performing LRFR load ratings.

2. Member shapes can often be selected from the BrR library of shapes, however, the load rating engineer should review all member dimensions to ensure they match with those shown on As-Built drawings, contract drawings, or previous rating calculations. Older structures may require manual input of member properties.

3. Parapet dead load (placed after the deck has cured) should be distributed to the fascia, first interior, and second interior members via a 50/35/15 percent distribution. This can be accomplished multiple ways. Options 1 and 2 have been used for several years, while Option 3 has recently been added via enhanced features first included in Version 6.7.

    1. One way this can be accomplished is to set the SUPERSTRUCTURE LOADS / DL DISTRIBUTION / STAGE 2 DL DISTRIBUTION method to USER DEFINED. The user can then input the appropriate dead load values (typically DC2 load case) for each member within each MEMBER ALTERNATIVE using the MEMBER LOADS window. Note that for cases with wearing surface input via the STRUCTURE TYPICAL SECTION / WEARING SURFACE tab, setting the DL distribution to USER DEFINED will cause BrR to ignore any wearing surface dead load information. Thus, the user must also manually compute this wearing surface dead load per member, and input the computed values using the MEMBER LOADS window.

    2. A second option for dead load application in BrR would be to maintain the default setting of SUPERSTRUCTURE LOADS / DL DISTRIBUTION / STAGE 2 DL DISTRIBUTION / UNIFORMLY TO ALL GIRDERS. This would allow the wearing surface to be computed correctly if input using the STRUCTURE TYPICAL SECTION / WEARING SURFACE tab. However, the user should change the concrete unit weight within all parapet and median APPURTENANCES to 0.00 kcf, and further manually compute these values and input in the MEMBER LOADS window for each affected member. This allows for the parapets or medians to remain to be assigned via the STRUCTURE TYPICAL SECTION / PARAPET tab, and also display in the STRUCTURE TYPICAL SECTION SCHEMATIC view. It is recommended that the actual parapet dimensions be input via the APPURTENANCES window to allow for correct display in the SCHEMATIC view, and to help to visually confirm that the travelway data agrees with the roadway width and parapet dimensions.

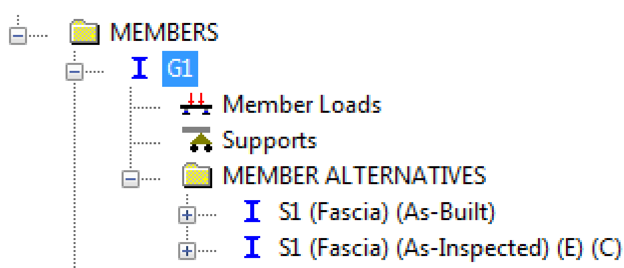
    3. A new feature has been added to Version 6.7 and later which allows for Stage 1 and/or Stage 2 dead load distribution by percentage. This distribution can be accessed via the SUPERSTRUCTURE LOADS / DL DISTRIBUTION tab. Since this version was released in the summer of 2015 at a time when nearly all Authority bridges were already modeled in BrR, it is unlikely that this method of parapet dead load distribution has been utilized for existing BrR models. However, the

load rating engineer should be aware of this feature, as it could be used in the event of barrier replacement, bridge replacement, or new bridge construction.

4. **NEW FOR VERSION 6.3**: Only one NJTA specific LRFR load factor file is currently required under SPECS / FACTORS / LRFR, if the model is set up to utilize this FACTOR file. The "set up" process entails linking each MEMBER ALTERNATIVE to the defined LRFR FACTOR FILE from within each MEMBER ALTERNATIVE / SPECS tab. It is not sufficient to simply add the FACTOR file to the model without this necessary linking to each member. For simplicity, the model can also be set up to utilize the SYSTEM DEFAULT settings under SPECS / SELECTION TYPE, which is the most common load factor approach for Authority BrR models. Note that separate load factor files, previously named Load Case A (HL-93, 3, 3S2, 33) and Load Case C (SU4, SU5, SU6, SU7), are no longer needed.

5. All BrR model superstructures shall be created as a GIRDER SYSTEM, such that ALL longitudinal primary members are individually modeled (MEMBER ALTERNATIVES). BrR Version 6.5 and subsequent versions now allows for REINFORCED CONCRETE SLAB SYSTEM ratings to be performed, in lieu of modeling them as a GIRDER LINE as was required in Versions 6.4 and prior. If an existing slab currently modeled as a GIRDER LINE (1' strip) is modeled correctly and is free from errors, the slab need not be remodeled as a REINFORCED CONCRETE SLAB SYSTEM unless noticeable benefits are determined to be provided by modeling a slab as a slab system.

   - When incorporating section losses into the BrR model, a separate MEMBER ALTERNATIVE for the member that exhibits section loss should be created. This will allow for the original, As-Built condition to be retained in the model. The As-Inspected MEMBER ALTERNATIVE should be set to EXISTING / CURRENT (E) (C) to ensure that any runs of complete spans or structures from the BRIDGE WORKSPACE or BRIDGE EXPLORER view utilize the As-Inspected MEMBER ALTERNATIVE. See below for a graphic representation of this requirement:



   If there are no section losses present for a given structure and the condition factor is identical for the As-Built and As-Inspected cases ($\varphi_c = 1.0$), only one MEMBER ALTERNATIVE (As-Built) needs to be created. Do not create an As-Inspected MEMBER ALTERNATIVE identical to the As-Built MEMBER ALTERNATIVE unless necessary, as this will lead to an unnecessary increase in file size for all bridges.

6. All spans shall be discretely modeled in BrR and contained in ONE .xml file (Ex., for a structure with 3 identical simple spans, each individual simple span must be created in BrR; this can easily be done by creating one SUPERSTRUCTURE DEFINITION, then copying and pasting for the remaining 2 spans; in this case the SUPERSTRUCTURE DEFINITION names would be Span 1, Span 2, and Span 3).

7. Diaphragm dead load should be computed by the load rating engineer and input within the FRAMING PLAN DETAIL window. The DIAPHRAGM LOADING SELECTION is not required for typical line girder analyses and is only required for analysis of curved girder

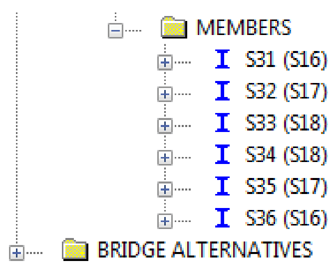
structures, in which case it allows for generation of the diaphragm live load force effects in the BrR output. The BRACING SPEC CHECK SELECTION and DIAPHRAGM DEFINITIONS data need not be input for girders analyzed using a line girder analysis. These parameters are used only when performing a 3D finite element analysis of straight or curved girders.

8. The wearing surface dead load (if present) should be input in the STRUCTURE TYPICAL SECTION / WEARING SURFACE window. This thickness should be assigned an appropriate unit weight based on the material and should also be assigned to the DW load case. See #3 above as it pertains to wearing surface dead load computed by the program if SUPERSTRUCTURE LOADS / DL DISTRIBUTION / STAGE 2 DL DISTRIBUTION is set to USER DEFINED.

9. CONNECTORS and SHEAR CONNECTORS for steel structures do not need to be input into BrR for the purposes of load rating. However, the presence of shear connectors must be acknowledged (under DECK PROFILE / SHEAR CONNECTORS for steel members) for composite action to be considered by BrR.

10. Do not link MEMBER ALTERNATIVES within BrR.

11. Spans and members shall be numbered in accordance with the current bridge inspection report. In cases where the member numbering shown on the plans differs from the member numbering shown in the bridge inspection report, the load rating engineer can place the plan designation in parentheses after the bridge inspection report member designation in BrR. All reference to these members throughout the calculations and on the load rating summary sheet should be based on the bridge inspection report member numbering. See below for an example:



12. For bridges that are oriented in a west-east direction and follow the WE/SN numbering convention, for modeling in BrR, identifying member alternative names will often need to be modified. This is because BrR numbers girders from left to right when looking station ahead, and for a west-to east continuous span, BrR will number the girders from north to south. In such a case, rename the girders so that they are numbered from south to north. Framing plan member numbering based on plan designation can be appended to the end of the member name in BrR as discussed above (i.e., S##(##) or G##(##)).

13. Additional dead load (web stiffeners, utilities, etc.) can be input into the program via the MEMBER LOADS window for a uniform load or can be input via MEMBER ALTERNATIVE / DESCRIPTION / ADDITIONAL SELF LOAD in terms of kips/ft or percentage. Note that BrR will not automatically compute the dead load due to transverse or longitudinal stiffeners input in the program.

14. Live load distribution factors, located within each MEMBER ALTERNATIVE under LIVE LOAD DISTRIBUTION, should be left blank when creating BrR models. BrR will automatically compute the live load distribution factors (for LFR or LRFR) during each analysis event when left blank. If the user populates these text boxes prior to an analysis event by using the COMPUTE FROM TYPICAL SECTION BUTTON, BrR will populate these

text boxes and will not autocompute during each analysis event. This may lead to errors or omissions if member spacing, beam shape, specifications, or other parameters used in live load distribution factor calculations are changed after the live load distribution factors are computed from the typical section. The live load distribution factors computed by the program can be reviewed by clicking on the VIEW ANALYSIS OUTPUT button and further selecting SUMMARY OF COMPUTED DISTRIBUTION FACTORS. This may be needed for designers who are performing an initial load rating as part of their design. Load ratings performed which utilize the current Edition LRFD Bridge Design Specifications may result in changes to the live load distribution factors when compared to previous load ratings in cases where the LIVE LOAD DISTRIBUTION factors have been left blank.

15. The DECK PROFILE / REINFORCEMENT window allows for input of the longitudinal deck reinforcement for slab on beam bridges. For members that are not composite, this data need not be entered. For composite members, the following is recommended as a guide for input:

    Simple spans – reinforcement need not be input (increase in ratings due to mild steel in deck will be negligible)

    Continuous spans – input reinforcement for the full length of the member; and further include any additional negative moment steel provided in the deck

    In cases where low legal load ratings are computed for composite members, consideration shall be given to including all deck steel in the model to increase the ratings.

16. If the load rating engineer should prefer to rate an entire span (all EXISTING members in one span) from the BRIDGE EXPLORER view, a BRIDGE ALTERNATIVE, SUPERSTRUCTURE, and SUPERSTRUCTURE ALTERNATIVE must be created under the BRIDGE ALTERNATIVES folder within the BRIDGE WORKSPACE view. All members identified as CURRENT AND EXISTING will be rated based on their designation within BrR.

<u>LOAD RATING VEHICLES</u>

1. Remember that additional LANE TYPE LEGAL LOADS should be considered when rating continuous spans or spans greater than 200 feet in length. When considering the LANE TYPE LEGAL LOAD in the rating for continuous spans, the LEGAL PAIR checkbox must be selected in the ADVANCED ANALYSIS SETTINGS to ensure a pair of legal trucks is considered in the analysis. Please refer to Section 3.2.3 and Figure 2 of this Load Rating Manual for details.

2. **NEW FOR VERSION 6.3**: Legal load vehicles Type 3, NJ Type 3S2, Type 3-3, Lane Type Legal Load, EV2 and EV3 should be input as ROUTINE LEGAL LOADS in BrR, and the Specialized Hauling Vehicles SU4 through SU7 should be input as SPECIALIZED HAULING LEGAL LOADS in BrR. The method of performing two separate BrR runs to consider all of the above vehicles, which was required in Versions 6.2 and prior, is no longer needed.

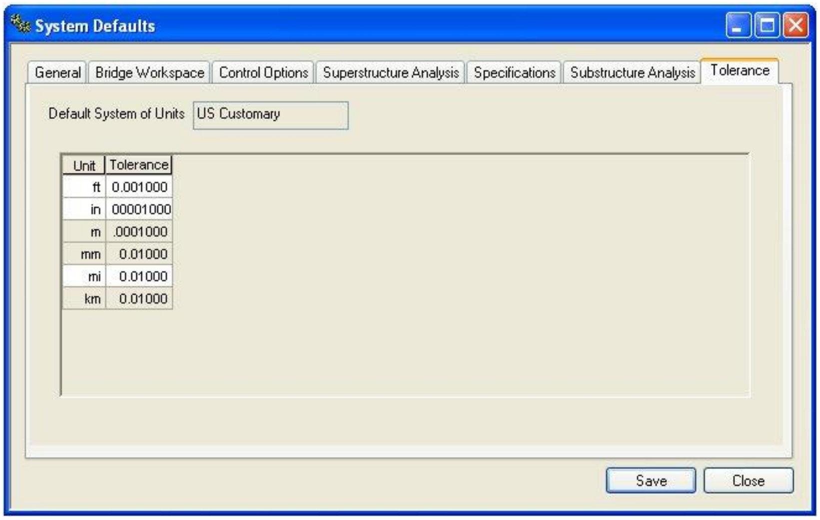
<u>BrR OUTPUT</u>

1. When the load rating analysis has been completed, the load rating engineer can left-click on the VIEW ANALYSIS REPORT icon on the toolbar to view a summary of load rating results. One significant limitation with BrR is the presentation of this data following a load rating analysis. Note that only the controlling rating factors are displayed in this table. <u>New in Version 6.4</u>: Following an analysis, the user can select the REPORT TOOL icon on the toolbar, and further select LRFR ANALYSIS OUTPUT as the REPORT TYPE, then left click

GENERATE. This will create an interactive, web-based summary of all load rating results for all vehicles (STRENGTH (Flexure and Shear) and SERVICE Limit States).

BrR TOLERANCE SETTINGS

1. BrR tolerance settings can be reviewed by clicking on the CONFIGURATION BROWSER icon, then double-clicking SYSTEM DEFAULTS and selecting the TOLERANCE tab. All BrR default settings should typically be set to the following dimensions. It is unlikely that these values will deviate from the below default values, however, if the load rating engineer is unable to reproduce previous ratings computed using BrR, the tolerance settings should always be reviewed when checking the accuracy of the model.



BrR GUIDELINES FOR RATINGS OF CONCRETE BOX AND FRAME CULVERTS

Version 6.4 (and later versions) of BrR Software includes LRFR evaluation capabilities for reinforced concrete culverts. The program is capable of analyzing and rating single and multi-cell box culverts with and without a bottom slab.

MODELING CULVERTS IN BRR

All NJTA culverts capable of being load rated using this software shall be rated in accordance with the requirements of this section.

Some of the required input for load ratings of reinforced concrete box culverts using AASHTOWare's Bridge Rating (BrR) software has been reviewed, and the following information has been provided for use in performing culverts ratings for the Authority. Focus below is on the input parameters unique to the rating of reinforced concrete box culverts.

Note that this guidance does not supersede sound engineering judgment, nor should it be blindly used for all culvert ratings. It is the responsibility of the load rating engineer and load rating reviewer to ensure that the parameters input into BrR are reasonable and appropriate for the structure being load rated.

Also, in the event of legal load rating factors less than 1.00, all assumptions made in the load rating should be reviewed to ensure they are not overly conservative.

A tree view of a typical culvert model in BrR (Version 6.4 shown) is given in Figure.A5.2

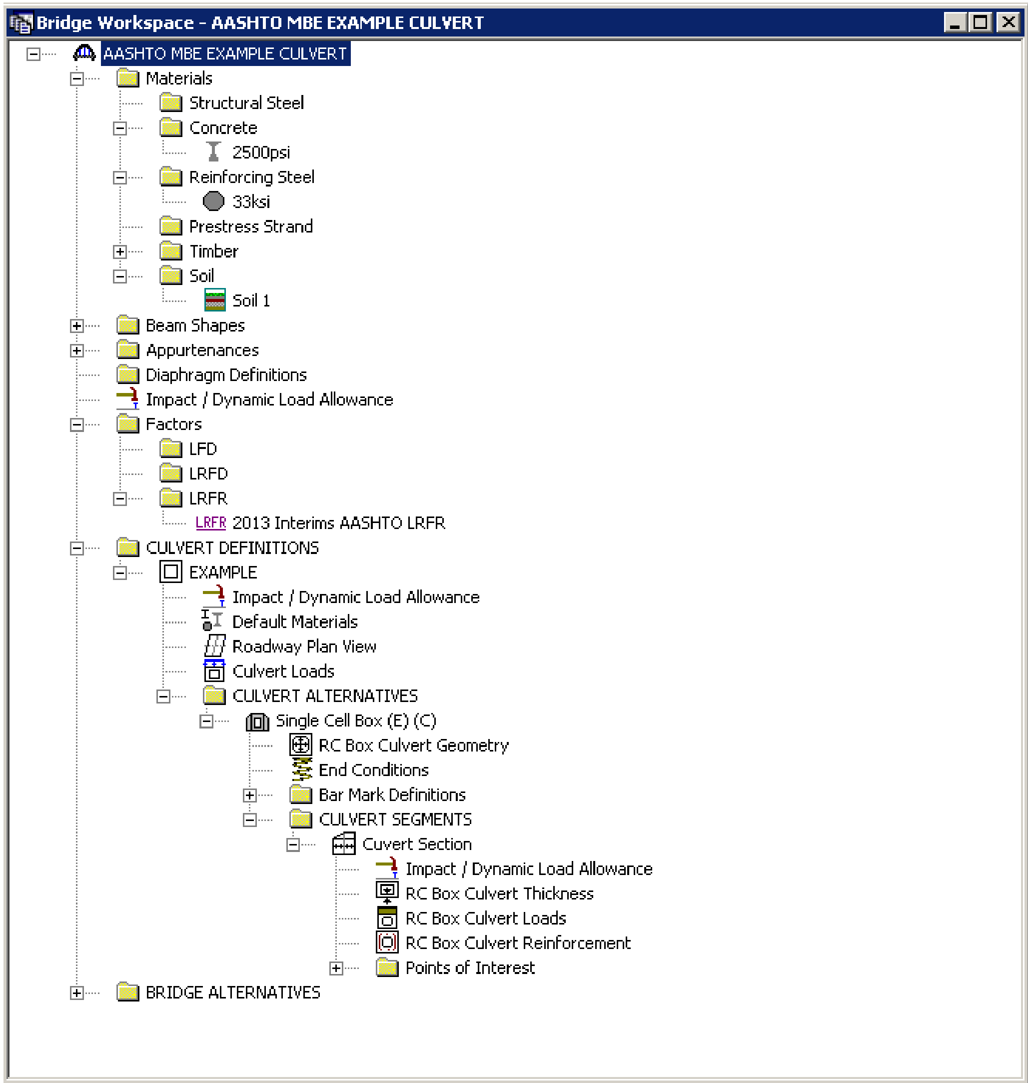


Figure.A5.2 Tree View of AASHTO-MBE Example Box Culvert

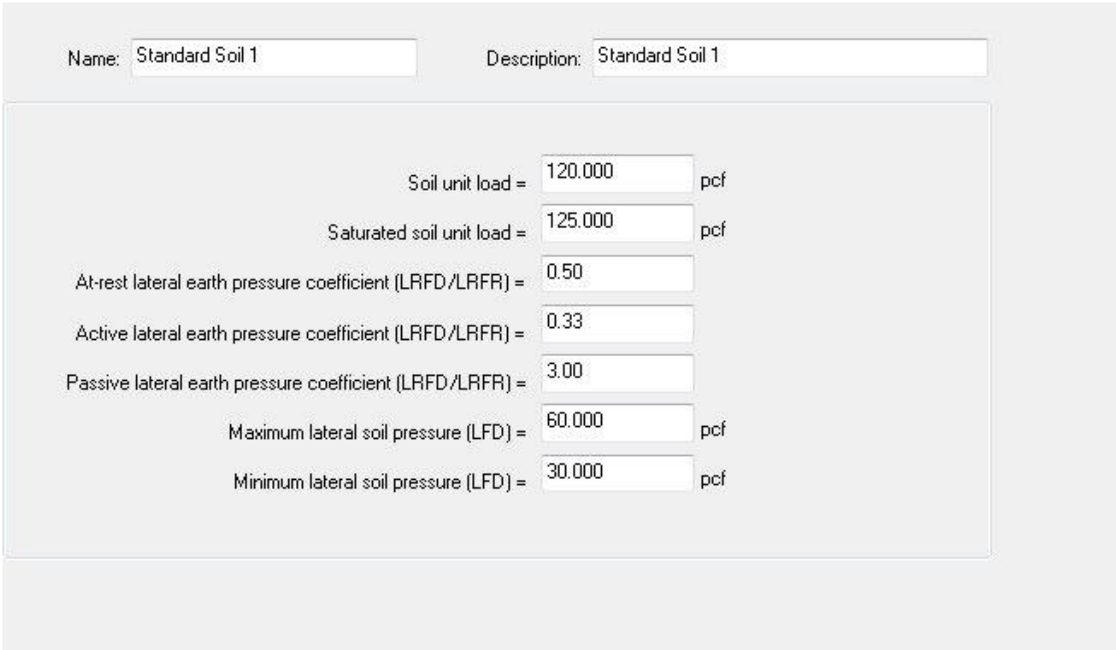


Figure A5.3 – Materials - Soil

Figure A5.3 represents the input window required for any soil defined within BrR. In most cases, this information is not included on the design drawings. Further, the Manual for Bridge Evaluation (current version) also does not necessarily specify values to be used when this information may not be known. Below is a brief discussion of the above, with guidance regarding selection of values if unknown.

Soil Unit Load
The above value of 120 pcf is an acceptable value to use when this is unknown. See LRFD Table 3.5.1-1, which shows that this value represents a typical unit weight for a sand, silt, and clay type soil.

Saturated Unit Load
The above value of 125 pcf is an acceptable value to use when this value is unknown.

Earth Pressure Coefficients
The following earth pressure coefficients may be used in situations where this information is not specified on the drawings or in the design calculations (if available). It should be noted that these values are typically conservative and appear to be based upon a drained friction angle (Φ) of 30 degrees.

At-rest lateral earth pressure coefficient (LRFD/LRFR) = 0.5
Active lateral earth pressure coefficient (LRFD/LRFR) = 0.33
Passive lateral earth pressure coefficient (LRFD/LRFR) = 3.00

Maximum and Minimum Lateral Soil Pressure (LFD)
This input parameter is not required for LRFR load ratings. It is acceptable to utilize the above noted values of 60 pcf (maximum) and 30 pcf (minimum) for all LRFR load ratings.

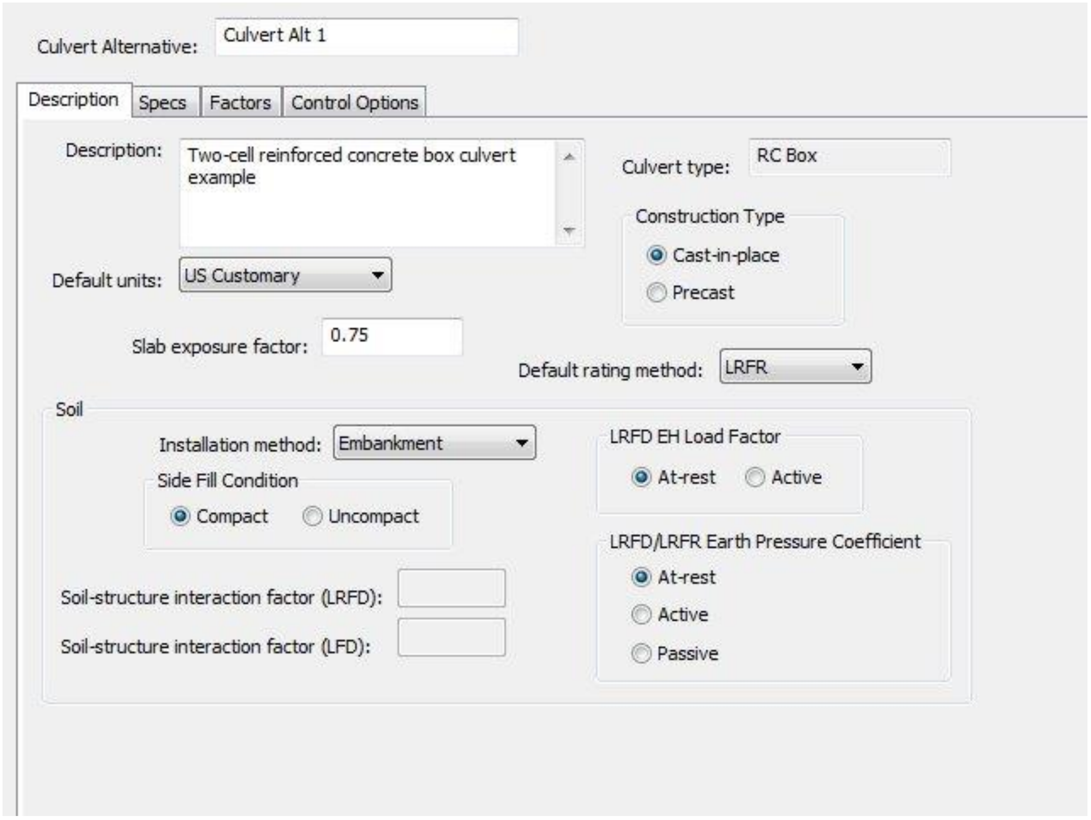


Figure A5.4 – Culvert Member Alternative – Description Window

Figure A5.4 represents the input window required for any culvert defined within BrR. In most cases, this information is not included on the design drawings. Further, the Manual for Bridge Evaluation (current version) also does not necessarily specify values to be used when this information may not be known. Below is a brief discussion of the above, with guidance regarding selection of values if unknown.

Surface Exposure Factor

The slab exposure factor is not required for load and resistance factor ratings and is used for crack control checks only when performing load and resistance factor design. Therefore, for LRFR for Authority bridge culverts, this input field can be left blank. Note that Version 6.8 now allows for input of surface exposure factors for the top slab exterior surface, bottom slab exterior surface, wall exterior surface, and interior surface.

Soil Installation Method (Embankment or Trench)

The selection of the type of soil installation effects the calculation of the total unfactored earth load acting on the culvert. LRFD section 12.11.2.2.1 presents two sets of equations, one for the embankment method, and one for the trench method:

- For embankment installations:

$$W_E = F_e \gamma_s B_c H \qquad (12.11.2.2.1\text{-}1)$$

in which:

$$F_e = 1 + 0.20\frac{H}{B_c} \qquad (12.11.2.2.1\text{-}2)$$

- For trench installations:

$$W_E = F_t \gamma_s B_c H \qquad (12.11.2.2.1\text{-}3)$$

in which:

$$F_t = \frac{C_d B_d^{\,2}}{HB_c} \le F_e \qquad (12.11.2.2.1\text{-}4)$$

By examining the above relationships, it can be seen that the earth load acting on the culvert is greatest when computed based on the embankment method of soil installation. Thus, in lieu of information regarding the method of construction, EMBANKMENT is recommended for use for Authority culvert ratings (conservative).

Compact / Uncompact

Per LRFD specifications, Fe shall not exceed 1.15 for installations with compacted fill along the sides of the box section or shall not exceed 1.40 for installations with uncompacted fill along the sides of the box section. For all bridge culverts for the Authority, it is reasonable to assume that the fill along the sides of the culvert is sufficiently compacted for analysis purposes. Unless inspection findings or design documents indicate otherwise, it is acceptable to assume compact side fill when analyzing bridge culverts.

Soil-structure Interaction Factor (LRFD / LFD)

The factors to be used for both LRFD and LFD are required only when a trench installation is performed. From review of the LRFD specifications, MBE specifications, and the BrR help menu, BrR currently has the ability to compute the soil structure interaction factor for embankment installation only. If trench installation is applicable, the user must compute manually the soil structure interaction factor and input it in the appropriate input box. See LRFD 12.11.2.2.1 and LRFD Figure 12.11.2.2.1-3 for details.

Construction Type (Cast-in-Place / Precast)

The selection of CONSTRUCTION TYPE in BrR determines the resistance factors that the software uses during the rating analysis. The following table provides a summary of those resistance factors:

Table A5 – Culvert Resistance Factors

Construction Type	Flexure	Shear
Cast-in-Place	0.90	0.85
Precast	1.00	0.90
Three-Sided	0.95	0.90

As can be seen from the above table, the most conservative resistance factors are associated with the cast-in-place construction type. This also is the most likely type of construction used for existing culverts not recently built (within the past 10 or 20 years). Recent culvert construction more frequently uses precast components, which may or may not be reflected in the plans or design documents. If the type of construction is unknown, it is acceptable to assume CAST-IN-PLACE construction.

For three-sided culverts, it is assumed that leaving the BOTTOM SLAB PRESENT checkbox unchecked in the RC BOX CULVERT GEOMETRY window will cause BrR to utilize the above three-sided resistance factors during the load rating.

Default Rating Method
Though not required, this setting can be set to LRFR since this methodology is currently being followed for all Authority bridge load ratings.

LRFD EH Load Factor and LRFD/LRFR Earth Pressure Coefficient
Unless inspection findings or design documents indicate otherwise, the side walls of both rigid box culverts and three-sided frames typically will not exhibit significant lateral deflection. As a result, it is acceptable to utilize the At-rest EH load factor and LRFD/LRFR earth pressure coefficient.

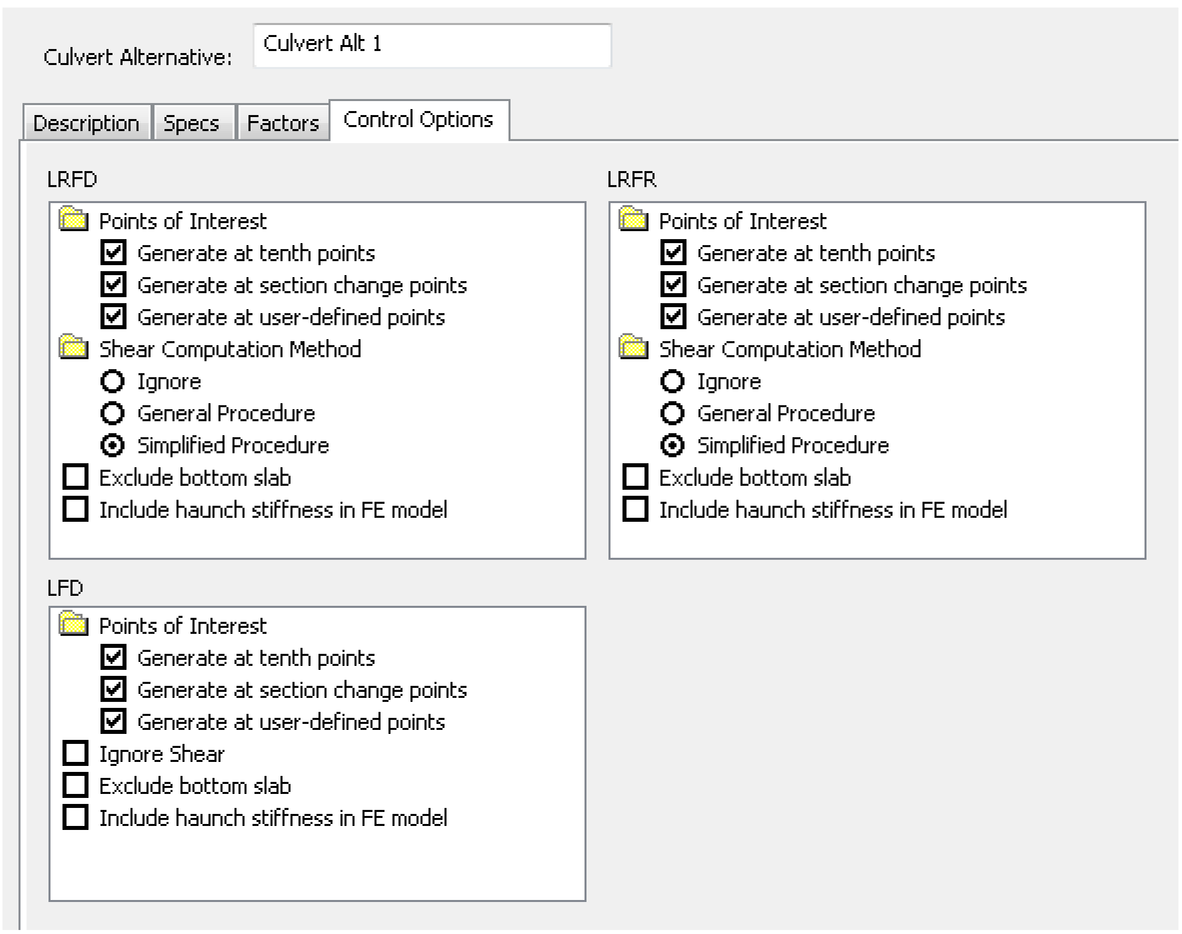


Figure A5.5 - Culvert Member Alternative – Control Options Window

On the CONTROL OPTIONS tab (See Figure A5.5), there are now three available options (IGNORE / GENERAL PROCEDURE / SIMPLIFIED PROCEDURE) for the SHEAR COMPUTATION METHOD (Version 6.8). The SIMPLIFIED PROCEDURE computes the shear resistance based on $\beta = 2.0$ and $\theta = 45°$.

The item entitled END CONDITION (See Figure A5.2) helps to model user-defined boundary conditions and connectivity definitions for the culverts. This provides the ability to release end moments to reflect the section reinforcing steel details. However, the program rates only at section locations as defined under CULVERT ALTERNATIVE / CONTROL OPTIONS. Therefore, it is required to select the option GENERATE AT SECTION CHANGE POINTS.

For the RC BOX CULVERT REINFORCEMENT, the program allows for input of reinforcing steel information as given in Figure A5.6. The program will calculate the development length of selected reinforcement based on the total length input in this window. Therefore, the load rating engineer shall enter the total as-built dimension of each bar to allow the program to evaluate development lengths accurately. For culvert ratings, reinforcing steel cut-off locations can have a significant influence on the ratings. The load rating engineer should be aware of the effects of development length on the culvert rating results and should consider adding additional points of interest in the BrR model to determine culvert component ratings at bar cut-off locations.

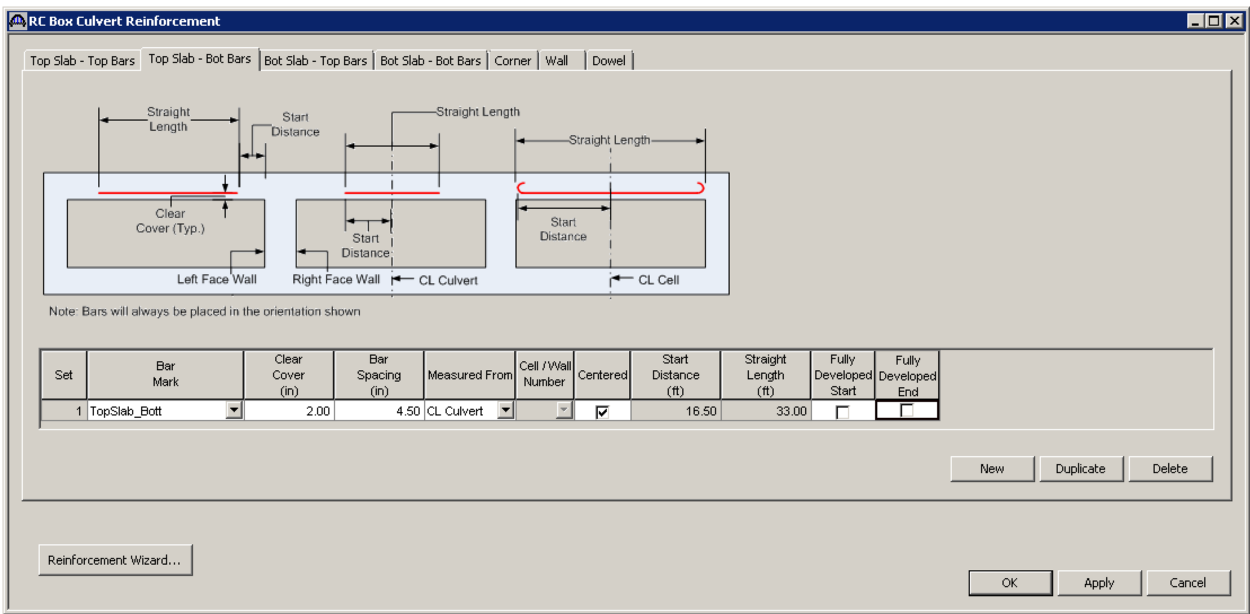


Figure A5.6 - Culvert Reinforcing Steel Schedule

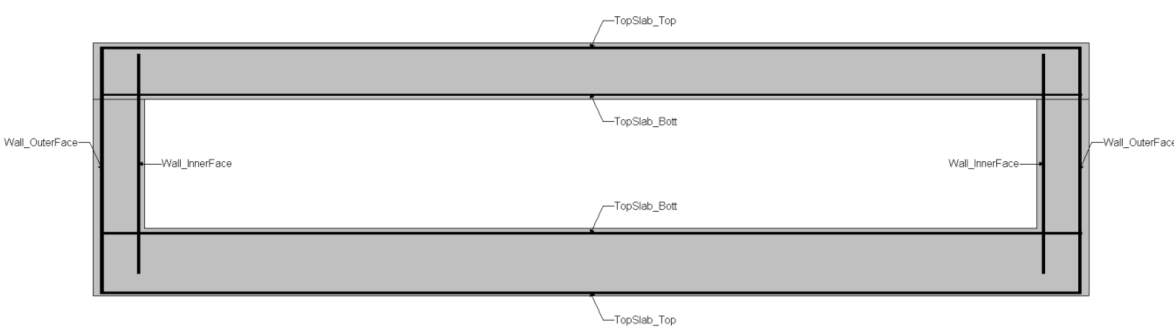


Figure A5.7 - BrR Schematic for Reinforcing Steel Detailing

Design load ratings shall be performed for the HL-93 vehicle at Inventory and Operating levels, routine legal load ratings shall be performed for the NJTA Specific Type 3S2, Type 3-3, Type 3, EV2 and EV3 vehicles, and specialized hauling legal load ratings shall be performed for the SU4, SU5, SU6 and SU7 vehicles. The lane type live loads are not distributed through the earth fill, thus the lane load component in the HL-93 live loads and lane type legal loads are excluded from culvert ratings.

BrR Software Culvert Rating Limitations and Issues

Based on review of the culvert load rating capabilities in BrR, the following limitations or issues were previously noted and remain in Version 6.8:

- User-Defined Dead Load: As given in the MBE example, the culvert top slab can be subjected to dead loads from non-structural components. The current BrR version does not provide a way to assign such user-defined dead load.

- Report Tool: This tool currently cannot be selected for culverts. This is an important feature as it provides an easy way to summarize all (shear/moment/moment-axial) ratings separately.

APPENDIX A2 BrR – Questions and Answers

This Appendix has been created to provide useful guidance regarding some of the most frequent questions raised during implementation of Load and Resistance Factor Ratings (LRFR) for the New Jersey Turnpike Authority.

If additional questions not covered in this Appendix arise, please contact your NJTA Liaison, as well as NJTA's Load Rating Representative for guidance. NJTA's current Load Rating Representative and contact information is as follows:

Scott Cavanaugh, P.E.
HNTB Corporation
Telephone: 973-434-3265
Email: scavanaugh@hntb.com

Questions and Answers:

1. Question: Is there a preferred way to enter the cross-section information into BrR, since the BrR software will automatically number the bridge members from LEFT to RIGHT?

   Answer: Yes. It is most important that the girder or stringer numbering in BrR match and agree with the numbering established by the Authority for the particular structure in question. This numbering convention can be found in the bridge inspection report for the structure. In general, this numbering typically progresses from the west to the east, or from south to north. Verify the already established member numbering for the structure in question before creating the BrR model. Do not make assumptions.

2. Question: The load rating manual currently specifies that the top 0.5" of the concrete deck slab be considered as dead load only. If a wearing surface or overlay exists as part of the original construction, can the load rating engineer consider the top 0.5" of the deck part of the effective structural deck?

   Answer: Yes, if overlay exists as part of the original construction for the structure being load rated, it is acceptable to use the full slab thickness for the structural depth of the slab.

3. Question: How should the load rating engineer approach a structure with splayed stringers (varying spacing along the length of the member)?

   Answer: Virtis version 6.1 and prior had limitations regarding input of splayed stringers. Virtis version 6.2 and beyond has improved capabilities and can now handle spans with splayed stringers (spacing varies at adjacent substructure units). Therefore, average beam spacing no longer needs to be input, as was previously required in Virtis v6.1. Further, BrR Version 6.7 has improved the computation of live load distribution factors of splayed stringers. Prior to Version 6.7, an average value was used for limited LLDF calculations. Now, in Version 6.7, the software computes LLDFs at 10^{th} points. This may lead to slight differences when compared to ratings computed using earlier versions.

4. Question: The current structure I am rating contains multiple superstructures (parallel spans) but has only one ADTT value. How should I split up the ADTT since this number is provided for the entire structure only?

   Answer: As discussed in Section 3.1.3, the inner roadways of the NJ Turnpike shall utilize an ADTT of 1000. For other structures (Garden State Parkway and NJ Turnpike), use the maximum one-way ADTT value, distributing ADTT to each superstructure unit based on number of lanes per superstructure, or some other reasonable distribution if unique conditions exist. Any unique conditions or modifications to the ADTT value should be well documented so that future load rating updates are done correctly.

5. Question: We have a single span reinforced concrete slab structure with 4' of fill above the slab. How should we perform the load ratings?

   Answer: For single span slab or multi-stringer structures with fill less than or equal to 6', BrR can be used and live load distribution factors can be calculated by hand based on the current depth of fill. Close review of the output should be performed to ensure actual conditions are being considered in the BrR model. Structures (not including culverts or rigid frames) with fill greater than 6' are not ideally rated using BrR.

6. Question: When creating the NJTA specific Type 3S2 Legal Load within the BrR Library, what WHEEL CONTACT WIDTH should be used for each axle?

   Answer: Though this parameter has no effect on the load rating of the longitudinal girders or stringers, the load rating engineer should utilize AASHTO's LRFD Specification 3.6.1.2.5 and the associated commentary which provides an equation to be used for the width, W = P / 0.8. Use this equation for consistency.

7. Question: Stay-in-Place (SIP) forms are present on this structure, but available plans do not provide a weight to be used in the BrR model for dead load. What dead load value should be used?

   Answer: Since the majority of structures have previous load ratings (LFR), review of these rating calculations will generally reveal a previous assumption or value used. If reasonable, these previous assumptions should be maintained. If previous ratings and plans do not provide this data, the load rating engineer should reference the NJTA Design Manual, Section 2, Structures Design which recommends a value of 13 lbs./ft.^{2} for SIP dead load. In lieu of any other information, this is a valid assumption for SIP dead load.

8. Question: We are getting a 0.661 rating in Shear from BrR for a reinforced concrete slab. AASHTO LRFD 5.14.4.1 says that slab bridges designed as per AASHTO 4.6.2.3 shall be considered satisfactory for shear. The MBE supports this in 6A.5.8. Do we need to report shear ratings for this member?

   Answer: Provided the member shows no visible signs of shear distress, shear ratings need not be reported in SIA Items 63 through 66 for reinforced concrete slab bridges (See MBE, Section 6A.5.8 for details). **However, shear ratings shall always be computed and shown on the load rating summary sheet for each structure rated.**

9. Question: We are load rating complex continuous structures on the NJ Turnpike that are slightly kinked at the continuous pier. In some cases, we also have kinked and splayed stringers, which results in varying stringer spacing at all supports. These conditions cannot be exactly modeled in BrR. How should we load rate and model this structure?

   Answer: If these conditions are found to exist, the load rating engineer should first bring this to the attention of the NJTA Load Rating Representative.

   Kinked girders only

   1. Ignore the kink and model the stringers as straight, which would allow for use of the same stringer spacing and span length but would require modification of the skew angles in BrR

to get the true span lengths of members. This change in the skew angle, which should generally be minor, should not greatly affect the rating results. The skew correction factor for LLDFs for shear should not need to be recomputed. Use of BrR values should be sufficient.

<u>Kinked and splayed girders (splay varies at more than two support locations)</u>

2. Ignore the kink and model the stringers as straight, and also hold the MAXIMUM girder spacing. This will be conservative and will lead to more dead load and more live load distributed to the splayed girders.

If low ratings are obtained using either of the two approaches, further refinement should be made. Such modifications as live load distribution factor revisions (#2) or skew correction factor calculations and revisions (#1 & #2) could be considered.

10. <u>Question:</u> What deck thickness input value is used by BrR for dead load calculations? I see that deck thickness is input via the SUPERSTRUCTURE TYPICAL SECTION WINDOW / DECK(CONT.) / TOTAL DECK THICKNESS and is also input within each MEMBER ALTERNATIVE within DECK PROFILE / DECK CONCRETE. Please advise.

    <u>Answer:</u> The deck information input via the DECK PROFILE window for each MEMBER ALTERNATIVE is used only for computation of section properties when a composite section has been defined. Review of the BrR help section also states that the input of deck info via the STRUCTURE TYPICAL SECTION window is considered during the analysis for dead load.

11. <u>Question:</u> A structure we are rating has a smooth riding surface (1). How do we apply a reduced impact factor in BrR during analysis?

    <u>Answer:</u> It is recommended that the impact value be modified via the ANALYSIS SETTINGS/ADVANCED/IMPACT. In the IMPACT text box, BrR requires input of the factor by which the full impact (33%) shall be multiplied by to obtain the reduced impact value. In this case, the value input to obtain 10% impact should be 0.303 (0.303*33 = 10). For 20%, the value input should be .606.

12. <u>Question:</u> For curved girder structures, diaphragm members are considered primary members and must also be rated in accordance with the NJTA LRFR load rating manual. Do the connections of the diaphragm to the curved girder require load rating?

    <u>Answer:</u> Since the diaphragm to girder connection in a curved girder structure would not be considered a non-redundant connection, these connections need not be rated according to the current load rating manual. This same concept would also apply to multi-stringer-floorbeam superstructures. For instance, it is <u>not</u> required to perform stringer connection ratings for the case where redundant stringers are connected directly to floorbeam webs. This would also qualify as a redundant connection and would not require rating. As discussed in the NJTA load rating manual, only connections of non-redundant systems require load rating.

13. <u>Question:</u> Section 2.2.3.2 (Concrete) of the NJ Turnpike Authority Structures Design Manual states that: "Concrete…shall be High Performance Concrete (HPC) with a minimum compressive strength (f'c) of 4,400 psi unless otherwise directed by the Authority's Engineering Department. The concrete strength for design using HPC shall be 4,000 psi." Further, "The value of the concrete strength (f'c) to be used for the design of reinforced concrete using Class A, B or C concrete shall be 500 psi less than the specified minimum compressive strength except for items using high performance concrete." For newly designed bridges what f'c value shall be used for load ratings?

Answer: For all ratings of new or widened structures which may have been designed based on the above noted design manual requirements, the f'c value indicated on the design drawings shall be used. Thus, a reduction of 400 psi (HPC) or 500 psi (Class A, B or C) shall not be made to the concrete member or deck strength during ratings.

14. Question: Should the As-Built condition consider wearing surface if the bridge was not initially designed with a wearing surface?

    Answer: For NJTA load ratings, the As-Built load rating should consider the structure as currently configured, with no section loss. This would typically involve review of the original As-Built drawings, supplemented with any information regarding median or fascia barrier revisions, superstructure widening or rehabilitation, new or additional wearing surface as observed and measured during the current bridge inspection, or any other modifications. As such, the As-Inspected load rating will primarily involve revisions due to member section loss or corrosion only. As-Inspected ratings may also involve a change in the surface roughness rating, superstructure condition factor, or ADTT. Due to the extensive superstructure modifications to many Authority bridges since initial construction, it is not required to have the As-Built load rating represent the condition of the bridge at the time of construction, especially since the load and resistance factor ratings are typically being performed well after the original construction.

15. Question: For modeling of a three-sided culvert in BrR, should the support conditions of the walls be set as pinned or fixed at the footing?

    Answer: For three-sided culverts, the connection of the side walls to the footing is modeled based on the reinforcing steel details. The plans should be reviewed, and if the three-sided culvert details show that a moment resisting connection is present at the wall connection to the footing, then the three-sided culvert shall be modeled with fixed supports.

16. Question: I am currently updating a load rating for a structure which has been widened. The members added are located to the LEFT looking station ahead in the BrR model. In order to make use of the existing BrR model, it seems that I have to go through several steps (See below) to update the model and was wondering if there was an easier way to simply add members to the left of the leftmost member in an existing model?

    1. Modify the NUMBER OF GIRDERS within the SUPERSTRUCTURE DEFINITION

    2. COPY and PASTE existing MEMBER ALTERNATIVES as necessary, and create NEW MEMBER ALTERNATIVES for the widening members

    3. Revise the FRAMING PLAN DETAIL/GIRDER SPACING data as necessary to reflect the correct member spacing

    Answer: The method you describe above is currently the only way to make use of the existing model data when a structure has members added on the left side (looking station ahead). Note that when you increase the number of members in BrR for a SUPERSTRUCTURE ALTERNATIVE, BrR will always add the new members on the right side (looking station ahead).

17. Question: My firm recently designed a bridge for the Authority which utilized the newer HL-93 tandem axle weight (increased from 25 kips to 50 kips) and HL-93 lane load (increased from

0.640 k/ft to 0.700 k/ft) per the NJTA Design Manual, Structures Design, Section 2.2.2. Should these same modified vehicles also be used for the load rating?

Answer: No, these modified vehicles should not be used for the load rating. The standard HL-93 design vehicle should be used and not be modified for the load rating. This ensures that all load ratings utilize the same design vehicle and can be equally compared. The actual design vehicle should be noted on the load rating summary sheet under "Design Loading:". Further, a clarifying note is recommended below the rating factor summary to clearly note that the load rating has utilized the unmodified (Standard) HL-93 design vehicle. **NEW IN 2017**: The As-Designed rating should also include the design vehicles as specified in the NJTA Design Manual (Structures Design). See Sections 3.2.2 and 4.4 for details.

18. Question: In all BrR models, both the SUPERSTRUCTURE DEFINITION and each MEMBER ALTERNATIVE have a SPECS tab. Are they both used by the software?

    Answer: The SPECS tab within the SUPERSTRUCTURE DEFINITION is used by BrR only when performing a 3D analysis. BrR uses the SPECS tab within each MEMBER ALTERNATIVE when performing a line girder analysis (common method of analysis for NJTA ratings). Thus, if not performing a 3D analysis, the SPECS tab within each SUPERSTRUCTURE DEFINITION need not be updated or modified as part of NJTA LRFR load ratings.

19. Question: We are load rating a structure that was recently widened, and the widened portion of the deck is thicker than the original deck. BrR does not allow for consideration of multiple deck thicknesses for a single SUPERSTRUCTURE. What is recommended for modeling this condition in BrR?

    Answer: It is recommended that the minimum deck thickness be used for the entire cross section, and additional dead load (DC1 typically) be calculated due to the thicker deck and applied to the necessary members in the BrR model.

20. Question: We are creating a bridge inspection report for our current inspection assignment. What date should be assigned to the load rating summary sheet file when copied from the 2011 report and saved to the 2017 report in InspectTech?

    Answer: Per Section 4.1.1 of this Manual, and a new requirement as of 2017-2018, the date used should match the date on the copied (and unchanged) load rating summary sheet. In this case, the date should be 04/01/2011. See the below image for details.

21. Question: We see that Section 3.5.2 (Concrete Bridges) has been updated as part of the 2018 Load Rating Manual updates (Version 9.4). How does this change affect past or future ratings using BrR?

    Answer: There should be no major changes required to past or future BrR load ratings. BrR has always followed the MBE guidance regarding the SERVICE III check (BrR checks HL-93 but does not check legal loads). This change was made to correlate the Load Rating Manual with the MBE and with what has typically been done to date using BrR and other software. For prestressed MEMBER ALTERNATIVES, the CONTROL OPTION tab includes a checkbox under LRFR to CONSIDER LEGAL LOAD TENSILE CONCRETE STRESS. If left unchecked, SERVICE III will not be considered for legal loads. If checked, SERVICE III will be considered for legal loads. As discussed in Section 3.5.2, SERVICE III should only be considered for legal loads if there is tensile cracking or other signs of distress in the prestressed beams.

22. Question: Recent updates to the Load Rating Manual specify that a dynamic load allowance of 33% shall be used for new or rehabilitation design. We are currently working on a bridge rehabilitation which involves a partial widening. What dynamic load allowance (impact) should be used for the new as well as existing members?

    Answer: Provided all computed legal load rating factors > 1.00, an impact value of 33% should be used for all members. If the rehabilitation results in legal load rating factors < 1.00 when using 33% impact, a reduced impact can be considered for use for the existing members.

23. Question: Should a reduced condition factor ($\phi_c < 1.0$, superstructure condition rating of 5 or below) be applied globally to the entire bridge, or locally to affected members only?

    Answer: A reduced condition factor should be first conservatively applied to the entire bridge (for simplicity and ease of analysis). A member-by-member approach to applying the condition factor may be utilized if the global application of a reduced condition factor results in legal load rating factors < 1.00. Also see Section 4.1.4.

24. Question: When using BRASS-Girder, the NJ Type 3S2 vehicle is not included in the vehicle library which leads to an analysis error. How can this vehicle be added to the BRASS vehicle library?

    Answer: The BRASS-Girder vehicle library can be edited using the Library Utility. This is a separate software program offered by BRASS-Girder which allows for editing of the BRASS vehicle library file (.BLV file extension). Historically, this executable was provided when purchasing BRASS-Girder, but now appears to be no longer included with the BRASS purchase. For assistance with updates to the BRASS-Girder library files or additional information please contact HNTB.

25. Question: Are reinforced concrete slabs previously modeled in BrR as a GIRDER LINE (1' strip) required to be remodeled as a REINFORCED CONCRETE SLAB SYSTEM in BrR?

    Answer: Refer to APPENDIX A1 > BrR MODELING > #5 (page A4). If an existing slab currently modeled as a GIRDER LINE (1' strip) is modeled correctly and is free from errors, the rating need not be updated nor the slab remodeled as a REINFORCED CONCRETE SLAB SYSTEM unless noticeable benefits are determined to be provided by modeling the slab as a slab system.

APPENDIX A3 Load Rating Updates of Existing Structures Previously Rated Using LRFR Methodology

The current NJTA Load Rating Manual (LRM) discusses re-rating of existing bridges in Section 2.1.2. Based on LRFR methodology, there are several important structure specific conditions or parameters which, if changed since the latest inspection referenced during the load rating, may lead to the need for load rating updates. These include the following:

- As-Inspected Conditions
- Change in Loading
- SIA Item 59 Coding Changes
- Significant ADTT Revisions
- Changes to the Surface Roughness Rating
- Evidence of Inaccuracies in Previous Load Ratings
- Rating Specification Changes

At any time during the bridge inspection contract, the consultant may contact the Authority's Load Rating Representative for further guidance regarding Authority load ratings or load rating updates.

<u>As-Inspected Conditions</u>

Existing LRM Guidance:

As noted in Section 2.1.2 of the current Load Rating Manual, a re-rating would usually be necessary if "section properties of controlling or non-controlling members have changed due to deterioration, rehabilitation, re-decking, or other structural alterations." Also, Section 2.1.3 and Appendix A5 provide additional guidance regarding ratings based on member deterioration.

Additional Guidance:

During the biennial bridge inspection, any areas of section loss which could have an effect on the rating results shall be documented in the field. Section loss measurements must be detailed as discussed in Section 4.1 and shall include all information necessary for potential load rating updates (remaining thickness, location of loss, area of loss (length/width/height) and a photo of the deteriorated area). Subsequent to the field inspection, the inspector shall add all section losses which could have an effect on the rating to a standardized Section Loss Table as part of the Authority's Section Loss Workbook procedure, which typically includes locations with 1/8" loss or greater (see Appendix A5). The load rating engineer shall then review the section losses entered in the Section Loss Table, and through the use of engineering judgment (as defined below), determine if load rating updates are warranted.

'Engineering judgment' in certain instances may allow the load rating engineer to conservatively neglect losses where they do not negatively affect the controlling load rating of the investigated member. However, each individual bridge and its condition / deficiencies is unique, thus section losses must be evaluated individually by both the bridge inspection team leader and load rating engineer prior to determining that the losses can be neglected. For example, see below for possible scenarios regarding observed section loss in steel members and the subsequent engineering judgment that allowed conservative neglecting of the losses.

- Example 1: Moderate section loss to the web of simple span members near midspan
    - *Since web losses occur in an area of low shear effect where current shear rating factors are much greater than 1.00, section losses may be considered negligible and need not be explicitly input in the load rating model.*
- Example 2: Moderate section loss to flanges of single span beams near beam ends
    - *Since flange losses occur in an area of low flexural effects where current flexural rating factors are much greater than 1.00, section losses may be considered negligible and need not be explicitly input in the load rating model.*

For load rating updates, the Authority will allow the load rating engineer to exercise this level of engineering judgment for steel members. However, this is not a recommended practice for concrete members (reinforced concrete T-beams, prestressed I-beams, reinforced concrete slabs, etc.). Please note that As-Inspected findings should always be reviewed and assessed to determine the need to apply them to the As-Inspected load ratings. Where deteriorations or section losses are to be conservatively neglected, the load rating engineer shall document all instances where this is done, and also provide an inventory and written rationale of such instances with the load rating report. The written summaries shall be similar to the above listed examples.

It is ultimately the load rating engineer's responsibility to utilize their knowledge and engineering judgment to determine the criticality of the section loss findings. The information provided above is intended as a guide only.

Summary:

It is the responsibility of the load rating engineer to determine what deterioration, if any, shall be included in the load rating calculations for any given structure. As noted above, engineering judgment may be utilized during the load rating update process to determine which structures (if any) shall be recommended for load rating updates.

Changes in Loading

Existing LRM Guidance:

As noted in Section 2.1.2 of the current Load Rating Manual, a re-rating would usually be necessary if "dead load has changed due to resurfacing or other non-structural alterations".

Additional Guidance:

At the current time, any significant superstructure rehabilitation or re-decking that could significantly affect the dead load of any rated member is typically being load rated by the Design Consultant in accordance with the current NJTA Design Manual and the NJTA Load Rating Manual. Thus, it is not expected to have many cases where updates due to changes in loading are needed.

Summary:

The load rating engineer is not expected to review in detail the existing load rating report and model to compare to existing conditions. Instead, the load rating engineer assisted by the bridge inspection team leader, shall review available NJTA records to determine if any work has been performed on the structure since the last load rating which could affect the rating results. If it is found that work has been done since the previous inspection which could affect the ratings, the structure shall be recommended for load rating updates.

SIA Item 59 Coding Changes

Existing LRM Guidance:

As noted in Section 2.1.2 of the current Load Rating Manual, a re-rating would usually be necessary if "The primary member general condition rating has changed". Member condition and the condition factor (φ_c) are further discussed in Section 3.3.2.

Additional Guidance:

Based on load and resistance factor rating methodology, the condition factor is tied directly to Structural Inventory and Appraisal Item 59 (Superstructure). See the below table, referenced from both the LRM and the MBE:

Table MBE 6A.4.2.3-1 Condition Factor: ϕ_c .

Superstructure Condition Rating (SI & A Item 59)	Equivalent Member Structural Condition	ϕ_c
6 or higher	Good or Satisfactory	1.00
5	Fair	0.95
4 or lower	Poor	0.85

Based on review of this table, only SIA Item 59 coding of 5 or lower affects the rating results. For structures with this coding, the condition factor reduces to a value less than 1.00, which reduces the member capacity at the Strength Limit State. See below for the member resistance equation as taken from Section 3.3.1 of the NJTA Load Rating Manual:

For Strength Limit States, member capacity is given as:

$$C = \phi_c \ \phi_s \ \phi \ R_n$$

Where:

ϕ_c = Condition Factor

ϕ_s = System Factor

ϕ = LRFD Resistance Factor

For the purpose of load rating updates, the load rating engineer should review all bridge inspection report data from the current inspection and identify any bridge in which the coding is to be changed from the previously assigned value. From this group of bridges with Item 59 coding changes, the load rating engineer should further review and identify all bridges where the coding change results in a change in the condition factor. These bridges should be recommended for load rating updates.

Summary:
Identify any bridge that has resulted in a <u>change</u> in the Item 59 coding which will further result in changes to the condition factor. From this list, recommend performance of rating updates for the following cases:

1. *Structures that currently exhibit legal load ratings less than 1.00, and the condition factor increases or decreases*
2. *Any structure where the condition factor decreases*

<u>One-way ADTT Revisions</u>

Existing LRM Guidance:
As noted in Section 2.1.2 of the current Load Rating Manual, a re-rating would usually be necessary if there are "significant changes in truck traffic volume used for selecting the live load factor".
Additional Guidance:
At the current time, significant changes to the one-way ADTT of any existing Authority structure that would affect the rating is not anticipated.

Summary:
Updates for changes to one-way ADTT need not be performed as part of any current load rating updates. It is assumed that the current load ratings properly reference the LRM or SIA data, as needed, for the correct one-way ADTT values.

<u>Surface Roughness Ratings</u>

Existing LRM Guidance:
As noted in Section 2.1.2 of the current Load Rating Manual, a re-rating would usually be necessary if there is an "increase in the surface roughness rating (worsened rideability)". The rideability rating and its relation to dynamic load allowance are further discussed in Section 3.2.6.
Additional Guidance:
Existing LRFR ratings should have typically assumed a smooth riding surface (coding = 1) for the As-Built condition. The riding surface coding for the As-Inspected ratings should have been based on the latest bridge inspection surface roughness rating. Thus, any revisions to the surface roughness rating when compared to the most current load rating report shall be considered for potential load rating updates.

Summary:
Identify any bridge that has resulted in a <u>*change*</u> *in the As-Inspected rideability rating of the structure. For those structures, rating updates shall be recommended for the following cases:*

1. *A worsened rideability (increase in coding value) which results in an increase in the legal load impact used in the ratings*
2. *An improved rideability (decrease in coding value) which results in an increase in ratings for a structure with controlling legal load rating factors less than 1.00*

<u>Identification of Previous Load Rating Errors or Omissions</u>

Existing LRM Guidance:
As noted in Section 2.1.2 of the current Load Rating Manual, a re-rating would usually be necessary if "review of previous load ratings reveals significant errors or inaccuracies".
Additional Guidance:
As part of biennial bridge inspections, the consultant is expected to perform a cursory review of the current load rating summary sheet and associated files to ensure that the current bridge condition is reflected in the load rating analysis. It is not the Authority's intention to require detailed reviews of past consultant's load rating models, calculations, and final load rating reports. If significant load rating errors or omissions are identified by the consultant, these issues should be brought to the Authority's immediate attention for possible action.
For example, some issues that have been identified during past load rating reviews which would be classified as significant errors or omissions are:

- Past load ratings which did not include all members (perhaps by omission of past or recent bridge widening contracts)
- Missing load rating deliverables (working files, load rating report PDF, or necessary reference drawings)
- ***Common Error***: Past load ratings which did not utilize the condition factor that was identified in the most recent bridge inspection report (note that this is not a change in the condition factor, but instead an error in initially establishing the condition factor during load rating)
- Other incorrect rating parameters used for the analysis (dynamic load allowance, system factor, ADTT, etc.)
- Incorrect use of a reduced dynamic load allowance (10% or 20%) when load rating transverse cross girders

Summary:
Notify the Authority Liaison immediately of any bridge load rating that contains significant errors or omissions. The Authority Liaison will then determine the proper course of action (performance of missing member ratings, acquisition of missing files from previous consultants, etc.).

<u>Rating Specification Changes</u>

Existing LRM Guidance:
As noted in Section 2.1.2 of the current Load Rating Manual, a re-rating would usually be necessary due to "rating specification changes".
Additional Guidance:
At the current time, it is not the Authority's intention to perform rating updates of the entire bridge inventory due to minor specification changes. As specifications are refined and updated in the future, this position will be revisited and reassessed.
Since initial ratings using LRFR methodology have been performed for the Authority since 2010, several editions of the design and load rating specifications have been used. The load rating engineer shall determine if specification changes will affect the critical ratings for a given structure, and if so, rating updates should be recommended. Rating updates shall also be recommended in the rare case where state legal load rating factors are currently less than 1.00, and brief review of the load ratings

indicates that an increase in the controlling ratings may be realized by updating using the latest specifications. Based on the current status of the Authority's LRFR inventory, updates for this reason are not expected.

Summary:
Rating updates based on specification changes shall be recommended if:

1. *Specification changes are expected to affect the critical ratings of a given structure.*
2. *The subject structure currently exhibits controlling legal load rating factors less than 1.00 and may result in rating increases if using the revised specifications.*

Authority Notification

As a ***MANDATORY*** action item prior to ANY load rating update, the bridge inspection and load rating consultant shall first ***notify the Authority of the recommended updates and receive permission from the Authority Liaison before proceeding with the updates***.

APPENDIX A4 Emergency Vehicle Ratings

This Appendix has been created to provide guidance and direction regarding performance of Emergency Vehicle ratings in accordance with the Authority's requirements while also adhering to the November 2016 FHWA Memo pertaining to Load Rating for the FAST Act's Emergency Vehicles. The memo provides some flexibility in how the analysis should be performed, requiring more detailed guidance for the performance of these ratings to ensure consistency amongst all Authority bridge load ratings.

1. <u>AASHTOWare's Bridge Rating Software (BrR)</u>

The following guidance was developed using BrR Version 6.8.2.3002. Refer to Section 3.2.7 (Legal Load Rating for Emergency Vehicles) of the Authority's Load Rating Manual for direction regarding when to utilize the below noted method of analysis.

<u>Method 1</u>

Method 1 utilizes the specified Emergency Vehicle as a routine legal load, considering typical single-lane and multi-lane loading scenarios. Other unrestricted legal loads are <u>not</u> applied as adjacent vehicles using this method. Method 1 can be performed using either LRFR or LFR methodologies.

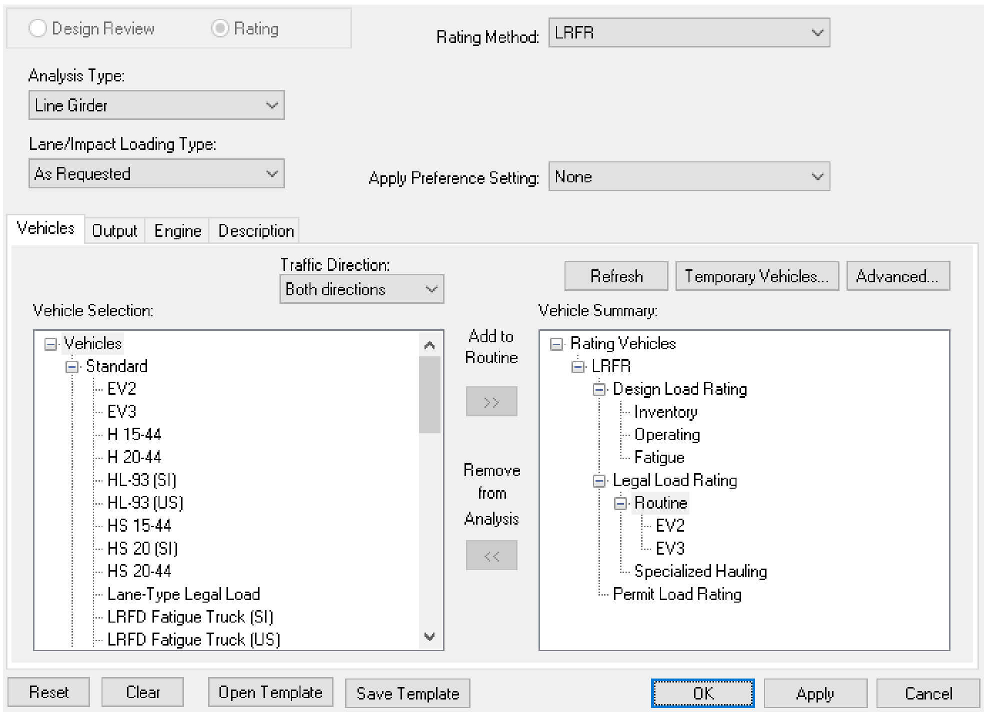
For simplicity, the following guidance has been prepared with only the EV2 and EV3 settings displayed. The following settings can be combined with other required design and legal vehicles for the Authority to minimize the number of analysis runs that are needed when determining the controlling ratings for all vehicles.

<u>Important Considerations When Using BrR</u>

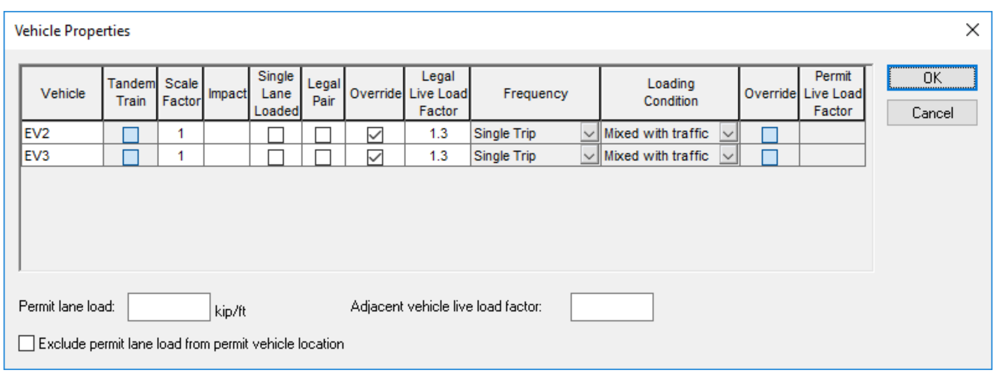
<u>Striped Travelway</u> – In a few cases, Authority bridges with LRFR rating factors less than 1.00 for legal loads were modified to consider only striped lanes per MBE 6A.2.3.2 to more accurately model the structure and also increase the legal load ratings. When performing EV ratings, the travelway used in the BrR model should be assumed to include both active striped lanes and available shoulders or other areas that can potentially experience live loading. In other words, the travelway should not be reduced nor restricted to only the striped lanes. For bridges that currently consider only striped lanes, the BrR file will require modification to include all necessary areas for possible live load placement. Emergency response vehicles often utilize shoulders and non-travel lanes; thus the load ratings must consider the possibility that EVs could occupy these areas. Raised safetywalks or sidewalks need not be loaded with EVs during load rating.

BrR Analysis Settings for Non-Buried Structures

Method 1 (LRFR) – Utilizing EV2 and EV3 as routine legal loads (no adjacent legal loads)

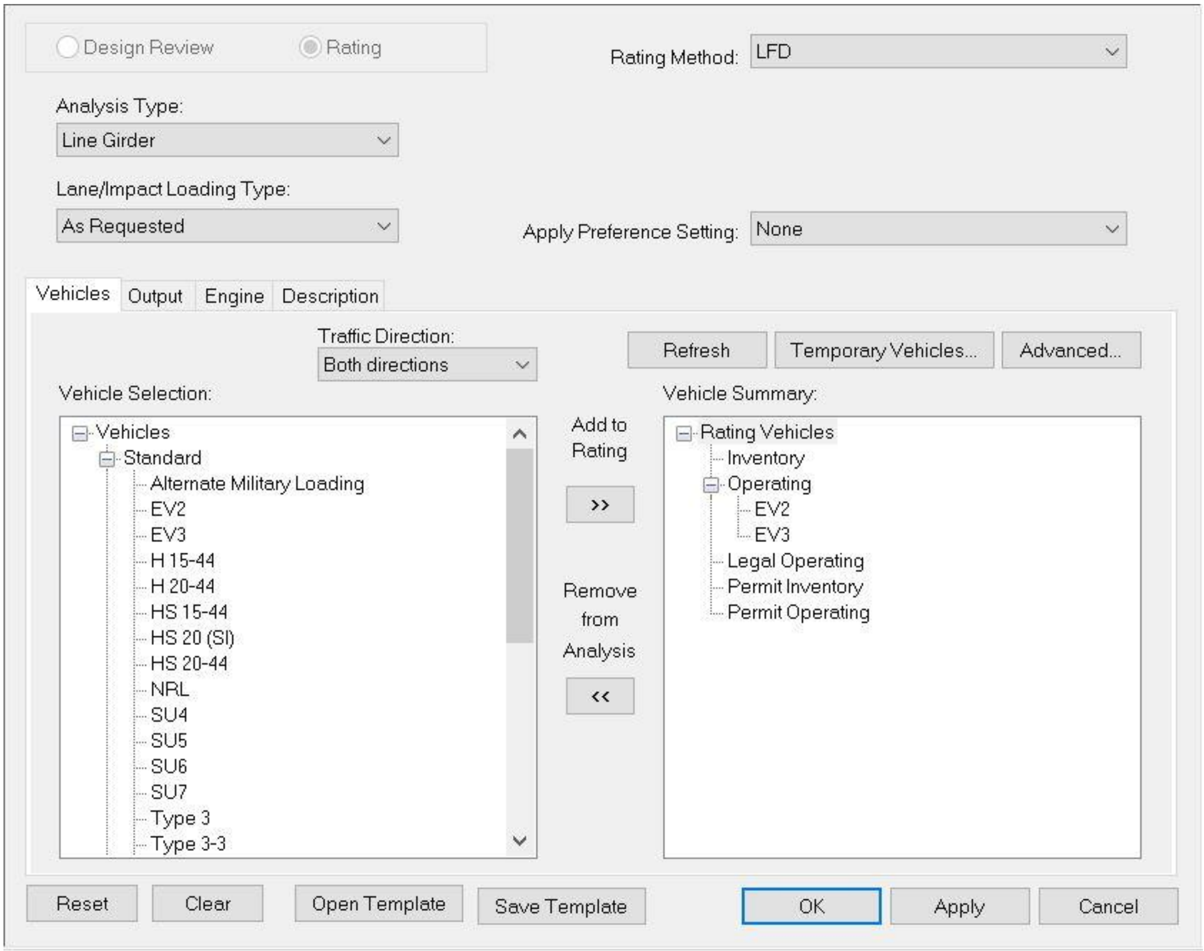


EV's should be assigned to the LEGAL LOAD RATING / ROUTINE category as shown above in the ANALYSIS SETTINGS window. This is in accordance with the FHWA Memo which specifies that load ratings should be determined for the emergency vehicle configurations at the Legal Load level for LRFR. The EV vehicles should already be included in your vehicle library as STANDARD vehicles.

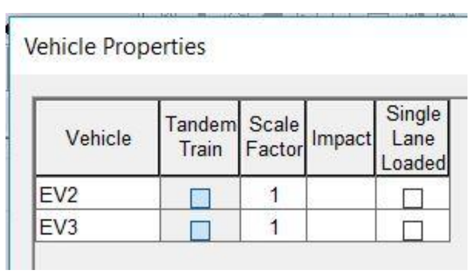


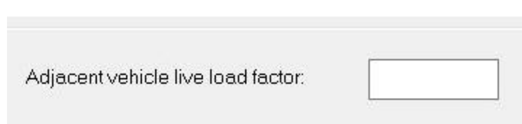
Then, select the ADVANCED button, which opens the above window. In accordance with the FHWA memo, set the live load factor to 1.3 by selecting OVERRIDE, then input 1.3 in the LEGAL LIVE LOAD FACTOR input cells. However, for buried structures (i.e., reinforced concrete box culverts, three-sided reinforced concrete rigid frames, reinforced concrete slabs, etc.), a live load factor of 2.0 should be used, as discussed further below (BrR EV Analysis Settings for Buried Structures). The above window has been set to utilize a maximum impact value of 33% for both EVs. Revisions to the IMPACT column, as discussed in Appendix A2, Question 11, can be made to modify the impact as needed. Per the FHWA's Questions and Answers document titled Load Rating for the FAST Act's Emergency Vehicles (Revision R01, March 16, 2018), Question No. 46, the EVs shall utilize the same impact as that specified in the AASHTO MBE for normal legal loads.

Method 1 (LFR) – Utilizing EV2 and EV3 as routine legal loads (no adjacent legal loads)



EV's should be assigned to the OPERATING category as shown above in the ANALYSIS SETTINGS window. This is in accordance with the FHWA Memo which specifies that load ratings should be determined for the emergency vehicle configurations at the Operating level only for LFR. The EV vehicles should already be included in your vehicle library as STANDARD vehicles.

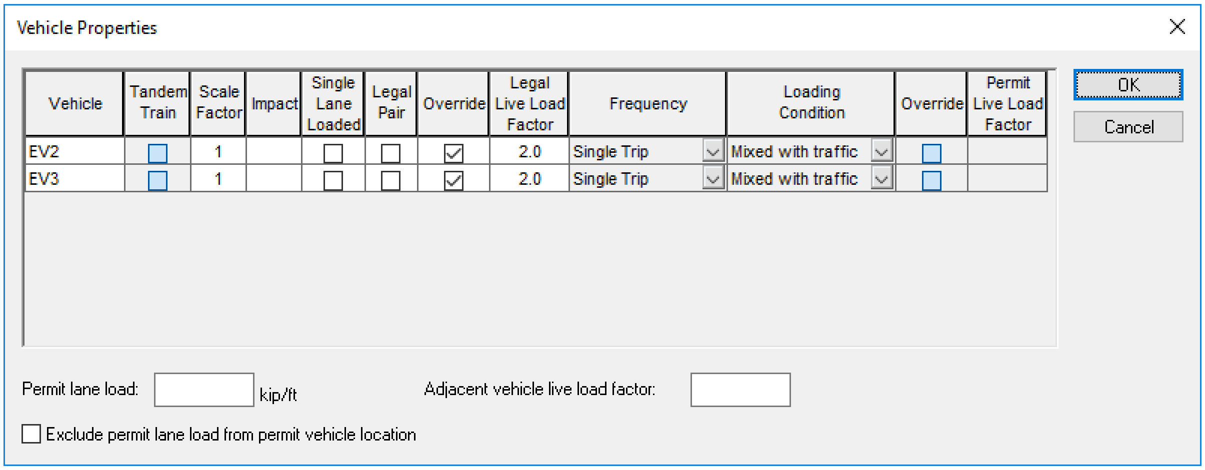




No modifications are required to the ADVANCED ANALYSIS SETTING window in BrR for LFR analysis using Method 1 (see above). This is because the default live load factor (1.3) at the Operating Level using LFR has been specified for use per the FHWA Memo.

BrR EV Analysis Settings for Buried Structures

Method 1 (using LRFR only) - Utilizing EV2 and EV3 as routine legal loads (no adjacent legal loads)



After assigning the EV2 and EV3 rating vehicles to the LEGAL LOAD RATING / ROUTINE category, selecting the ADVANCED button opens the above window. A legal live load factor of 2.0 must be utilized for EVs for all buried structures using Method 1, in accordance with Question No. 24 of the FHWA's Questions and Answers document titled Load Rating for the FAST Act's Emergency Vehicles (Revisions R01, March 16, 2018).

APPENDIX A5 Section Loss Workbook

The Authority has developed a formal section loss documentation procedure to be followed during major and routine bridge inspection and load ratings. This document is referred to as the Section Loss Workbook and includes both a narrative guidance and working Excel spreadsheet. The Section Loss Workbook procedure allows for uniform and consistent documentation of primary structural steel member section loss and determination of which members warrant load rating updates through the utilization of a standardized, detailed Section Loss Table. It also allows for uniform and consistent recommendations to be made regarding the need for structural steel member repair or strengthening and structural steel member condition state assessment in the bridge element inspection forms.

A Section Loss Table shall be completed for every bridge with section losses that could have an effect on the load rating. Based on past load ratings for the Authority's bridges, all section losses with 1/8" depth or greater shall be included in the Section Loss Table. Section losses with less than 1/8" depth or other deficiencies that could have an effect on the rating may need to be included as deemed necessary based on engineering judgment.

Once a Section Loss Table is completed, a "Section Loss Load Rating Form" (SLLRF) shall be generated from the Section Loss Table via the appropriate built-in Excel macro and included in the Load Rating Report in accordance with Section 4.1.

Version 1.0 (July 2020) of the complete Section Loss Workbook procedure document is attached herein as part of Appendix A5 and includes all details, step-by-step instructions, and directions for use on the procedure itself and on completing the accompanying Section Loss Table. This document is intended to be a living document in that changes will be issued as warranted because of changes in policy or procedure. A detailed Questions & Answers document, along with the Section Loss Workbook procedure document and a Section Loss Table template Excel file, are also currently accessible via the HELP / DOCUMENTATION menu within InspectTech.

New Jersey

Turnpike Authority

Section Loss Workbook

Version 1.0

July 2020

Prepared By:

GPI

In Association With:

HNTB

New Jersey Turnpike Authority
Section Loss Workbook, V1.0

Introduction

The steps presented herein outline the Authority's section loss documentation and LRFR load rating update warrants procedure (i.e. identifying, assessing and classifying, etc.) to be followed during the preparation of Major and Routine Biennial Bridge Inspection Reports when primary structural steel members exhibit section loss of 1/8" deep (D) or greater. In order to ensure a comprehensive procedure, relevant information included in the LRFR Load Rating Reports is also to be considered to better facilitate the necessity for LRFR load rating update warrants and to better correlate the Biennial Bridge Inspection findings and LRFR Load Rating Reports. This Workbook's procedure allows for uniform and consistent documentation of primary structural steel member section loss and determination of which members warrant LRFR load rating updates through the utilization of a standardized, detailed Section Loss Table (SLT - **See Attachment 1**). Additionally, it allows for uniform and consistent recommendations to be made regarding the need for structural steel member repair / strengthening and structural steel member condition state assessment in the bridge element inspection forms.

Major Bridge Procedure for Primary Structural Steel Member Section Loss Documentation and LRFR Load Rating Update Warrants:

The following steps shall be utilized to document primary structural steel member section loss and determine associated LRFR load rating update (or special structural analysis) warrants, including recommendations for structural steel repairs / strengthening when necessary, for inclusion in the Biennial Bridge Inspection Reports (at primary locations of primary components for primary members only - **See the definitions of these terms included with Table 1 below**):

1. Draft Biennial Bridge Inspection Report Checklist QCF 1.1 - Major Bridges Report Checklist (Consultant InspectTech Report Quality Control Review):
   - Refer to the Inspection Report section entitled "Section Loss Information":
     - Answer "Y" if there are primary members with section loss of 1/8"D or greater.
     - Otherwise answer "N".
2. Section Loss Documentation for Primary Members with Section Loss of 1/8"D or Greater (if required by Step 1):
   - For 2020 and 2021 cycle Biennial Bridge Inspection Reports - Refer to the existing / non-standard section loss summary table(s) prepared for the latest cycle Biennial Bridge Inspection Report and/or LRFR Load Rating Report, whichever is most current (if already existing):
     - Migrate the existing / non-standard table(s) over to the standardized, detailed SLT (**See Attachment 1**) and update accordingly for the current cycle inspection findings. Attachment 1 includes directions for use.
     - If the existing / non-standard table(s) does not already exist, the standardized, detailed SLT (**See Attachment 1**) shall be populated with the current cycle inspection findings. Attachment 1 includes directions for use.
   - For 2022 and forward cycle Biennial Bridge Inspection Reports - Refer to the standardized, detailed SLT prepared for the latest cycle Biennial Bridge Inspection Report and/or LRFR Load Rating Report, whichever is most current:
     - Update the standardized, detailed SLT (**See Attachment 1**) accordingly for the current cycle inspection findings. Attachment 1 includes directions for use.
   - Prepare the SLT line item entries as necessary for each primary member type (i.e. trusses, girders, floorbeams, stringers, box beams, etc.) on a single worksheet, organized by span and member type.

- SLT entries shall include only corrosion induced fatigue cracks associated with corrosion or corrosion holes. SLT entries shall not include "traditional" out-of-plane bending fatigue cracks or associated issues. Such fatigue cracks and associated issues shall be included elsewhere in the Biennial Bridge Inspection Report (i.e. Inspection Report section entitled "Superstructure 2 (Superstructure)" or in a separate Report section created and added to the Report).
- SLT entries may include areas of section loss measuring less than 1/8"D or other deficiencies that could have an impact on the rating as deemed necessary based on engineering judgment.

3. Determination if LRFR Load Rating Updates (or Special Structural Analyses) are Required for Primary Members with Section Loss of 1/8"D or Greater (if required by Steps 1 and 2):

- The standardized, detailed SLT will automatically calculate the percentage of section loss for each entry based on the As-Built (Original) and As-Inspected (Measured Section Loss) information input and areas automatically calculated. In conjunction with the controlling rating factor input for each entry, the SLT will then automatically determine if there could be an impact on the rating.
  - ➢ Recommend all SLT entries identified to possibly have an impact on the rating (i.e. "Review Load Rating Effect" = "Yes") for LRFR load rating updates (or special structural analyses) in the Biennial Bridge Inspection Report section entitled "Conclusions" within the "Load Rating" statement. These SLT entries are not recommended for repair in the Inspection Report until the Load Rating Engineer reviews and determines that a repair for each is required in accordance with the directions for use presented in Attachment 1, including updating the SLT accordingly.

    Note: *For Major Bridges, this sub-step (i.e. the performance of LRFR load rating updates) is typically not performed between the Draft and Final Inspection Report submissions; therefore, the recommendations in the two Reports typically will not differ. However, this may not always be the case due to the potential lag of the LRFR load rating updates behind the Inspection Report submissions. As a result, the recommendations to be made in the Draft and Final Inspection Reports are truly dependent upon the timing between when the Load Rating Engineer review / determination and update of the SLT are completed versus the Inspection Report submission dates.*

  - ➢ However, all SLT entries with corrosion holes and/or corrosion induced fatigue cracks shall also be recommended for repair in the Biennial Bridge Inspection Report sections entitled "Recommendations", "Repairable Deficiencies", and "Superstructure 2 (Superstructure)" regardless of whether a possible impact on the rating has been identified. These SLT entries are recommended for repair in the Inspection Report because these types of deficiencies have more recently been attributed to the development of much more significant structural issues at several bridges / bridge members.
- "Special Structural Analyses" pertain to any analyses required to evaluate any unconventional SLT entries that are not possible to evaluate using conventional LRFR load rating update methods (i.e. analysis of deteriorated bearing stiffeners and/or immediately adjacent web on both sides, etc.).
- Include the SLT-generated "Section Loss Information Report Form" (SLIRF) in the Biennial Bridge Inspection Report section entitled "Section Loss Information".
- Upload the working file for the prepared SLT to InspectTech in accordance with the OPS Scope of Services requirements.

Table 1 provided on Page 3 outlines all the possible Major Bridge deficiency and recommendation combinations for primary members based on Steps 2 and 3 above. It also includes other possible combinations for primary / secondary members with advanced section loss requiring repair that are not included in Steps 2 and 3 above.

Table 1

Possible Major Bridge Deficiency and Recommendation Combinations

Deficiency		**Recommendation**
Category	**Description**	
"N/A" **As Denoted in the Inspection Report Section / Field Form Entitled "Superstructure 2 (Superstructure)".**	• Primary locations of primary components for primary members with section loss determined by the SLT to possibly have an impact on the rating (i.e. "Review Load Rating Effect" = "Yes") but not yet reviewed by the Load Rating Engineer (**See Attachment 1**).	• Recommend LRFR load rating updates (or special structural analyses) in the Inspection Report section entitled "Conclusions" within the "Load Rating" statement.
	• Primary locations of primary components for primary members with section loss determined by the SLT to possibly have an impact on the rating (i.e. "Review Load Rating Effect" = "Yes") that have been reviewed by the Load Rating Engineer and determined to not require repair (**See Attachment 1**).	• None.
	• Other.	• None.
"B" **As Denoted in the Inspection Report Section / Field Form Entitled "Superstructure 2 (Superstructure)".**	• Primary locations of primary components for primary members with section loss determined by the SLT to possibly have an impact on the rating (i.e. "Review Load Rating Effect" = "Yes") that have been reviewed by the Load Rating Engineer and determined to require repair (**See Attachment 1**).	• Recommend repair in the Inspection Report sections entitled "Recommendations", "Repairable Deficiencies" and "Superstructure 2 (Superstructure)".
	• Primary locations of primary components for primary members with corrosion holes and/or corrosion induced fatigue cracks requiring repair regardless of whether a possible impact on the rating has been identified by the SLT (**See Attachment 1 and Note 1 below**).	• Recommend repair in the Inspection Report sections entitled "Recommendations", "Repairable Deficiencies" and "Superstructure 2 (Superstructure)".
	• Secondary locations of primary components for primary members with corrosion holes and/or corrosion induced fatigue cracks requiring repair (**See Note 1 below**).	• Recommend repair in the Inspection Report sections entitled "Recommendations", "Repairable Deficiencies" and "Superstructure 2 (Superstructure)".
	• Secondary members with corrosion holes and/or corrosion induced fatigue cracks requiring repair (**See Note 2 below**).	• Recommend repair in the Inspection Report sections entitled "Recommendations", "Repairable Deficiencies" and "Superstructure 2 (Superstructure)".
"E" **As Denoted in the Inspection Report Section / Field Form Entitled "Conclusions" within the "Category E" Statement.**	• Primary and secondary member deficiencies are not typically included within the "Category E" statement in the Inspection Report section entitled "Conclusions", unless particularly noteworthy (i.e. an actively developing condition increasing in extent from cycle-to-cycle, members exhibiting deficiencies uncommon to them, etc.).	• None typically. Recommend interim monitoring only if on a basis of less than 2 years.

Notes:

1. These deficiencies are automatically recommended for repair because they have more recently been attributed to the development of much more significant structural issues at several bridges and bridge members due to secondary impacts on primary locations associated with alternate load paths being taken (i.e. the Structure W107.87 Girder 4 emergency repair in early 2018, where the base of web

corrosion hole and corrosion induced fatigue crack on the "joint side" of the bearing stiffener was allowing the girder to rotate about the base of web / top of lower flange (instead of at the bearing) and therefore propagating the similar base of web corrosion hole and corrosion induced fatigue crack on the "span side" of the bearing stiffener along the base of web and then ultimately into and partially across the lower flange in front of the bearing).

2. These deficiencies are automatically recommended for repair because they could possibly develop much more significant structural issues at these or their surrounding bridge members due to secondary impacts associated with alternate load paths being taken.

Definitions:

1. Primary Locations of Primary Components for Primary Members include the "span side" of flanges, the "span side" of webs, bearing stiffeners and immediately adjacent web on both sides, and other similar main load carrying locations and components.
2. Secondary Locations of Primary Components for Primary Members include the "joint side" of flanges, the "joint side" of webs, and other similar minor load carrying locations and components.
3. Secondary Components for Primary Members include intermediate stiffeners, longitudinal stiffeners, and other similar secondary components.

Routine Bridge Procedure for Primary Structural Steel Member Section Loss Documentation and LRFR Load Rating Update Warrants:

The following steps shall be utilized to document primary structural steel member section loss and determine associated LRFR load rating update (or special structural analysis) warrants, including recommendations for structural steel repairs / strengthening when necessary, for inclusion in the Biennial Bridge Inspection Reports (at primary locations of primary components for primary members only - **See the definitions of these terms included with Table 2 below**):

1. Draft Biennial Bridge Inspection Report Checklist QCF 1.2 - Routine Bridges Report Checklist (Consultant InspectTech Report Quality Control Review):
   - Refer to the Inspection Report section entitled "Section Loss Information":
     - Answer "Y" if there are primary members with section loss of 1/8"D or greater.
     - Otherwise answer "N".

2. Section Loss Documentation for Primary Members with Section Loss of 1/8"D or Greater (if required by Step 1):
   - For 2020 and 2021 cycle Biennial Bridge Inspection Reports - Refer to the existing / now non-standard NJTA Section Loss Documentation material(s) (i.e. field measurements sketch with table, AASHTOWare's Bridge Rating (BrR) Software load rating input deterioration profile with table and rolled / built-up I-beam sketches, etc.) prepared for the most recent cycle Biennial Bridge Inspection Report and/or LRFR Load Rating Report, whichever is most current (if already existing):
     - Migrate the existing / now non-standard material(s) over to the standardized, detailed SLT (**See Attachment 1**) and update accordingly for the current cycle inspection findings. Attachment 1 includes directions for use.
     - If the existing / now non-standard material(s) does not already exist, the standardized, detailed SLT (**See Attachment 1**) shall be populated with the current cycle inspection findings. Attachment 1 includes directions for use.
   - For 2022 and forward cycle Biennial Bridge Inspection Reports - Refer to the standardized, detailed SLT prepared for the latest cycle Biennial Bridge Inspection Report and/or LRFR Load Rating Report, whichever is most current:
     - Update the standardized, detailed SLT (**See Attachment 1**) accordingly for the current cycle inspection findings. Attachment 1 includes directions for use.

- Prepare the SLT line item entries as necessary for each primary member type (i.e. girders, floorbeams, stringers, box beams, etc.) on a single worksheet, organized by span and member type.
- SLT entries shall include only corrosion induced fatigue cracks associated with corrosion or corrosion holes. SLT entries shall not include "traditional" out-of-plane bending fatigue cracks or associated issues. Such fatigue cracks and associated issues shall be included elsewhere in the Biennial Bridge Inspection Report (i.e. Inspection Report section entitled "Superstructure 2 (Superstructure)" or in a separate Report section created and added to the Report).
- SLT entries may include areas of section loss measuring less than 1/8"D or other deficiencies that could have an impact on the rating as deemed necessary based on engineering judgment.

3. Determination if LRFR Load Rating Updates (or Special Structural Analyses) are Required for Primary Members with Section Loss of 1/8"D or Greater (if required by Steps 1 and 2):
   - The standardized, detailed SLT will automatically calculate the percentage of section loss for each entry based on the As-Built (Original) and As-Inspected (Measured Section Loss) information input and areas automatically calculated. In conjunction with the controlling rating factor input for each entry, the SLT will then automatically determine if there could be an impact on the rating.
     - Recommend all SLT entries identified to possibly have an impact on the rating (i.e. "Review Load Rating Effect" = "Yes") for LRFR load rating updates (or special structural analyses) in the Biennial Bridge Inspection Report section entitled "Conclusions" within the "Load Rating" statement. These SLT entries are not recommended for repair in the Inspection Report until the Load Rating Engineer reviews and determines that a repair for each is required in accordance with the directions for use included in Attachment 1.

       Note: *For Routine Bridges, this sub-step (i.e. the performance of LRFR load rating updates) is typically performed between the Draft and Final Inspection Report submissions; therefore, the recommendations in the two Reports typically will differ. However, this may not always be the case due to the potential lag of the LRFR load rating updates behind the Inspection Report submissions. As a result, the recommendations to be made in the Draft and Final Inspection Reports are truly dependent upon the timing between when the Load Rating Engineer review / determination and update of the SLT are completed versus the Inspection Report submission dates.*

     - However, all SLT entries with corrosion holes and/or corrosion induced fatigue cracks shall also be recommended for repair in the Biennial Bridge Inspection Report section entitled "Superstructure 2 (Superstructure)" regardless of whether a possible impact on the rating has been identified. These SLT entries are recommended for repair in the Inspection Report because these types of deficiencies have more recently been attributed to the development of much more significant structural issues at several bridges / bridge members.
   - "Special Structural Analyses" pertain to any analyses required to evaluate any unconventional SLT entries that are not possible to evaluate using conventional LRFR load rating update methods (i.e. analysis of deteriorated bearing stiffeners and/or immediately adjacent web on both sides, etc.).
   - Include the SLT-generated "Section Loss Information Report Form" (SLIRF) in the Biennial Bridge Inspection Report section entitled "Section Loss Information".
   - Upload the working file for the prepared SLT to InspectTech in accordance with the OPS Scope of Services requirements.

Table 2 provided on Page 6 outlines all the possible Routine Bridge deficiency and recommendation combinations for primary members based on Steps 2 and 3 above; it also includes other possible combinations for primary / secondary members with advanced section loss requiring repair that are not included in Steps 2 and 3 above.

Table 2 Possible Routine Bridge Deficiency and Recommendation Combinations		
Deficiency		**Recommendation**
Category	**Description**	
"N/A" **As Denoted in the Inspection Report Section / Field Form Entitled "Superstructure 2 (Superstructure)".**	• Primary locations of primary components for primary members with section loss determined by the SLT to possibly have an impact on the rating (i.e. "Review Load Rating Effect" = "Yes") but not yet reviewed by the Load Rating Engineer (**See Attachment 1**).	• Recommend LRFR load rating updates (or special structural analyses) in the Inspection Report section entitled "Conclusions" within the "Load Rating" statement.
	• Primary locations of primary components for primary members with section loss determined by the SLT to possibly have an impact on the rating (i.e. "Review Load Rating Effect" = "Yes") that have been reviewed by the Load Rating Engineer and determined to not require repair (**See Attachment 1**).	• None.
	• Other.	• None.
"B" **As Denoted in the Inspection Report Section / Field Form Entitled "Superstructure 2 (Superstructure)".**	• Primary locations of primary components for primary members with section loss determined by the SLT to possibly have an impact on the rating (i.e. "Review Load Rating Effect" = "Yes") that have been reviewed by the Load Rating Engineer and determined to require repair (**See Attachment 1**).	• Recommend repair in the Inspection Report section entitled "Superstructure 2 (Superstructure)".
	• Primary locations of primary components for primary members with corrosion holes and/or corrosion induced fatigue cracks requiring repair regardless of whether a possible impact on the rating has been identified by the SLT (**See Attachment 1 and Note 1 below**).	• Recommend repair in the Inspection Report section entitled "Superstructure 2 (Superstructure)".
	• Secondary locations of primary components for primary members with corrosion holes and/or corrosion induced fatigue cracks requiring repair (**See Note 1 below**).	• Recommend repair in the Inspection Report section entitled "Superstructure 2 (Superstructure)".
	• Secondary members with corrosion holes and/or corrosion induced fatigue cracks requiring repair (**See Note 2 below**).	• Recommend repair in the Inspection Report section entitled "Superstructure 2 (Superstructure)".
"E" **As Denoted in the Inspection Report Section / Field Form Entitled "Conclusions" within the "Category E" Statement.**	• Primary and secondary member deficiencies are not typically included within the "Category E" statement in the Inspection Report section entitled "Conclusions", unless particularly noteworthy (i.e. an actively developing condition increasing in extent from cycle-to-cycle, members exhibiting deficiencies uncommon to them, etc.).	• None typically. Recommend interim monitoring only if on a basis of less than 2 years.

Notes:

1. These deficiencies are automatically recommended for repair because they have more recently been attributed to the development of much more significant structural issues at several bridges / bridge members due to secondary impacts on primary locations associated with alternate load paths being taken (i.e. the Structure W107.87 Girder 4 emergency repair in early 2018, where the base of web corrosion hole and corrosion induced fatigue crack on the "joint side" of the bearing stiffener were

allowing the girder to rotate about the base of web / top of lower flange (instead of at the bearing) and therefore propagating the similar base of web corrosion hole and corrosion induced fatigue crack on the "span side" of the bearing stiffener along the base of web and then ultimately into and partially across the lower flange in front of the bearing).

2. These deficiencies are automatically recommended for repair because they could possibly develop much more significant structural issues at these or their surrounding bridge members due to secondary impacts associated with alternate load paths being taken.

Definitions:

1. Primary Locations of Primary Components for Primary Members include the "span side" of flanges, the "span side" of webs, bearing stiffeners and immediately adjacent web on both sides, and other similar main load carrying locations and components.
2. Secondary Locations of Primary Components for Primary Members include the "joint side" of flanges, the "joint side" of webs, and other similar minor load carrying locations and components.
3. Secondary Components for Primary Members include intermediate stiffeners, longitudinal stiffeners, and other similar secondary components.

Related Major and Routine Bridge Procedure for Primary Structural Steel Member Condition State Assessment in the Bridge Element Inspection Forms:

In order to also ensure uniformity and consistency for this Biennial Bridge Inspection Report task, which is directly related to the Major and Routine Bridge procedures for primary structural steel member section loss documentation and LRFR load rating warrants, the following items shall be utilized accordingly:

1. Category "N/A" deficiencies for primary locations of primary components for primary members with section loss determined by the SLT to possibly have an impact on the rating (i.e. "Review Load Rating Effect" = "Yes") but not yet reviewed by the Load Rating Engineer shall be coded in Condition State 4 under the bridge element defect "Corrosion (1000)".

2. Category "N/A" deficiencies for primary locations of primary components for primary members with section loss determined by the SLT to possibly have an impact on the rating (i.e. "Review Load Rating Effect" = "Yes") that have been reviewed by the Load Rating Engineer and determined to not require repair shall be coded in Condition State 3 under the bridge element defect "Corrosion (1000)".

3. Category "B" deficiencies for primary locations of primary components for primary members with section loss determined by the SLT to possibly have an impact on the rating (i.e. "Review Load Rating Effect" = "Yes") that have been reviewed by the Load Rating Engineer and determined to require repair shall be coded in Condition State 4 under the bridge element defect "Corrosion (1000)".

4. Category "B" deficiencies for primary locations of primary components for primary members with corrosion holes and/or corrosion induced fatigue cracks requiring repair regardless of whether a possible impact on the rating has been identified by the SLT shall be coded in Condition State 4 under the bridge element defect "Corrosion (1000)".

5. Category "B" deficiencies for secondary locations of primary components for primary members with corrosion holes and/or corrosion induced fatigue cracks requiring repair shall be coded in Condition State 4 under the bridge element defect "Corrosion (1000)".

ATTACHMENT 1

STANDARDIZED, DETAILED SECTION LOSS TABLE (SLT)

This Section Loss Table (SLT) is to be used by Bridge Inspectors and Load Rating Engineers to document section loss and other areas of deterioration that would cause a reduction in the load carrying capacity of bridge elements. It is intended that all areas of deterioration will be recorded and determination of the status of that recorded deterioration will be updated each inspection cycle. This Section Loss Table will also provide documentation between the measured field deterioration and the properties used in the load rating calculations.

Directions for Use:

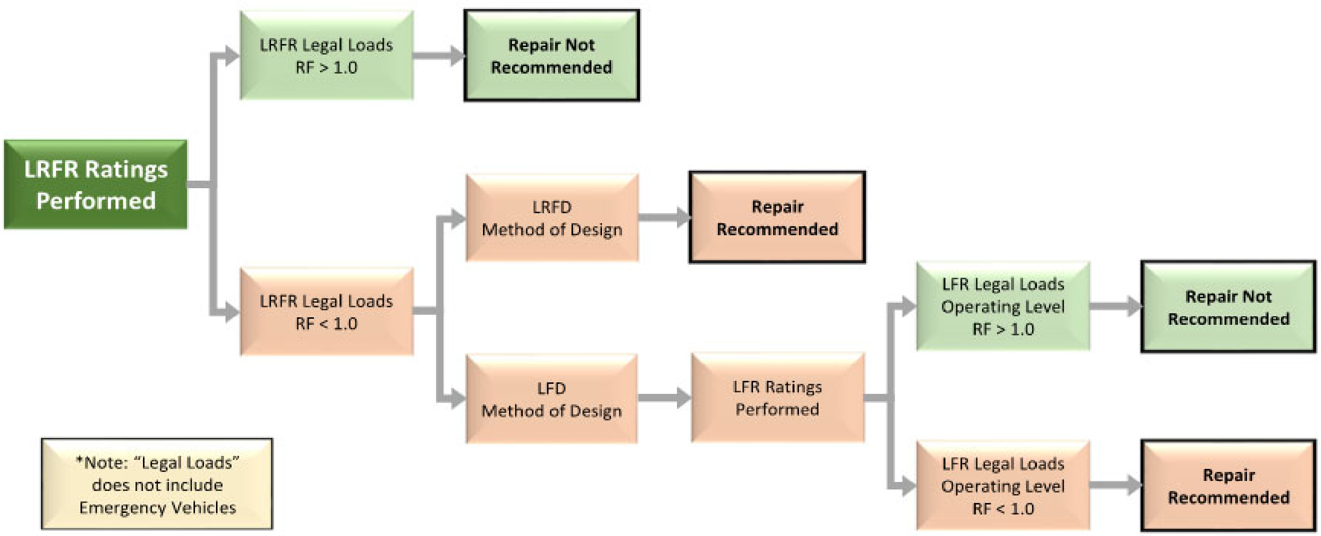
1. Enable Marcos for the Section Loss Table.
2. To create a new file, generate a "Section Loss Field Form" by executing the "Create SLFF and PDF" Macro for use in the field to document section loss and areas of deterioration that may have an impact on the load carrying capacity of the member being inspected.
3. For Updating an existing Section Loss Table, the Bridge Inspector should generate a "Section Loss Field Form" by executing the "Create SLFF and PDF" Macro for use in the field to review and update the findings. The Bridge Inspector should set the Status (Section Loss Table Worksheet Column Q) of all the lines to "Existing" or "Repaired" prior to creating the form.
4. Each measured location of Section Loss is to be entered into the Worksheet entitled "Section Loss Table" on separate lines by the Bridge Inspector.
5. Do not insert or delete lines into the Section Loss Table Worksheet. Use the "Add Row" and "Delete Row" Macros to add and remove lines from the Worksheet. Lines should only be deleted to remove empty lines.
6. The Bridge Inspector shall enter their initials and date of input into Section Loss Table Worksheet Cells AY3 and BA3. The checker shall enter their initials and date of check in Cells AY4 and BA4.
7. The Bridge Inspector shall enter in the date when the section loss was first recorded (Section Loss Table Worksheet Column A). "Unk." should be entered in this column if the date is unknown.
8. When the section loss is updated, the Bridge Inspector should enter in the date of the update (Section Loss Table Worksheet Column B).
9. The member type (Section Loss Table Worksheet Column E) is to indicate if the member is built-up (riveted member, welded plate, girder, etc.) or a rolled shape.
10. The Bridge Inspector is responsible for entering the as-built section properties for each line (Section Loss Table Worksheet Columns G-H). The Area (Section Loss Table Worksheet Column I) is computed automatically.
11. The measured section loss (Section Loss Table Worksheet Columns J-K) is to be filled-out by the Bridge Inspector. The Loss Area (Section Loss Table Worksheet Column L) is computed automatically. The Loss Location (Section Loss Table Worksheet Columns M-N) is to be entered into the spreadsheet by the Bridge Inspector. The distance "X" is the distance from the beginning of the member to the start of the loss. The distance "L" (Section Loss Table Worksheet Column O) is the length of the loss.

12. The percent loss is computed by the Worksheet (Section Loss Table Worksheet Column P). This section loss is computed by element and is not the section loss across the entire section.
13. The Bridge Inspector shall identify the Status for each location of section loss (Section Loss Worksheet Column Q). The "Status" that are to be used include; (1) New, (2) Revised, (3) Existing, (4) Repaired, and (5) Not Found. The Worksheet has been conditionally formatted to differentiate between the Status.
14. For locations that have been "Repaired", the Bridge Inspector shall identify the Construction Contract that the repair was conducted in.
15. The Bridge Inspector shall enter in the controlling load rating of the bridge for HL-93 Inventory and the controlling Legal Load rating from the previous bridge inspection report (not including EVs) (Section Loss Table Worksheet Columns V-W).
16. The Worksheet will determine if the finding will have an impact on the rating (Section Loss Worksheet Column X) based on the percent of section loss to an element (>5%) and the controlling rating factor (>2.5). This column is to be used by the Bridge Inspector to compute the number of locations that will be recommended for LRFR updates.
17. The Load Rating Engineer (LRE) is to enter in their initials and the date of the input in the Section Loss Table Worksheet Cells BD3 and BF3. The Load Rating Reviewer's (LRR's) initials and date of check should be entered into Cells BD4 and BF4.
18. The Section Loss Table Worksheet can be sorted by span or by member type. The "Sort" Macro will also automatically re-size the height of the cells.
19. The LRE will review each line where a "Yes" has been included in the column "Review Load Rating Effect" and make a determination regarding the need to include the finding in the load rating (Section Loss Table Worksheet Column Y). The LRE can provide a comment on the determination in the column labeled "Load Rating Notes".
20. The LRE shall enter in the year of the load rating update (Section Loss Table Worksheet Column Z).
21. Due to program limitations, equivalent sections may be required to develop the load rating model; therefore, the section loss applied in the analysis may not directly correspond to the measured section loss information tabulated by the Bridge Inspector. If an equivalent section is not required, then the LRE should enter a "-" into Section Loss Table Worksheet Columns AE, AF, AK, and AL. If equivalent sections are used, then the Equivalent Modeled Section Loss should be entered into Section Loss Table Worksheet Columns AK and AL for use in the load rating model.
22. If an Equivalent Section is not required, then the Modeled Section Loss should be developed from the information recorded by the Bridge Inspector and entered into Section Loss Table Worksheet Columns AH and AI.
23. The section loss area (Section Loss Table Worksheet Columns AG, AJ, and AM) is computed by the Worksheet.
24. The section loss location (Section Loss Table Worksheet Column AN) and length (Section Loss Table Worksheet Column AS) of the modeled section loss shall be entered into the Worksheet. A description of the modeled section loss can be entered into the Worksheet (Section Loss Table Worksheet Column AO).
25. The LRE shall enter the revised controlling load rating factors in the Worksheet (Section Loss Table Worksheet Columns AU-AV).

26. The LRE will determine if the section loss requires repair by employing the repair threshold guidelines provided on the Worksheet entitled "Repair Threshold".
27. Once determined, the LRE will signify section losses requiring repair by selecting "Yes" or "No" in the column "Repair Required" (Section Loss Table Worksheet Column AW). The LRE will enter annotation relating to the section loss in the column "Repair Notes" (Section Loss Table Worksheet Column AX).
28. The LRE must generate a "Section Loss Load Rating Form" by executing the "Create SLLRF and PDF" Macro. This Form will be included in the Load Rating Report for the structure.
29. The Bridge Inspector must generate a "Section Loss Information Report Form" by executing the "Create SLIRF and PDF" Macro. This Form will be included in the Biennial Bridge Inspection Report.

Repair Threshold

The following repair threshold procedure is to be used by Load Rating Engineers to determine structural steel repair warrants based on the results of the LRFR analyses. The procedure follows the Authority's current "method of design" protocol for establishing the appropriate load rating methodology toward identifying the repair warrants. It is intended that this procedure will be employed during each inspection cycle so that the latest conditions are captured and addressed.



<u>Note</u>:

1. The Load Rating Engineers shall continue to follow the guidelines set forth in Section 4.1.4 of the Authority's latest Load Rating Manual for addressing cases where the load ratings for legal loads (excluding Emergency Vehicles) fall below the required 1.00 rating factor.

ADD ROW | REMOVE ROW | SORT | CREATE SLFF AND PDF | CREATE SLLRF AND PDF | CREATE SLIRF AND PDF

STRUCTURE: MP XX.XX
INSPECTION YEAR: ______
MADE BY: ______ DATE: ______
CHECKED BY: ______ DATE: ______
SHEET: ______ OF ______

Bridge Inspection Input

Year Added	Year Revised	Span	Member	Type	Comp.	As-Built (Original)			Measured Section Loss			Loss Location		L	% Loss	Status	Status Notes	Controlling Rating Factor	
						H / W (in)	Thickness (in)	Area (sq in)	H / W (in)	T (in)	Loss Area (sq in)	X (ft)	Description	(ft)				HL 93 (Inv.)	Legal

Load Rating Engineer Input

Review Load Rating Effect	Included in Load Rating	Year Load Rated	Load Rating Notes	Equivalent Section			Modeled Section Loss			Equivalent Modeled Section Loss			Modeled Loss Location		L	% Loss	Revised Rating Factor		Repair Required	Repair Notes
				H / W_{eq} (in)	T_{eq} (in)	Area (sq in)	H / W (in)	T (in)	Loss Area (sq in)	H / W (in)	T (in)	Area (sq in)	X (ft)	Description	(ft)		HL 93 (Inv.)	Legal		