Office of Bridges and Structures

Bridge Rating Manual

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Developed By:

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DISCLAIMER

THE BRIDGE RATING MANUAL IS PUBLISHED SOLELY TO PROVIDE INFORMATION AND GUIDANCE TO BRIDGE RATING ENGINEERS IN THE STATE OF IOWA. THIS MANUAL IS ISSUED TO SECURE, SO FAR AS POSSIBLE, UNIFORMITY OF PRACTICE AND PROCEDURE IN COMPLIANCE WITH THE NATIONAL BRIDGE INSPECTION STANDARDS AND THE AASHTO MANUAL FOR BRIDGE EVALUATION. THIS MANUAL IS NOT PURPORTED TO BE A COMPLETE GUIDE IN ALL AREAS OF BRIDGE RATING AND IS NOT A SUBSTITUTE FOR ENGINEERING JUDGMENT.

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CHAPTER 1
INTRODUCTION

1.1 PURPOSE

The purpose of this manual is to document the Iowa Department of Transportation (Iowa DOT) policy and procedures for load rating and posting of structures within the State of Iowa. This manual is intended to ensure that every bridge is rated as to its safe load carrying capacity. This manual presents guidelines and procedures for rating bridges and outlines the documentation required.

1.2 SCOPE

The requirements presented in this manual are to be followed by Iowa DOT Office of Bridges and Structures (OBS) staff as well as by consultants performing work for Iowa DOT in the load rating and posting of structures. Additionally, consultants, county personnel, and city personnel performing load ratings for counties and municipalities within the State of Iowa shall follow requirements of this document unless directed otherwise.

1.3 DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

1.3.1 Definitions

The following terms in this manual are used as defined below:

- *Bridge* – A structure, including supports, erected over a depression or an obstruction such as water, a highway, or a railway; having a track or passageway for carrying traffic or other moving loads; and having an opening measured along the centerline of the roadway of more than 20 feet between undercopings of abutments or spring lines of arches or extreme ends of openings for multiple boxes. It may also contain multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening. All structures that meet this definition do not necessarily need inspection and rating per National Bridge Inspection Standards (NBIS) requirements.
- *Governing Component* – The component of a structure with the least live load carrying capacity.
- *Inventory Level* – Generally corresponds to the rating at the design level of reliability for new bridges in the American Association of State Highway and Transportation Officials (AASHTO) Specifications, but reflects the existing bridge and material conditions with regard to deterioration and loss of section.
- *Inventory Rating* – Load ratings based on the Inventory Level, which allow comparison with the capacity for new structures and, therefore, result in a live load that can safely utilize an existing structure for an indefinite period of time.
- *Live Load Distribution Factor* – The fraction of a rating truck or lane load assumed to be carried by a structural component. The AASHTO Standard Specifications for Highway Bridges uses wheel lines whereas the AASHTO LRFD Bridge Design Specifications uses axles.
- *Load Rating* – The process of determining the live load capacity of a structure based on analysis of its current condition.
- *Operating Level* – Maximum load level to which a structure may be subjected; generally corresponds to the rating at the Operating Level of reliability in past load rating practice.
- *Operating Rating* – Load ratings based on the Operating Level, which generally describe the maximum permissible live load to which the structure may be subjected. Allowing unlimited numbers of vehicles to use the bridge at Operating Level may shorten the life of the bridge.
- *Rating Factor* – The ratio of the available capacity in excess of dead load to the live load demand.

- *Redundant* – Where multiple load paths exist so that if one element fails, alternate load paths will allow the load to be redistributed.

1.3.2 Abbreviations and Acronyms

The abbreviations and acronyms used in this manual are defined in Table 1.3.2.

Table 1.3.2. Abbreviations and Acronyms

Abbreviation	Term
AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
ADTT	Average Daily Truck Traffic
ASD	Allowable Stress Design
ASR	Allowable Stress Rating
BDM	Iowa DOT “Bridge Design Manual”
EOR	Engineer of Record
FCM	Fracture Critical Members
FHWA	Federal Highway Administration
Iowa DOT	Iowa Department of Transportation
LFD	Load Factor Design
LFR	Load Factor Rating
LRFD	Load and Resistance Factor Design
LRFR	Load and Resistance Factor Rating
MBE	AASHTO “Manual for Bridge Evaluation”
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
OBS	Iowa DOT Office of Bridges and Structures
QA	Quality Assurance
QC	Quality Control
SI&A	Structure Inventory and Appraisal
SIIMS	Structure Inventory and Inspection Management System

1.4 REFERENCES

The user is encouraged to refer to the following references for additional information when performing a load rating:

- AASHTO Publications
  - Standard Specifications for Highway Bridges, 17th Edition
  - AASHTO LRFD Bridge Design Specifications, 6th Edition
  - The Manual for Bridge Evaluation, 2nd Edition (MBE)
- Iowa DOT Publications
  - Bridge Design Manual (BDM)
  - Bridge Inspection Manual

Iowa Truck Information Guide

- FHWA Publications

  Publication No.FHWA-IF-09-014, February 2009, "Load Rating Guidance and Examples for Bolted and Riveted Gusset Plates in Truss Bridges"

  Manual on Uniform Traffic Control Devices

- Other

  American Institute of Steel Construction (AISC), 1990, Iron and Steel Beams 1873 to 1952

  NCHRP Report 725, Guidelines for Analysis Methods and Construction Engineering of Curved and Skewed Steel Girder Bridges

  NCHRP Report 406, Redundancy in Highway Bridge Superstructures

  NCHRP Report 458, Redundancy in Highway Bridge Substructures

  23 CFR 650 Subpart C, National Bridge Inspection Standards

  Iowa Code Section 321.463

1.5 COORDINATION

Users should direct questions concerning the applicability or requirements of the referenced documents to the State Bridge Maintenance and Inspection Engineer.

1.6 REVISIONS

Revisions may be the result of changes in Iowa DOT specifications, FHWA requirements, or AASHTO requirements.

Users are invited to send suggestions for revisions to the Office of Bridges and Structures, Maintenance Section. Suggestions need to be written with identification of the problem, the recommended revision, and the reason for the recommendation.

All revisions affecting OBS policy will be approved by the Assistant Bridge Engineer and Bridge Maintenance Engineer.

After this manual is complete, approved policy and editorial revisions will be indicated with a line in the margin of the applicable page.

CHAPTER 2
LOAD RATING CHECKING AND QA/QC

2.1 GENERAL REQUIREMENTS

The goal of Iowa DOT is to provide a safe transportation system. Both in-house and consultants' load rating results should be checked for accuracy as part of the Quality Assurance (QA)/Quality Control (QC) process.

2.2 LOAD RATING REVIEW

When load ratings require review based on the Load Rating Evaluation Form in the Structure Inventory and Inspection Management System (SIIMS), checks shall be performed by an engineer or engineer intern qualified to do load rating.

2.2.1 Computer Program Verification

Whenever possible, perform longhand verification of a portion of the computer analysis to satisfy the load rater or checker that the computer program is accurate and performing as intended.

2.2.2 Independent Check

An independent check of the rating should be performed whenever possible. When computer programs are used, the checker should 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.

2.3 QA/QC

2.3.1 QC Review

A QC review of the load rating results must be performed by a professional engineer licensed in the State of Iowa. All load ratings must be certified by a professional engineer licensed in the State of Iowa.

2.3.2 QA Review

A QA review shall be performed according to in-house procedures for ratings performed by Iowa DOT personnel and according to the consultant's policies for ratings performed by a consultant.

2.3.3 Specific Requirements

2.3.3.1 Iowa DOT Ratings QA Review

For ratings performed by Iowa DOT personnel, on average two bridge ratings should be reviewed every month.

2.3.3.2 County/Municipality Ratings QC Review

Ratings performed by county/municipal personnel shall comply with Iowa DOT Instructional Memorandum 2.120.

2.3.3.3 Consultant Ratings

Consultants are responsible for the QA/QC of their work, checking both accuracy and completeness.

CHAPTER 3
LOAD RATING PROCESS

3.1 GENERAL

The load rating work discussed in this manual is covered by the specifications in the current version of the MBE and as modified by this manual. The load rating must be performed under the supervision of an engineer by an engineer or engineering intern.

3.2 INSPECTION DATA USED FOR LOAD RATING

A complete list of inspection data required for the load rating of a bridge would be too voluminous to include in this manual. Therefore, the user is directed to the MBE, Section 4, and to Iowa DOT's Bridge Inspection Manual for requirements.

3.3 CONCEPTS AND LOAD RATING METHODOLOGIES

The following concepts are to be applied to the load rating process:

1. Members of substructures need not be routinely live load rated. Substructure elements such as pier caps and columns should be rated in situations where the engineer has reason to believe that their capacity may govern the load capacity of the entire bridge.
2. Using engineering judgment, all superstructure spans and live load carrying components of the span shall be load rated for moment, shear, and axial (where appropriate) until the governing component is established. If the engineer, using engineering judgment, determines that certain components will not control the rating, then a full investigation of the non-controlling elements is not required.
3. For most structures, the governing rating shall be the lesser of the shear capacity or moment capacity of the critical component. For more complex structures, other forces such as axial or principal shear may control the rating.
4. Iowa DOT typically uses LARS Bridge by Bentley; however, the load rater may use other software, spreadsheets, and hand calculations as necessary to perform the rating.
5. When consultants perform load ratings, they will follow the requirements of this manual and the current MBE. Consultant load ratings shall be signed and sealed by a professional engineer registered in the State of Iowa. The consultant shall have QC procedures in place.

3.4 NEW BRIDGE

3.4.1 Ratings Performed by Iowa DOT

When load rating the structure, perform the load rating per the Load and Resistance Factor Rating (LRFR) method. For a new bridge, the Engineer of Record (EOR) shall either submit the LARS input file (if it meets the parameters to be load rated by LARS) or load rate the structure by other means if it is a "non-standard" type of structure.

3.4.2 Ratings Performed by Others

When load rating the structure, perform the load rating per the LRFR method. For a new bridge, the EOR shall either submit the completed BARSINPUT.XLT (if it meets the parameters of the Excel file) or load rate the structure by other means if it is a "non-standard" type of structure. If the consultant does not have a copy of this spreadsheet from a previous project, they should obtain it from OBS. The completed Excel file or rating calculations shall be submitted at the same time the final bridge design calculations are submitted to Iowa DOT.

3.5 EXISTING BRIDGE

Refer to Chapters 6 through 17 of this manual, inclusive, for Iowa DOT's policies on rating methods to use for the various structural types.

An existing load rating performed utilizing the Allowable Stress Rating (ASR) or the Load Factor Rating (LFR) method does not have to be reanalyzed with newer methods.

When an existing structure with an ASR requires reanalysis, the structure should be load rated using the LFR or the LRFR method.

3.6 REHABILITATED BRIDGES

Prior to developing the scope of work for bridge widening and/or rehabilitation projects, OBS or its consultant will review the inspection report(s) and the existing load rating to determine the suitability of the bridge project.

If the existing load rating is inaccurate or was performed using an older method (for example, ASR or LFR), a new load rating shall be performed for the existing bridge in accordance with this manual. All bridge widening or rehabilitation projects shall be designed in accordance with the current BDM.

If the bridge does not have an Operating load rating factor greater than or equal to 1.25 prior to an overlay and/or retrofit rail installation, then after the overlay and/or retrofit rail is placed, the bridge's Operating load capacity must be checked to verify that the Operating Capacity is above the legal load limits and that the bridge does not require posting.

3.7 USE OF COMPUTER SOFTWARE

The use of in-house and/or commercial computer software and spreadsheets is encouraged to aid in the load rating calculations. The load rater and checker are responsible for using the software and/or spreadsheets appropriately, interpreting the results appropriately, and performing independent checks as required.

Internally, OBS personnel utilize the following programs and spreadsheets to load rate structures:

- Commercial Software

  LARS/Bridge Modeler – This software package can be used to rate steel girder, prestressed girder, concrete slab, timber beam, and truss bridges using the ASR, LFR, or LRFR methods.

  Virtis – This software package can be used to load rate steel girder, prestressed girder, concrete slab, timber beam, and truss bridges using the ASR, LFR, or LRFR methods**.**

  Culvert rating software is under development.

- Spreadsheets

  BARSINPUT – This spreadsheet is used to generate a LARS input file.

CHAPTER 4
DATA COLLECTION

4.1 GENERAL

The collection of relevant and pertinent existing data about the structure is required to perform the load rating. The available information for a specific bridge may be assembled from many different sources or may rely exclusively on inspection and field measurements when other information does not exist. It is the rating engineer's responsibility to determine the reliability and applicability of all available information used to support the rating.

4.2 EXISTING PLANS

Existing plans are used to determine loads, bridge geometry, and section and material properties. Such plans include as-bid plans, as-built plans, shop drawings, and repair plans. Design plans, also referred to as as-bid plans, are created by the designer and used as a contract document for bidding and constructing the project. Construction record plans, also referred to as as-built plans, are contract design plans that have been modified to reflect changes made during construction. Changes from the as-bid plans during fabrication may not be represented in the as-built plans, but would be documented in the shop drawings. Repair plans that document repairs performed during the life of the structure may also be available. Plans may not exist for some structures, and in these cases, field measurements will be required.

4.3 INSPECTION REPORTS

Prior to performing a load rating, inspection reports must be reviewed to determine if there is deterioration or damage that needs to be accounted for in the rating. In addition, inspection reports may contain pertinent measurements of members or may note if additional loading is present. Over the life of the structure, undocumented repairs and/or changes during construction or erection may have taken place without the appropriate documentation. These changes may be discovered and documented within the inspection report. Inspection report photos and measurements can also be used to verify members and measurements in existing plan documents.

Photographs and field measurement of losses should be reported in the inspection report. It is the responsibility of the rating engineer to determine the extent of the losses and their impact on the load carrying capacity of the structure.

4.4 OTHER RECORDS

Other structure history records may exist that will provide additional information pertinent to the load rating. These records may override specifications or measurements that are reported in the as-bid plans or repair plans. Examples of pertinent records are:

- Correspondence
- Field Testing Reports
- Maintenance History
- Material Test Reports
- Mill Reports
- Posting History

CHAPTER 5
GENERAL REQUIREMENTS

5.1 CONDITION OF BRIDGE MEMBERS

The condition and extent of deterioration and defects of structural components of the bridge shall be considered in the rating computations. This information should be based on a recent thorough field investigation.

5.2 DEAD LOADS USED TO DETERMINE RATINGS

The dead load unit weights given in the current AASHTO LRFD Bridge Design Specifications shall be used in the absence of more precise information. However, normal weight reinforced concrete shall be assumed to have a unit weight of 150 pcf unless it is known otherwise.

5.3 SIDEWALK LOADING OR PEDESTRIAN LOADING USED TO DETERMINE RATINGS

5.3.1 Sidewalk Loading Using the ASR or LFR Method

Per the MBE, Article 6B.6.2.4, "Sidewalk loadings used in calculations for safe load capacity ratings should be probable maximum loads anticipated. Because of site variations, the determination of loading to be used will require engineering judgment, but in no case should it exceed the value given in AASHTO Standard Specifications. The Operating Level should be considered when full truck and sidewalk live loads act simultaneously on the bridge."

5.3.2 Pedestrian Loading Using the LRFR Method

Per the MBE, Article 6A.2.3.4, "Pedestrian loads on sidewalks need not be considered simultaneously with vehicular loads when load rating a bridge unless the rating engineer has reason to expect that significant pedestrian loading will coincide with the maximum vehicular loading. Pedestrian loads considered simultaneously with vehicular loads in calculations for load ratings shall be the probable maximum loads anticipated, but in no case should the loading exceed the value specified in LRFD Design Article 3.6.1.6."

5.4 LIVE LOADS USED TO DETERMINE RATINGS

5.4.1 ASR or LFR Method

The following list provides the live loads used by Iowa DOT when rating a structure using either the ASR or LFR method. For application of the live loads, refer to other portions of this chapter.

- **Rating Live Load**
  - HS20-44 Vehicle (See the MBE, Figures 6B.6.2-1 and 6B.6.2-2)
- **Legal Loads**
  - Routine Commercial Traffic (Figure 5.4.1-1)
    - Type 4
    - Type 3S3A
    - Type 3-3
    - Type 3S3B
    - Type 4S3
  - Specialized Hauling Vehicle (SHV)
    - SU7 (Figure 5.4.1-2)

- **Permit Trucks (See Figure 5.4.1-3)**
  - 90 kip Six-Axle Vehicle
  - 136 kip (A) Seven-Axle Truck with Triple-Axle Configuration
  - 136 kip (B) Seven-Axle Truck with a Quad-Axle Configuration
  - 156 kip Eight-Axle Truck with a Quad-Axle Configuration

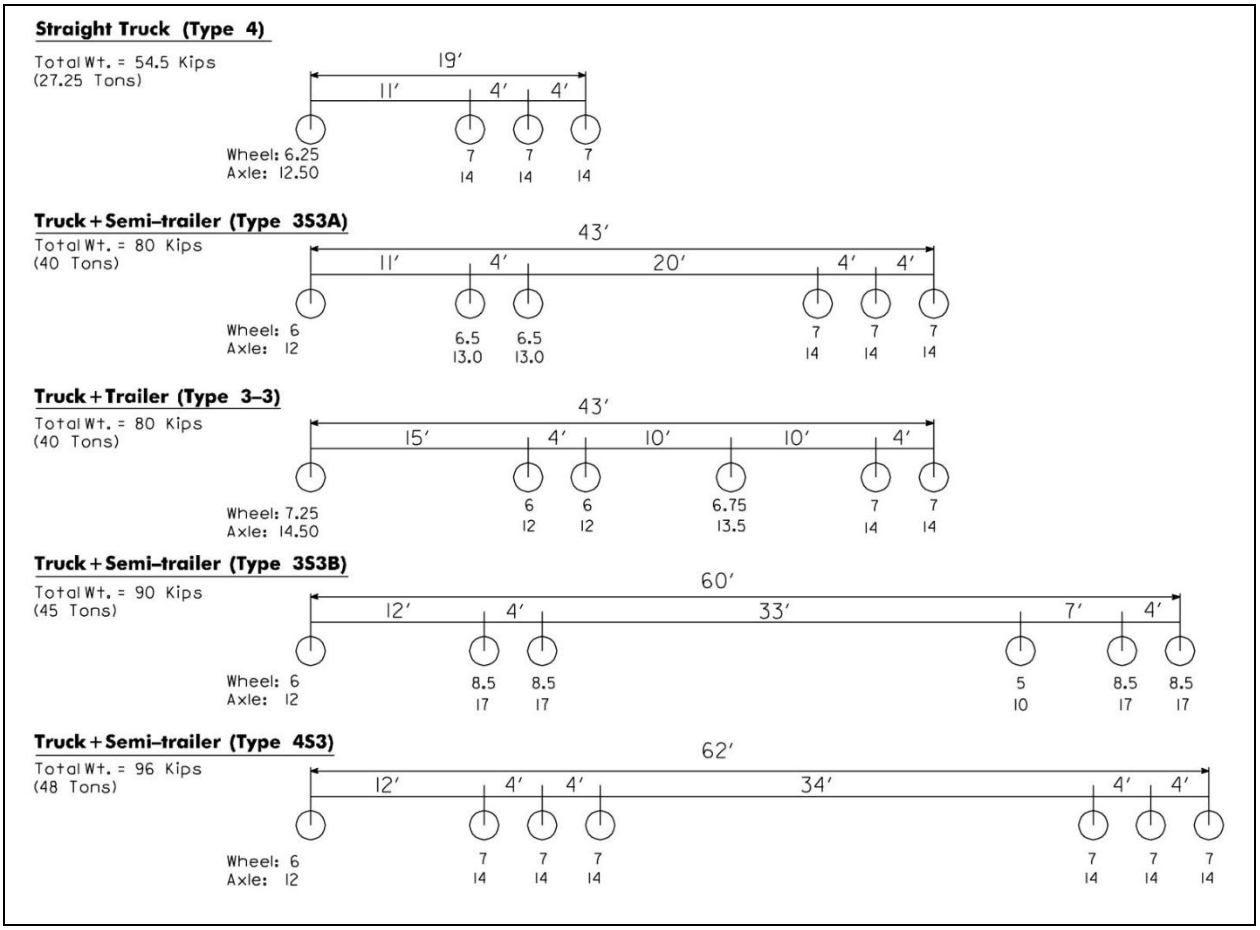

Figure 5.4.1-1. Legal Loads (Wheel and Axle Loads Shown in Kips)

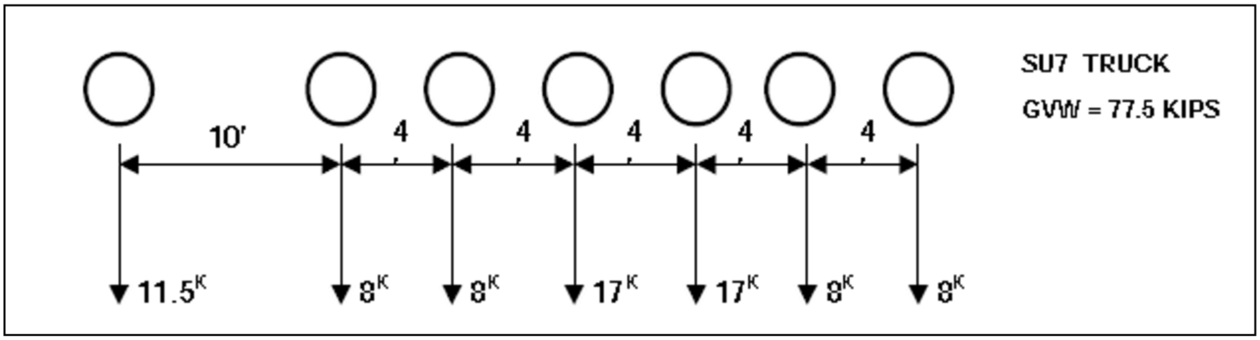

Figure 5.4.1-2. SU7 Legal Load (Showing Axle Loads)

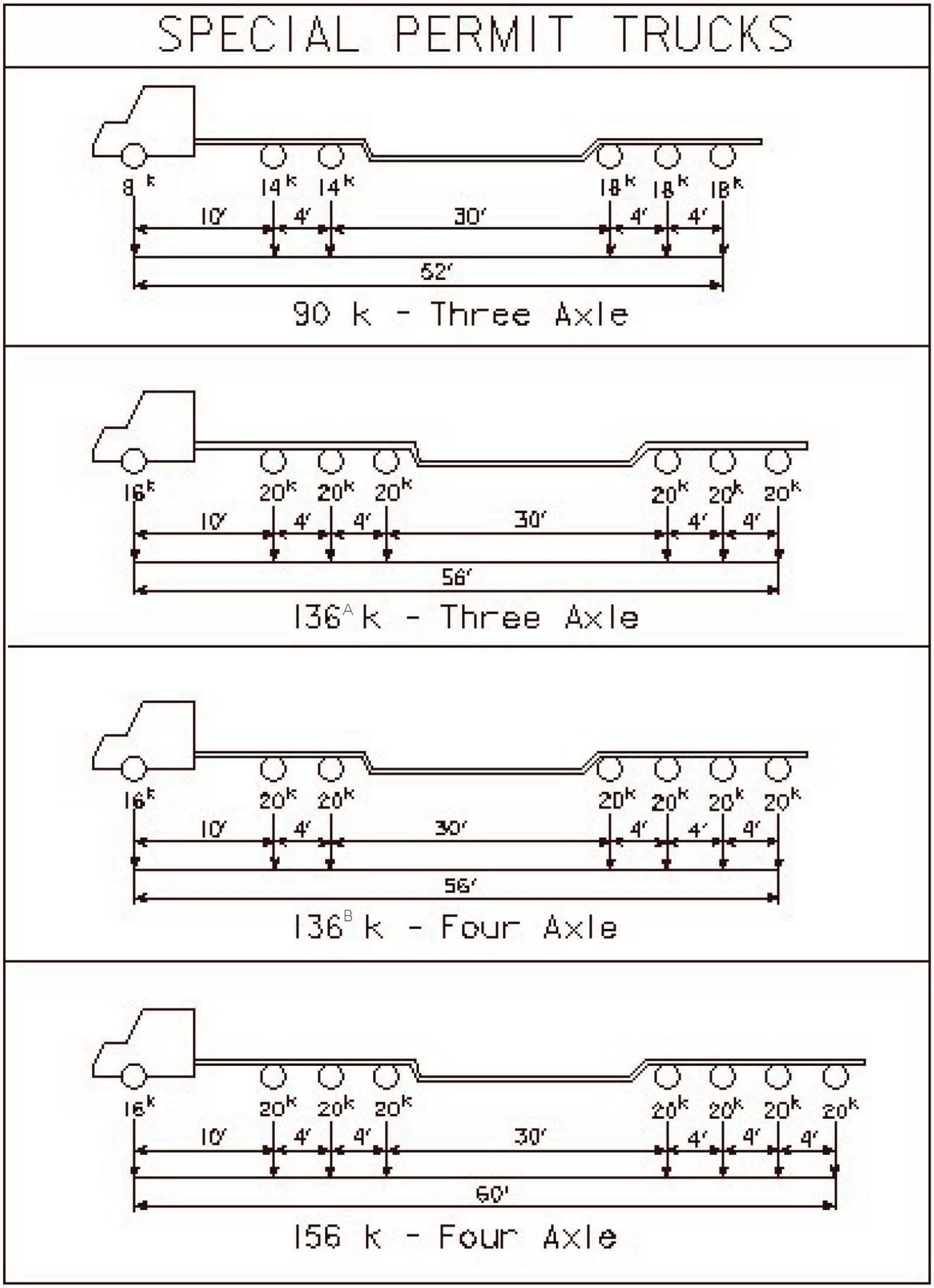

Figure 5.4.1-3. Permit Trucks

5.4.2 LRFR Method

The following live loads shall be used when rating a structure using the LRFR method:

- **Design Live Load**
  - HL-93 Vehicle (See the MBE, Figure C6A-1)
- **Legal Loads**
  - Routine Commercial Traffic (Figure 5.4.1-1)
    - Type 4
    - Type 3S3A
    - Type 3-3
    - Type 3S3B
    - Type 4S3
    - Lane-Type Legal Load
      - For Negative Moments and Reactions at Interior Supports (See the MBE, Article 6A.4.4.2.1a, the second bullet).
      - For Spans Greater Than 200 Feet (See the MBE, Article 6A.4.4.2.1a, the third bullet).
      - For bridges with ADTT <500, the 0.2 klf lane load may be excluded, but the 0.75 factor shall be changed to 1.0.

Routine Commercial Traffic shall be rated for the cases as summarized in Table 5.4.2.

Table 5.4.2. Routine Commercial Traffic Rating Summary Table

	Negative Moment and Reactions at Interior Supports	Positive Moment
Spans <= 200 ft	1) State Legal Trucks[a] Applied Separately* 2) Lane-Type Legal Load Model (A lane load of 0.2 klf combined with two State Legal Trucks[a] multiplied by 0.75 heading in the same direction separated by 30 ft)*	1) State Legal Trucks[a] Applied Separately*
Spans > 200 ft	1) State Legal Trucks[a] Applied Separately* 2) Lane-Type Legal Load Model (A lane load of 0.2 klf combined with two State Legal Trucks[a] multiplied by 0.75 heading in the same direction separated by 30 ft)* 3) Lane-Type Legal Load Model (State Legal Trucks[a] multiplied by 0.75 combined with a lane load of 0.2 klf)**	1) State Legal Trucks[a] Applied Separately* 2) Lane-Type Legal Load Model (State Legal Trucks[a] multiplied by 0.75 combined with a lane load of 0.2 klf)**

* *Load cases applied for all span lengths*

** *This load case only apply to spans > 200ft (e.g. For a four span bridge with spans of 250'-100'-250'-100', this load shall only apply to the two 250 ft spans)*

[a] *State Legal Trucks are used to refer to Routine Commercial Traffic Trucks shown in Figures 5.4.1-1*

  - Specialized Hauling Vehicle (SHV)
    - SU7 (Figure 5.4.1-2)
- **Permit Trucks (See Figure 5.4.1-3)**
  - 90 kip Six-Axle Vehicle
  - 136 kip (A) Seven-Axle Truck with Triple-Axle Configuration
  - 136 kip (B) Seven-Axle Truck with a Quad-Axle Configuration
  - 156 kip Eight-Axle Truck with a Quad-Axle Configuration

5.5 WIND LOADS

Wind loads are not normally considered in load rating unless special circumstances justify otherwise. However, the effects of wind load on special structures such as movable bridges, long-span bridges, and other high-level bridges should be considered in accordance with applicable standards.

5.6 IMPACT AND LIVE LOAD TRANSVERSE DISTRIBUTION

5.6.1 Impact

The live load impact used for rating the Design Live Load and the Legal Live Load shall be as specified in the MBE. Section 6, "Part A" shall be used for the determination of the impact when using the LRFR method, and Section 6, "Part B" shall be used for the determination of the impact when using the ASR and LFR methods. Iowa DOT does not recommend using the reduced impact in Table C6A4.4.3-1.

For live load impact applied to Permit Loads, see Section 5.9 of this manual.

5.6.2 Live Load Transverse Distribution

The transverse live load distribution used for rating shall be as specified in the MBE, Section 6, "Part A" for the LRFR method and Section 6, "Part B" for the ASR and LFR methods.

When a refined method of analysis is used for the transverse distribution of live load (for example, methods other than the approximate method), the truck and lane load shall be positioned to maximize the force effect being analyzed. Positioning of the truck and uniform lane load within a design lane or adjacent lane is illustrated in Figure 5.6.2 for roadway widths greater than 24 feet when using the LRFR method. The live load positioning in this figure also pertains to application of the HS20-44 vehicle, with the exception that the truck and lane would be rated separately. Positioning of truck and uniform lane loads for roadway widths less than 24 feet shall be as directed in the MBE.

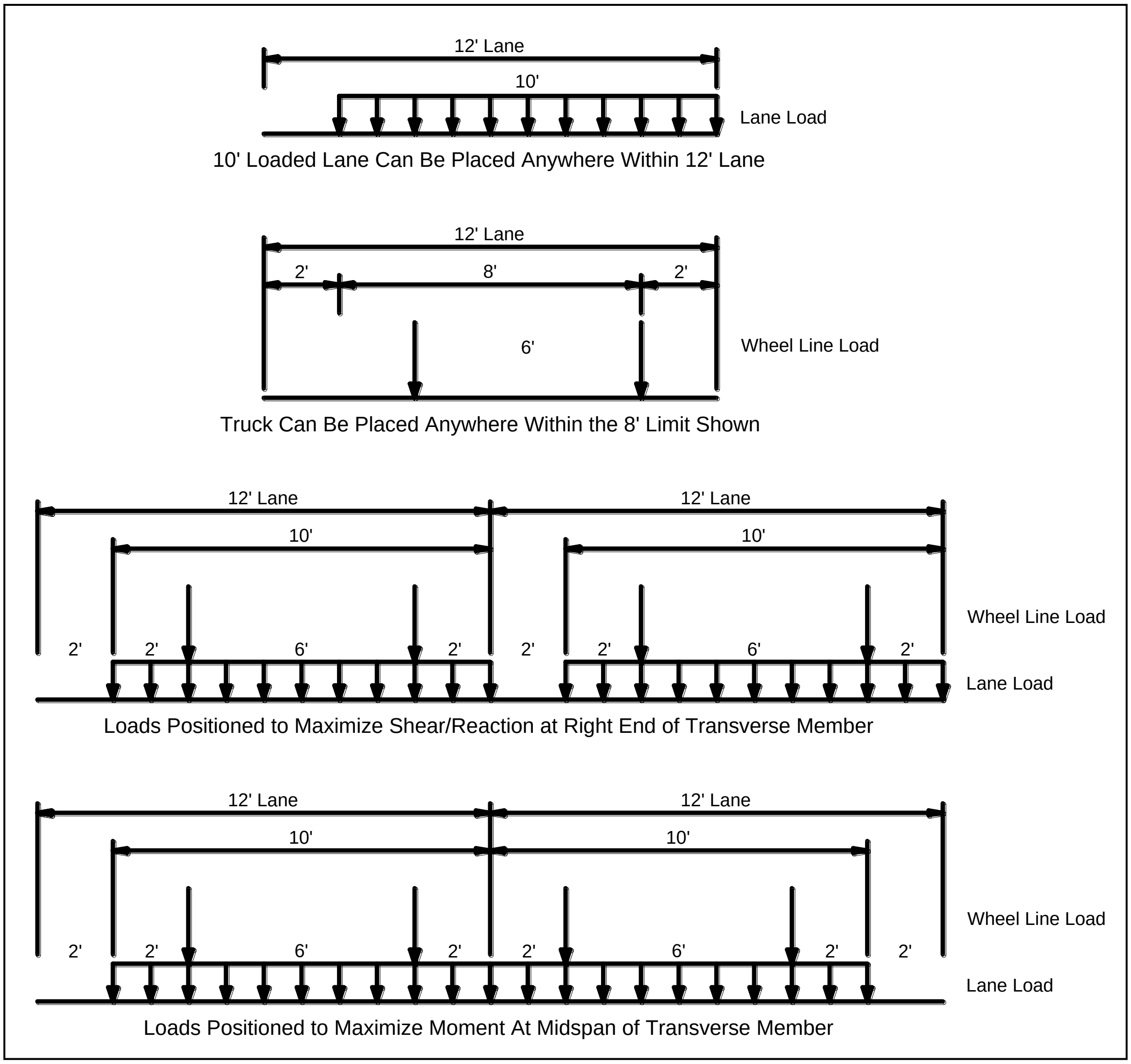

Figure 5.6.2. Examples of Live Load Positioning Using the LRFR Method

5.7 MATERIAL PROPERTIES FOR LOAD RATING

The material properties used for the ratings of all structures shall be based on the material grade or design stresses specified in the plans. In the absence of plans, or if the plans do not specify the material grades or design stresses, then the load rater must use other means to determine the appropriate material properties based on the information available. Typically, this information is based on the year the bridge was constructed and/or designed and can be found in the MBE, Section 6. Also, if the edition of the AASHTO bridge design specification is noted in the plans, this reference can provide useful information that could be used in determining the material properties or in helping to verify the material properties obtained from another source.

The following values are used by Iowa DOT and should be used by the load rater for the materials noted below unless otherwise shown in the design plans, or known by other means.

5.7.1 Structural Steel (Yield Strengths)

The values for structural steel are as follows:

- A7 Steel
  - Prior to Year 1934 – 30 ksi
  - After Year 1934 – 33 ksi
- For Unknown Grade
  - Prior to Year 1905 – 26 ksi
  - Year 1905 to Year 1936 – 30 ksi
  - Year 1936 to Year 1962 – 33 ksi
  - After Year 1962 – 36 ksi

5.7.2 Steel Rivets

For values for steel rivets, refer to the MBE, Table 6A.6.12.5.1-1. The rater shall take note that these values were updated in the "2011 Interim Revisions to the Manual for Bridge Evaluation."

5.7.3 Reinforcing Steel

The values for reinforcing steel are as follows:

- Prior to Year 1905 – 26 ksi
- Year 1905 to Year 1944 – 33 ksi
- Year 1944 to Year 1980 – 40 ksi
- After Year 1980 – 40 ksi. Most designs used 60 ksi reinforcing steel during this time, but without knowing for sure, conservatively assume 40 ksi.

5.7.4 Prestressing Steel

Where the tensile strength of the prestressing strand is unknown, the values specified in the MBE, Table 6A.5.2.3-1, based on the date of construction may be used. Stress-relieved strands should be assumed when strand type is unknown.

5.7.5 Timber

The values for timber are as follows:

- Prior to Year 1972 – See Table 5.7.5 for rating stresses. This table is based on the 1972 AASHTO Interims. For reference purposes, a copy of the 1972 AASHTO Table 1.10.1 is provided in Appendix A.
- Year 1972 to October 2010 – Refer to the latest edition of the AASHTO Standard Specifications for Highway Bridges.
- After October 2010 – Refer to the current edition of the AASHTO LRFD Bridge Design Specifications.

Table 5.7.5. Timber Rating Stresses for ASR Method

Yr	Member	Treatment	Grading	F_b		F_t		F_v		F_c (Perpendicular)		F_c (Parallel)	
				I	O	I	O	I	O	I	O	I	O
Prior to 1960	Beams and Stringers[1,4]	Treated	Graded or Ungraded (Assume Select Str.)	1600	2128	950	1264	128	170	258	348	1000	1330
		Untreated	Ungraded Falsework Str.	1200	1596	-	-	80	106	260	346	1000	1330
	Floor Planks[2,3]	Treated	Graded or Ungraded (Assume No. 1 Str.)	1496	1990	840	1117	184	245	258	343	875	1164
		Untreated	Ungraded Falsework Str.	1200	1596	-	-	80	106	260	346	1000	1330
	Posts and Timbers[1,4]	Treated	Graded or Ungraded (Assume Select Str.)	1500	1995	1000	1330	128	170	258	343	1092	1452
		Untreated	Ungraded Falsework	1200	1596	-	-	80	106	260	346	1000	1330
1960 to around 1972	Beams and Stringers[1,4]	Treated	Graded Dense Select Str.	1900	2427	1100	1463	128	170	305	406	1183	1573
		Treated	Ungraded (Assume Select Str.)	1600	2128	950	1264	128	170	258	343	1000	1330
		Untreated	Ungraded Falsework Str.	1200	1596	-	-	80	106	260	346	1000	1330
	Floor Planks[2,5]	Treated	Graded or Ungraded (Assume No. 1 Str.)	1496	1990	840	1117	184	245	258	343	875	1164
		Untreated	Ungraded Falsework Str.	1200	1596	-	-	80	106	260	346	1000	1330
	Posts and Timbers[1,4]	Treated	Graded or Ungraded (Assume Select Str.)	1500	1995	1000	1330	128	170	258	343	1092	1452
		Untreated	Ungraded Falsework	1200	1596	-	-	80	106	260	346	1000	1330

Notes:
Stress units = psi
I = Inventory
O = Operating

[1] *Values have been adjusted for wet condition, beams, stringers, and posts per 1972 AASHTO Interim, Lumber Stresses, Table 1.10.1, footnote 7.*

[2] *Values have been adjusted for wet condition, floor plank per 1972 AASHTO Interim, Lumber Stresses, Table 1.10.1, footnote 6.*

[3] *Values have been adjusted for flat usage per 1972 AASHTO Interim, Lumber Stresses, Table 1.10.1, footnote 4.*

[4] *Values have been adjusted for split equal to ¾ x Narrow face: F_v multiplier = 1.5, stringers, beams, and posts per 1972 AASHTO Interim, Lumber Stresses, Table 1.10.1, footnote 8.*

[5] *Values have been adjusted for no split; F_v multiplier = 2.0, floor plank per 1972 AASHTO Interim, Lumber Stresses, Table 1.10.1, footnote 8.*

5.8 INVENTORY AND OPERATING RATING METHODS

5.8.1 ASR and LFR Methods

The HS20-44 live load (truck and lane load) shall be used as the rating live load. The truck and lane load shall be rated separately at the Inventory and Operating Levels, and the controlling rating between the truck and lane loadings shall be reported. If the Inventory Rating Factor for the HS vehicle is below 1.0, the structure shall also be rated for the Iowa Legal Loads at the Inventory and Operating Levels. Although not required, if the Inventory Rating Factor for the HS vehicle is greater than 1.0, it is recommended that the bridge also be rated for the Legal Trucks if it does not take much more effort to do so, such as would be the case if the bridge is a type easily rated using a computer software package. All structures are required to be rated for Permit Loads, which shall be performed at the Operating Level.

For spans over 200 feet in length, the Legal Loads shall be rated according to the MBE, Article 6B.7.2.

5.8.2 LRFR Method

The HL-93 vehicle shall be used as the design live load and shall be rated at the Inventory and Operating Level. If the Inventory Rating Factor for the HL-93 vehicle is below 1.0, the structure shall also be rated for the Iowa Legal Loads. Although not required, if the Inventory Rating Factor for the HL-93 vehicle is greater than 1.0, it is recommended that the bridge also be rated for the Legal Trucks if it does not take much more effort to do so, such as would be the case if the bridge happens to be a type easily rated using a computer software package. All structures are required to be rated for Permit Loads.

All ratings shall be expressed in terms of rating factors for all vehicle types rounded to the nearest two decimal places.

5.8.3 When to Use ASR, LFR, or LRFR

All bridges, other than timber type, designed prior to October 1, 2010, or built or rehabilitated since 1994 shall be rated using the LFR or the LRFR method. All bridges designed after October 1, 2010, shall be rated using the LRFR method.

Timber decks, superstructures, and substructures built before October 1, 2010, shall use the ASR or LRFR method as there is no LFR method for this type of bridge.

Masonry including stone, concrete block or clay brick may be rated using the ASR method.

5.8.4 When to Use Field Evaluation and Documented Engineering Judgment

Field evaluation and documented engineering judgment can be used in Operating and Inventory Ratings when the following criteria are satisfied:

- Plans are not available for reinforced/prestressed concrete structures.
- Severe deterioration is found in superstructure (includes reinforced/prestressed concrete, steel, and timber superstructures) or substructures. To use this method, the superstructure/substructure condition rating shall not be higher than three.

Documentation of engineering judgment must include rating calculations for the critical locations. These calculations are a baseline that should be used to explain how engineering judgment was used to determine the load ratings. All reasonable efforts should be taken to base the Inventory and Operating Ratings on calculated values.

5.9 PERMIT LOAD ANALYSIS

5.9.1 Permit Trucks

Rating of Permit Loads is required for all State-owned bridges. Rating of Permit Loads for county and city bridges is recommended, but not required. Rating of Permit Loads by the LRFR method is not required, but can be used at the owner's discretion.

5.9.1.1 All Permit Trucks Other Than the 90 kip Permit Truck

All Permit Loads are to be analyzed for single-lane loading assuming the permit load is centered on the roadway cross section. Full impact is used for a 65 mph or higher speed zone, and low impact (10 percent impact factor) is used for a 55 mph or less speed zone.

5.9.1.2 90 kip Permit Truck Only

This permit vehicle shall be rated for the following two cases:

- Case 1 – One lane loading positioned at center of the deck cross section and assuming full impact.
- Case 2 – Multiple-lane loading assuming that the permit load is moving at 5 mph within lane limits and using a 10 percent impact factor.

5.10 LOAD FACTORS, CONDITION FACTORS, AND SYSTEM FACTORS

5.10.1 Load Factors

5.10.1.1 ASR and LFR Methods

There are no load factors associated with the ASR method. For the LFR method, the load factors specified in the MBE should be used.

5.10.1.2 LRFR Method

For the LRFR method, the load factors shown in the MBE shall be used.

The ADTT used to select the live load factors shall be taken from the Structure Inventory and Appraisal (SI&A) Sheet. The value should be obtained using the following equation:

ADTT = ADT*(% Truck/100)

Where ADT is Item 29 and % Truck is Item 109 on the SI&A Sheet

If the bridge is one directional, the calculated value is for one direction. However, if the bridge is two directional, it should be assumed that 55 percent of the total traffic is one directional, unless known otherwise. The 55 percent assumption is taken from the AASHTO LRFD Bridge Design Specifications, Article C3.6.1.4.2. The calculated ADTT needs to be converted to a single lane value by use of the appropriate factor from the AASHTO LRFD Bridge Design Specifications, Table 3.6.1.4.2-1.

If the ADTT is unknown, the most conservative value in the table should be used. Linear interpolation is permitted for determining the appropriate load factor.

Per Article 6A.4.5.4.2c of the MBE, the load factors as given in Table 6A.4.5.4.2a-1 shall be increased when using a refined analysis.

5.10.2 Condition Factor

5.10.2.1 ASR and LFR Methods

Not applicable.

5.10.2.2 LRFR Method

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.

The condition factor for new bridges shall be taken as 1.0. The Condition Factors are presented in the MBE, Table 6A.4.2.3-1.

Note that the Condition Factor is not a means to account for actual losses or deterioration. The actual losses and/or deterioration needs to be accounted for in the rating prior to applying the Condition Factor. The use of the Condition Factor is optional based on the engineer's judgment.

5.10.3 System Factor

5.10.3.1 ASR and LFR Methods

Not applicable.

5.10.3.2 LRFR Method

System factors that correspond to the load factor modifiers in the AASHTO LRFD Bridge Design Specifications should be used for bridges designed by the LRFD method (that is $\varphi_s=1/(\eta_D*\eta_R)$. The system factors listed in the MBE are more conservative than the LRFD design values and may be used at the discretion of the rating engineer until they are modified in the AASHTO LRFD Bridge Design

Specifications. A rating factor slightly less than 1.0 for a new bridge caused by this practice is considered acceptable.

5.11 LOAD TESTING

Load testing should be considered when certain conditions exist that make conventional methods of analysis less reliable. Specific situations that may lead to load testing are as follows:

1. Deterioration is difficult to quantify.
2. Conventional analysis methods are difficult to apply to a unique structural configuration.
3. There is a public need to allow larger vehicles to cross a bridge than the conventional analysis will allow.

CHAPTER 6
REINFORCED CONCRETE DECKS

6.1 INTRODUCTION

This section covers the rating of reinforced concrete decks. A reinforced concrete deck supported by stringers, girders, or floor beams should be rated when the condition is questionable.

6.2 POLICIES AND GUIDELINES

When design plans are available, the applicable concrete strength and reinforcing steel yield strength should be used. If plans or material information is not available, the value used should be as shown in this manual, Chapter 5, for the reinforcing steel and in the MBE, Section 6, for the concrete strength.

CHAPTER 7
TIMBER DECKS

7.1 INTRODUCTION

This section covers the rating of timber decks. Timber decks shall be rated for bending and horizontal shear capacity.

7.2 POLICIES AND GUIDELINES

The ASR or LRFR method shall be used for timber decks built before October 2010 as there is no LFR method for this type of material.

The LRFR method shall be used for timber bridges built after October 2010. Refer to the AASHTO LRFD Bridge Design Specifications, Table 8.4.1.1.4-1, for stress limits.

Unless plans show material properties or the material properties are otherwise known, refer to Table 5.7.5 or to the values noted in the current edition of the AASHTO LRFD Bridge Design Specifications.

CHAPTER 8
REINFORCED CONCRETE SUPERSTRUCTURES

8.1 INTRODUCTION

This section covers the rating of reinforced concrete girders and longitudinally reinforced concrete slabs. This section does not cover prestressed concrete members. All reinforced concrete girders and slabs shall be rated.

8.2 POLICIES AND GUIDELINES

When design plans are available, the applicable concrete strength and reinforcing steel strength should be used. If material information is not available, the value used should be as shown in this manual, Chapter 5, for the reinforcing steel and in the MBE, Section 6, for the concrete strength. The LARS defaults used by Iowa DOT are shown in Figure 8.2.

8.2.1 Reinforced Concrete Slab Bridges

The reinforcing in the top and bottom mats should be distributed over a 12-inch width. Typically, the spacing is not in increments that are evenly divided into 12 inches. Iowa DOT's policy is to take the total area of three bars and divide it by the three spaces and multiply this result by 12 inches to provide an area of reinforcing per foot width of deck. In equation form, $A_s=12*(A_1+A_2+A_3)/(3*s)$.

The edge girder section is not typically load rated.

8.2.2 ASR or LFR Method

No exceptions to the MBE should be made.

8.2.3 LRFR Method

No exceptions to the MBE should be made.

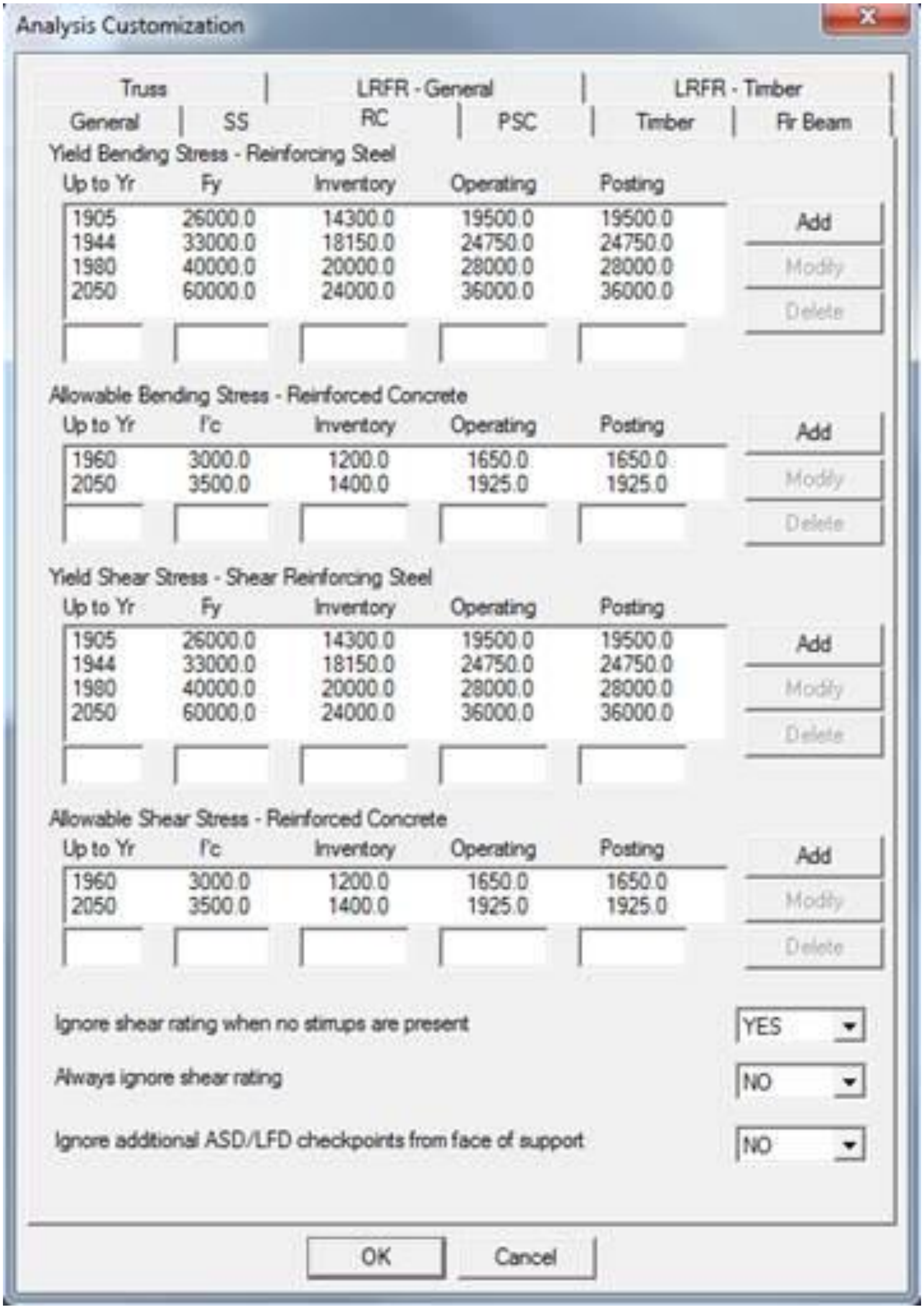

Figure 8.2. Analysis Customization Input Form from LARS (Showing Defaults Used by IaDOT)

CHAPTER 9
PRESTRESSED CONCRETE GIRDER SUPERSTRUCTURE

9.1 INTRODUCTION

This section covers the rating of prestressed concrete girders. All prestressed concrete bridges are to be rated.

9.2 POLICIES AND GUIDELINES

When design plans are available, the applicable concrete strength and prestressing steel strength should be used. If material information is not available, refer to the MBE, Section 6, for the appropriate year of construction.

Iowa DOT uses the following:

1. Elastic shortening is not applied to a transformed beam section because the transformed section already accounts for the elastic shortening effect.
2. The dead loads applied to the girder during construction should be applied to the transformed section.
3. OBS does not use 2n for calculating the stress due to long-term superimposed dead loads. Current policy is to use “n” for all dead load cases.
4. If the sacrificial wearing surface is present on the deck, it should be assumed to be removed for the purpose of rating; otherwise, the full deck thickness shall be considered in the rating.
5. Composite prestressed concrete girder bridges were designed with the deck continuous over the supports. The girders of these bridges were not made continuous over the support. Bridges meeting this description can be load rated as simple spans.

9.2.1 Software-Specific Iowa DOT Policy

9.2.1.1 LARS

Iowa DOT policy specific to LARS is as follows:

1. The LARS defaults used by Iowa DOT are shown in Figure 9.2.1.1.
2. When using LARS, the low tendon stress check is not performed unless the engineer determines that there is a large separation between the strands that may stress the bottom layer of strands appreciably more than the other layers.
3. The LARS program does not allow the percentage of ultimate stress to be input manually. The program uses 70% Fu based on the year of construction. OBS uses values of 70%, 72.644%, and 75% Fu in many cases, and sometimes the value varies amongst girders in the same bridge due to their lengths being different. OBS personnel should use the PPCBeam spreadsheet to verify LARS results.
4. The LARS program does not use the transformed section in the same way OBS does for the elastic analysis. The Inventory Rating in LARS will typically be less than what the spreadsheet analysis calculates. OBS personnel should use the spreadsheet to verify the ratings less than HS20 or rating factors less than 1.0.
5. The LARS program does not have the ability to input non-composite dead load on the girder other than the concrete deck load and self weight of the girder. Because the diaphragm weight cannot be applied directly in LARS, its weight must be converted to an equivalent deck thickness for each girder analyzed. Additional deck thickness can be added to the deck thickness to account for the weight of the diaphragm so that it will approximate the moment caused by the presence of the diaphragm. The following routine is used by OBS:

a. Convert the diaphragm weight to a uniform weight along the girder using the following formula:
   i. Diaphragm at Centerline: 2.00*Diaphragm Weight/Span Length
   ii. Diaphragm at $^{1}/_{3}$ Points: 2.67*Diaphragm Weight/Span Length
   iii. Diaphragm at $^{1}/_{4}$ Points: 4.00*Diaphragm Weight/Span Length
   iv. Diaphragm at $^{1}/_{5}$ Points: 4.80*Diaphragm Weight/Span Length
   v. Diaphragm at $^{1}/_{6}$ Points: 6.0*Diaphragm Weight/Span Length
b. Convert the above calculated uniform weight to an equivalent slab thickness, and add this amount to the actual slab thickness. The thickness should be determined by using the actual deck width used to calculate the dead load. The effective deck thickness shall not be adjusted by this routine.

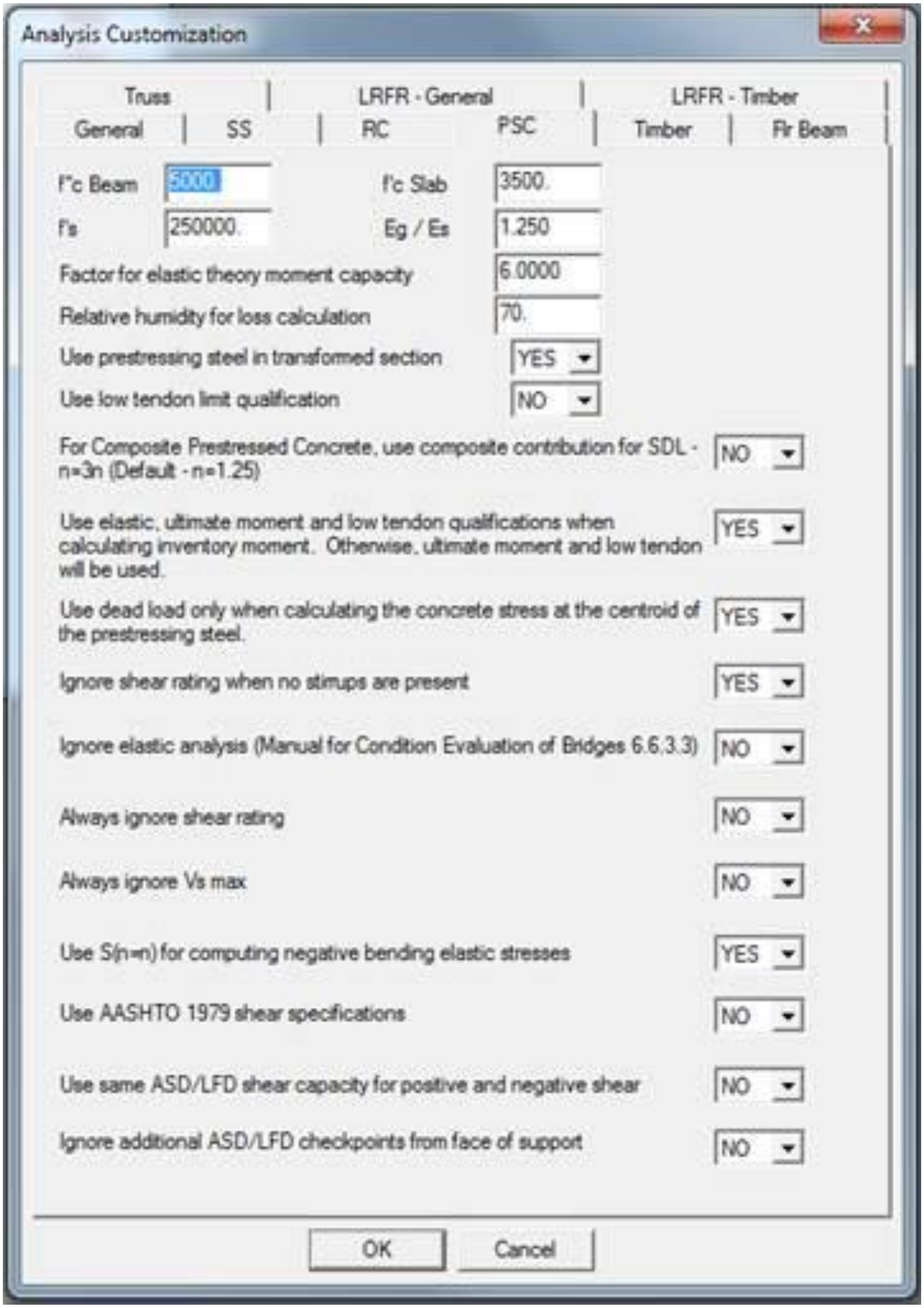

Figure 9.2.1.1. Analysis Customization Input Form from LARS (Showing Defaults)

9.2.2 ASR or LFR Method

No exceptions to the MBE should be made other than noted above.

9.2.3 LRFR Method

No exceptions to the MBE should be made other than noted above.

CHAPTER 10
STEEL SUPERSTRUCTURES

10.1 INTRODUCTION

This section covers the rating of steel girders. All steel superstructure bridges shall be rated.

10.2 POLICIES AND GUIDELINES

The plastic capacity of a girder can be used for determining the load capacity. All required checks must be satisfied in the AASHTO specifications before the plastic capacity is allowed.

Girders with shear studs or anchors are considered to have composite sections in positive bending regions. Although shear studs or anchors may be present in negative bending regions, composite action is not considered.

10.2.1 Analysis and Rating

10.2.1.1 Special Considerations

The following items shall be considered:

- 3D or grid analysis shall not incorporate top flange or bottom flange lateral bracing members (for example, wind bracing in the plane of the flanges) unless permitted by OBS. If lateral bracing members are incorporated into the analysis, they shall be treated as primary members.
- Top flanges of "Through Girder" bridges shall be considered unbraced unless it can be shown otherwise by acceptable analysis methods and permitted by OBS.
- In-span hinges shall be rated for bending, shear, and bearing.
- Bolted splices in fracture critical girders shall be rated.
- Cross frames and diaphragms resisting primary loads shall be rated (e.g. a substringer supported by a cross frame).
- Rating for Service II is required when using the LRFR method; however, the use of Service II is optional for permit rating.
- If the sacrificial wearing surface is present on the deck, it shall be assumed removed for the purposes of rating; otherwise the full deck thickness shall be considered in the rating.
- Fatigue analysis is not typically performed.

10.2.1.2 Tangent Girders

Analysis and rating of tangent girders should be performed as follows:

- The engineer is responsible for selecting the appropriate analysis method for the bridge being rated. Some analysis methods available include:
  - Line girder
  - Grid
  - 3D analysis
- Rate for bending and shear at controlling locations

10.2.1.3 Curved Girders

Analysis and rating of curved girders should be performed as follows; refer to NCHRP Report 725, Guidelines for Analysis Methods and Construction Engineering of Curved and Skewed Steel Girder Bridges:

- Use one of the following analysis methods:
  - Line girder with V-Load method
  - Grid
  - 3D analysis
- Rate curved girders as follows:
  - Incorporate lateral flange bending effects.
  - Rate for bending and shear at controlling locations.
  - Rate cross frames
  - For rating curved girder bridges with a degree of curvature less than or equal to 3 degrees, Iowa DOT allows the girders to be analyzed as straight girders. The span length used in the analysis should be the length along the curve of the girders. However, the rating engineer should refer to ASSHTO LRFD Bridge Design Specification, Articles 4.6.1.2.4b and c, for additional information, and should consider these articles when the bridge has unusual geometry or other factors that may require a more refined analysis.

10.2.2 Software-Specific Iowa DOT Policy

10.2.2.1 LARS

Iowa DOT policy specific to LARS is as follows:

1. The LARS defaults used by Iowa DOT are shown in Figure 10.2.2.1.
2. The LARS program requires the web depth and thickness for the shear rating; therefore, rolled shapes are to be converted to plate sections or input as a known rolled shape available in the program’s library. The library does contain all shapes and sizes, especially those used in older bridges. When the rolled shape is converted to a plate girder, the plates chosen should result in a section modulus as near as practical to the actual section modulus of the rolled shape. Additionally, the web height should be adjusted to maintain the section height; however, the web thickness used in the equivalent section shall be the actual web thickness.
3. The length of cover plates should be input reducing the total length of the plate by the development length at each end of the plate. Iowa DOT policy assumes the development length is equal to 1.5 times the width of the cover plate.
4. Ratings should be performed at each flange and web section change, including cover plate cut-offs. However, LARS does not allow section changes to occur at tenth points; therefore, section changes must be adjusted to occur at a location other than a tenth point.
5. Welded girders typically have transverse stiffeners located along their length. Currently, LARS input requests the maximum stiffener spacing to be input between lateral bracing points. However, using the maximum spacing will give an overly conservative shear spacing; therefore, it is recommended to use the actual spacing of the stiffeners at locations of high shear. This limitation of the program may require multiple investigations for shear.
6. The splicing points, which should correspond to girder dead load inflection points, are generally used as the transition points between the composite and non-composite regions of a girder.
7. LARS does not have the ability to input non-composite dead load on the girder other than the concrete deck load and self weight of the girder. Because the diaphragm weight cannot be applied directly in LARS, its weight must be converted to an equivalent deck thickness for each girder analyzed. Additional deck thickness can be added to the deck thickness to account for the weight of the diaphragm so that it will approximate the moment caused by the presence of the diaphragm. The following routine is used by OBS:

a. Convert the diaphragm weight to a uniform weight along the girder using the following formula:
   i. Diaphragm at Centerline: 2.00*Diaphragm Weight/Span Length
   ii. Diaphragm at $^{1}/_{3}$ Points: 2.67*Diaphragm Weight/Span Length
   iii. Diaphragm at $^{1}/_{4}$ Points: 4.00*Diaphragm Weight/Span Length
   iv. Diaphragm at $^{1}/_{5}$ Points: 4.80*Diaphragm Weight/Span Length
   v. Diaphragm at $^{1}/_{6}$ Points: 6.0*Diaphragm Weight/Span Length
b. Convert the above calculated uniform weight to an equivalent slab thickness, and add this amount to the actual slab thickness. The thickness should be determined by using the actual deck width used to calculate the dead load. The effective deck thickness shall not be adjusted by this routine.

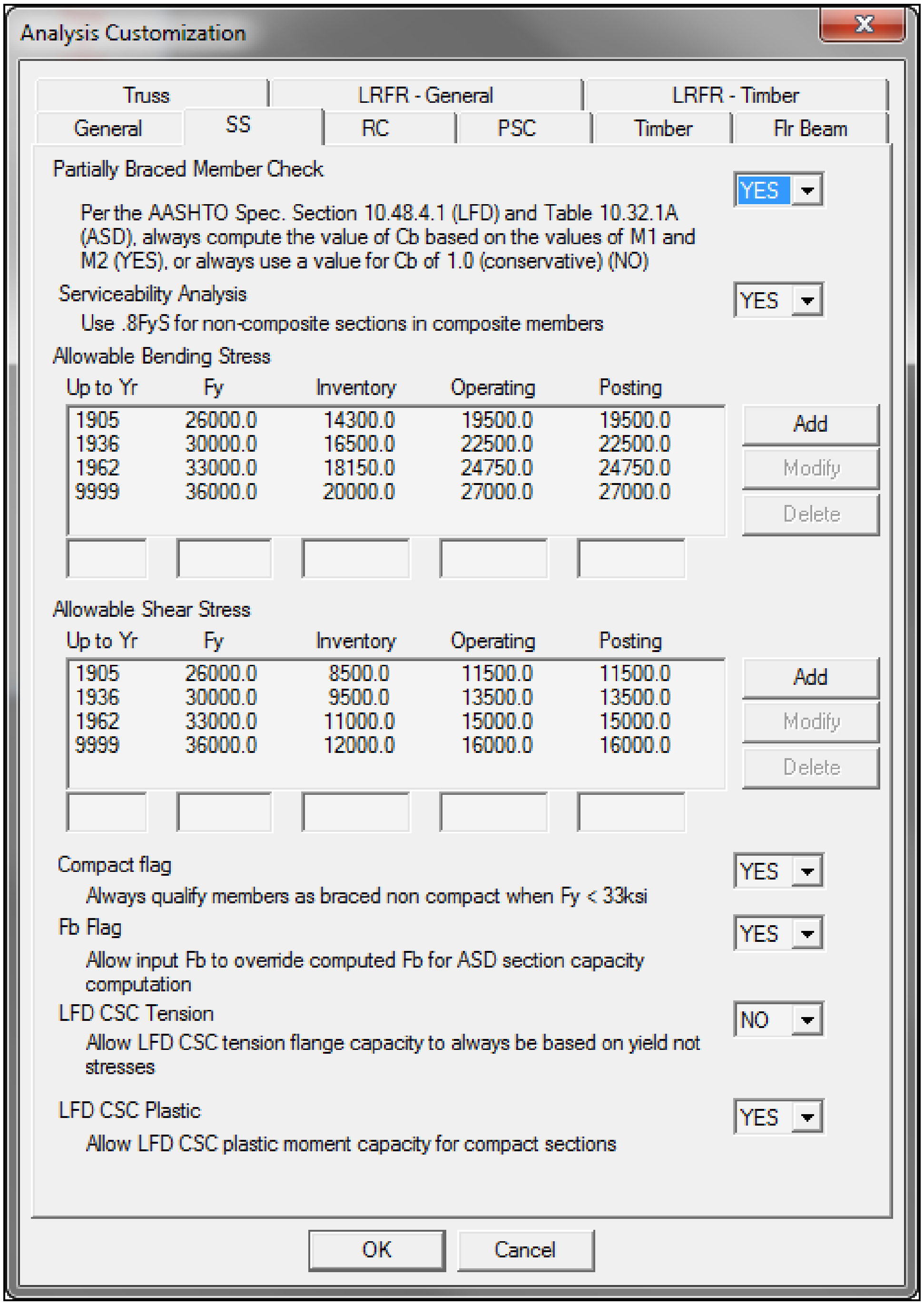

Figure 10.2.2.1. Analysis Customization Input Form from LARS (Showing Defaults)

10.2.3 ASR or LFR Method

No exceptions to the MBE should be made other than noted above.

10.2.4 LRFR Method

No exceptions to the MBE should be made other than noted above.

CHAPTER 11
STEEL TRUSS SUPERSTRUCTURE

11.1 INTRODUCTION

This section pertains to the rating of steel truss superstructures. All steel trusses shall be rated.

11.2 POLICIES AND GUIDELINES

Iowa DOT uses the following policies and guidelines:

1. Truss Members – A rating is required for all members in the truss. When the truss is symmetrical about its midspan centerline, then all the members on only one side of the midspan centerline require a rating. A rating is required only for members carrying live load (for example, typically a rating is not required for portal or sway bracing members, however, cross frames of deck trusses supporting stringers are required).
2. Interior Floor Beams – A rating is required for the critical interior floor beam. To determine the critical floor beam, more than one interior floor beam may require investigation due to variations in cross-sectional size, grade of material, loads, or any other determining factor.
3. End Floor Beams – A rating is required for an end floor beam when its cross-sectional size is different from that used for the interior floor beams or when member deterioration or loading could result in a lower rating factor than an interior floor beam.
4. Interior Stringers – A rating is required for the critical interior stringer. To determine the critical stringer, more than one interior stringer may require analysis due to variations in cross-sectional size, grade of material, span length, loads, or any other determining factor.
5. Exterior Stringers – A rating is required for an exterior stringer when its cross-sectional size is different from that used for the interior stringers or when member deterioration or loading could result in a lower rating factor than an interior stringer.
6. Gussets – A rating is required for all gussets carrying live load. Refer to Publication No. FHWA-IF-09-014, February 2009, titled "Load Rating Guidance and Examples for Bolted and Riveted Gusset Plates in Truss Bridges" for rating gusset plates. This publication presents a methodology for the rating of "simple" gusset plates using the LFR and LRFR methods. Many gusset plates are comprised of multiple plies of plates and/or splices at the gusset location that are not covered by the FHWA publication, so sound engineering judgment will be required to rate these types of gussets. It is beyond the scope of this manual to present a methodology for rating complicated gussets as there are too many types and combinations of gussets to cover. The FHWA publication presents a table of factored shear resistance for rivets; however, the user is cautioned that this table is not in agreement with the values in the most recent MBE (2nd Edition) and current interims. Therefore, the rater should use the values noted in the MBE unless other information proves otherwise.
7. Main Chord Splices – A rating is required for all splices present in the truss members.
8. Main Chord Pins – A rating is required for all pin hanger connections and pin bearing connections present in the truss.

CHAPTER 12
TIMBER SUPERSTRUCTURES

12.1 INTRODUCTION

This section pertains to the rating of timber superstructures. All timber bridges shall be rated.

12.2 POLICIES AND GUIDELINES

The ASR or LRFR method shall be used for timber bridges built before October 2010 as there is no LFR method for this type of bridge.

The LRFR method shall be used for timber bridges built after October 2010. Refer to the AASHTO LRFD Bridge Design Specifications, Table 8.4.1.1.4-1, for stress limits.

Iowa DOT uses the following:

1. Impact shall not be applied to timber structures per AASHTO.
2. Horizontal shear can often control the ratings and should always be checked.
3. Bending stress can be affected by imperfections in the members and should be accounted for in the rating calculations.
4. Vertical shear does not typically control the rating, but should be checked.

CHAPTER 13
CONCRETE AND MASONRY SUBSTRUCTURES

13.1 INTRODUCTION

This section pertains to the rating of concrete and masonry substructures.

13.2 POLICIES AND GUIDELINES

Iowa DOT uses the following criteria to determine when the substructure should be rated:

1. Substructures shall be rated when there is deterioration, tipping, or damage present that is determined to be detrimental to the substructure's load carrying capabilities.
2. Piles should be rated if a significant amount of soil has been lost by scour or other means around the pile that could cause a buckling issue or not provide enough soil for the geotechnical support of the pile in friction.
3. Pier caps shall be rated if there is deterioration or other structural issues present that would have an effect on the capacity of the cap.

CHAPTER 14
STEEL SUBSTRUCTURES

14.1 INTRODUCTION

This section pertains to the rating of steel substructures.

14.2 POLICIES AND GUIDELINES

Iowa DOT uses the following criteria to determine when the substructure should be rated:

1. Substructures shall be rated when there is deterioration, tipping, or damage present that is determined to be detrimental to the substructure’s load carrying capabilities.
2. Piles shall be rated if a significant amount of soil has been lost by scour or other means around the pile that could cause a buckling issue or not provide enough soil for geotechnical support of the pile in friction.
3. Pier caps shall be rated if there is deterioration or other structural issues present that would have an effect on the capacity of the cap.

CHAPTER 15
TIMBER SUBSTRUCTURES

15.1 INTRODUCTION

This section pertains to the rating of timber substructures.

15.2 POLICIES AND PROCEDURES

The ASR or LRFR method shall be used for timber bridges built before October 2010 as there is no LFR method for this type of bridge.

The LRFR method shall be used for timber bridges built after October 2010. Refer to the AASHTO LRFD Bridge Design Specifications, Table 8.4.1.1.4-1, for stress limits.

Iowa DOT uses the following criteria to determine when the substructure should be rated:

1. Substructures shall be rated when there is deterioration, tipping, or damage present that is determined to be detrimental to the substructure’s load carrying capabilities.
2. Piles shall be rated if a significant amount of soil has been lost by scour or other means around the pile that could cause a buckling issue or not provide enough soil for geotechnical support of the pile in friction.
3. Pier caps shall be rated if there is deterioration or other structural issues present that would have an effect on the capacity of the cap.

CHAPTER 16
BRIDGE-SIZED CONCRETE BOX CULVERTS

16.1 INTRODUCTION

This section pertains to the rating of bridge-sized concrete box culverts (that is, a length of 20 feet or greater between inside faces of outside walls measured along the centerline of the roadway).

16.2 POLICIES AND GUIDELINES

Culverts should be rated according to the guidelines provided in the MBE. If the plans or original design calculations do not exist, or severe deterioration exists, engineering judgment can be used. Engineering judgment must be based on a field evaluation. Field evaluation and engineering judgment ratings must be documented. (See the FHWA memo dated February 2, 2011, regarding "Revisions to the Recording and Coding Guide for the Structure, Inventory and Appraisal of the Nation's Bridges (Coding Guide) - Item 31, Design Load, and Items 63 and 65, Method Used to Determine Operating and Inventory Ratings.")

16.3 SOFTWARE

Concrete box culvert load rating software is under development.

CHAPTER 17
NON-TYPICAL BRIDGE TYPES

17.1 INTRODUCTION

This section pertains to bridge types that are not covered in other sections of this manual, such as steel arch bridges, concrete arch bridges, cable stayed bridges, suspension bridges, and railroad flatcar bridges.

17.2 POLICIES AND GUIDELINES

At this time, no policy guidelines exist for the rating of non-typical bridge types with the exception of railroad flatcar bridges. For railroad flatcar bridges, refer to Iowa Highway Research Board, Project TR-498, "Field Testing of Railroad Flatcar Bridges Volume I: Single Spans," dated August 2007. The rater should discuss the proposed methodology for non-typical types of bridges with his or her supervisor if done in-house, and with the contracting authority if done out of house.

CHAPTER 18
POSTING OF BRIDGES AND POSTING CONSIDERATIONS

18.1 GENERAL

The bridge owner shall post all bridges as required. Before weight limit posting is recommended, posting avoidance options should be discussed and approved by the supervisor (in-house) or contracting authority as these options may require additional analysis.

Posting bridges for load limit is a serious matter. Doing so can create a hardship on the motoring public and industry in the vicinity of the bridge. Bridges that rate low using the ASR method may be benefited by being rerated using the LFR method or the LRFR method to determine if the bridge can accommodate higher loads based on currently accepted codes. Similarly, bridges that rate low using the LFR method can be rerated using the LRFR method prior to posting.

18.2 POSTING FOR LEGAL TRUCK LOADS

Iowa DOT uses the following:

1. Posting signs should limit all vehicles as efficiently as possible. Posting for a single gross weight limit, maximum axle weight limit, or both are the most enforceable means of restricting vehicles. Any method described in the Manual for Uniform Traffic Control Devices (MUTCD) is appropriate. Using the signs in the MUTCD with pictorial images of vehicles is allowed as long as it is clearly understood that the number of axles shown on any one vehicle could be literally interpreted if or when a violation is taken to court.
2. Bridges that have adequate capacity for legal vehicles up to 40 tons, but do not have adequate capacity for legal vehicles over 40 tons should be posted for a maximum gross limit of 40 tons regardless of the allowable limit calculated. This eliminates confusion about any permit vehicles that are within the 40- to 48-ton range.
3. The minimum load posting value is 3 tons. Bridges not capable of carrying a minimum gross legal load weight of 3 tons shall be closed.
4. Iowa DOT’s policy for determination of the posting loads is using Iowa legal loads and the MBE.
5. The Operating capacity is generally used as the limit for posting. Limits below the Operating capacity can be used at the owner’s discretion. Limits below the Inventory capacity are generally not used.

18.3 POSTING CONSIDERATIONS

Posting avoidance is the application of engineering judgment to a load rating by modifying the MBE-defined procedures through the use of variances and exceptions. The methods of posting avoidance in this section are presented in an approximate hierarchy to provide the greatest benefit for the least cost. This hierarchy is not absolute and may change depending on the particular bridge being rated. Posting avoidance techniques may be used as follows:

1. Posting avoidance techniques are to be used to avoid weight limit posting, when appropriate, to extend the useful life of a bridge until strengthening or replacement of the bridge is planned and executed.
2. Posting avoidance techniques are not to be used when load rating a new bridge or when performing widening or rehabilitation.

18.3.1 Refined Methods of Analysis

Refined methods of structural analyses may be performed in order to establish an accurate live load distribution. Examples of refined methods include finite element analysis and load testing.

18.3.2 Service III Controlling Rating

If the load rating is controlled by Service III using the LRFR method and the current bridge inspection is showing no signs of either shear or flexural cracking, the load rating could be based on the Strength Limit State.

18.3.3 Stiffness of Traffic Barrier

The barrier rail stiffness could be considered and appropriately included, if necessary. Inclusion of the barriers acting compositely with the deck slab and beams should improve longitudinal load ratings. When barriers are considered in this manner, the difference in the modulus of elasticity of the lower strength barrier concrete relative to that of the deck slab and to that of the beams should be taken into account.

18.4 OPTIONS FOR RESTRICTING TRAFFIC

The following options may be used for restricting traffic:

- Post the bridge for the recommended two-lane maximum gross vehicle weights.
- Restrict traffic to one lane down the center of the bridge roadway. Traffic signals may be needed.
- Restrict traffic to one truck at a time. The direction of traffic that should have approach preference will need to be determined. One direction will be free to cross the bridge, and the opposite direction will be required to yield to oncoming traffic.
- Restrict traffic to one truck at a time, and post the bridge for the maximum gross vehicle weights. The direction of traffic that should have approach preference will need to be determined. One direction will be free to cross the bridge, and the opposite direction will be required to yield to oncoming traffic.

18.5 POSTING DOCUMENTATION

The posting limits shall be documented on the Load Rating Report in SIIMS. The load ratings of the legal vehicles can be performed for one-lane or two-lane traffic. The following shall be entered in SIIMS:

- Enter the corresponding load limits for each legal vehicle in the columns for one-lane or two-lane traffic depending on which situation will govern.
- In the Recommended Posting column of the Load Rating Table, enter the actual posting limits that are to be used on the signs, and choose whether it is a one-lane or two-lane posting from the drop-down list at the top of the column.
- If the posting will consist of only one gross weight limit, enter that limit in the first row for Straight Truck in the Recommended Posting column.

18.5.1 Operating Rating at 3 Tons or Less (NBI Item 64)

If a bridge remains open because its legal load capacity is above 3 tons but its Operating Rating is 3 tons or less, then this shall be documented in the Load Rating Report; otherwise, the bridge must be closed.

CHAPTER 19
LOAD RATING DOCUMENTATION

19.1 LOAD RATING REPORTED BY IOWA DOT PERSONNEL

Load ratings can be documented in SIIMS as a stand-alone report or as part of an inspection.

19.1.1 Load Rating in a Stand-Alone Report

The items to be checked in the "Create Report" form are shown in Figure 19.1.1-1. A sample Bridge Rating Report is shown in Figure 19.1.1-2.

19.1.1.1 Load Rating Calculations

The following steps shall be used to complete the load rating calculations:

1. Create a PDF report of the following Bridge Modeler output from LARS:
    a. Critical Member Report
    b. Member Summary Report
    c. Input Data
    d. Flexural Member Report of Critical Location
    e. Signed Load Rating Report with an electronic signature.
2. Attach the PDF report in the Report Info/Pictures tab under the type file of "Load Rating."
3. Attach hand calculations or output from other programs to the load rating calculation report.
4. Check the "Calculations Attached" box on the load rating form.

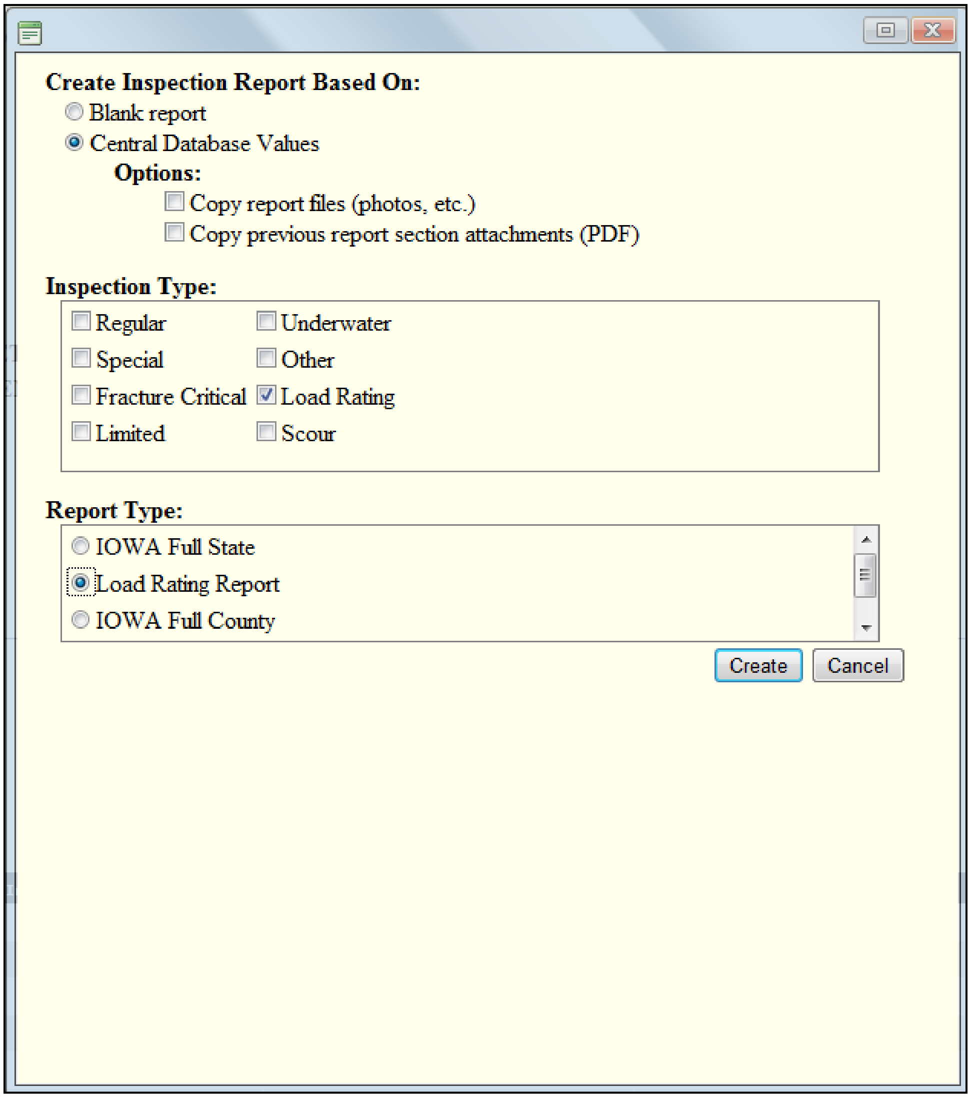

Figure 19.1.1-1. SIMMS Report Form

Iowa Department of Transportation
Form 532044 (12-09)

Bridge Load Rating Report

FHWA # (Item 8): 699780 Report By: ______ Date: ______

Bridge ID: 1800.1S702 Year Built (Item 27): 1900 Year Reconstructed (Item 106): 0

Width C-C: 10.4 Width O-O: 12.5 Bridge Structure Type (Item 43): 302

Feature Intersected (Item 6): SMALL STREAM (MHI)

STRUCTURAL INVENTORY AND APPRAISAL:

Design Load (Item 31): 0 - Unknown Lanes: 1

Operating Rating (Item 64): 4.0 Tons/RF Rating Method (Item 63): 2

Operating Rating is controlled by: ______ critical location ______

Inventory Rating (Item 66): 0.0 Tons/RF Rating Method (Item 65): 2

Inventory Rating is controlled by: ______ critical location ______

Comment: Bridge posted for one lane at 5 mph.

☑ (Calculations attached)

Deck (Item 58): 7 Superstructure (Item 59): 5 Substructure (Item 60): 6 Culvert (Item 62): N

Bridge Posting (Item 70): 0

Load Rating Table									Recommended Posting
Load Type	One Lane Traffic				Two Lane Traffic				1
	Type	Tons	Type	Tons	Type	Tons	Type	Tons	Tons
Straight Truck	4	12	3		4		3		12
Truck - Semi-trailer	3S3	18	3S2		3S3		3S2		18
Truck - Full-trailer	3-3	23	SU7		3-3		SU7		23
Triple Axle Group	4or4S3	9	3S3orB		4or4S3		3S3orB		9

Permit Vehicle Adequacy: 90K: No 136K A: No 136K B: No 156K: No

STRUCTURAL RATING

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and I am duly licensed Professional Engineer under the laws of the State of Iowa.

Signature ______ Date

Printed or Typed Name

License No.: ______ My license renewal date is December 31,

Comments:

Figure 19.1.1-2. SIMMS Bridge Load Rating Report

19.1.1.2 Load Rating Report

The following steps shall be used to complete the Load Rating Report form:

1. Sign the Load Rating Report using an electronic signature.
2. Print the signed copy and place it in the Load Rating binder.

19.1.2 Load Rating as Part of an Inspection

19.1.2.1 Load Rating Calculations

The following steps shall be used to complete the load rating calculations:

1. Create a PDF report of the following Bridge Modeler output from LARS:
    a. Critical Member Report
    b. Member Summary Report
    c. Input Data
    d. Flexural Member Report of Critical Location
    e. Signed Load Rating Report with an electronic signature
2. Upload the Bridge Modeler output PDF file into SIIMS using “Load Rating” Type, as shown in Figure 19.1.2.1.
3. Attach hand calculations or output from other programs to the load rating calculation report.
4. Attach hand “Calculations Attached” box on the Load Rating Report.

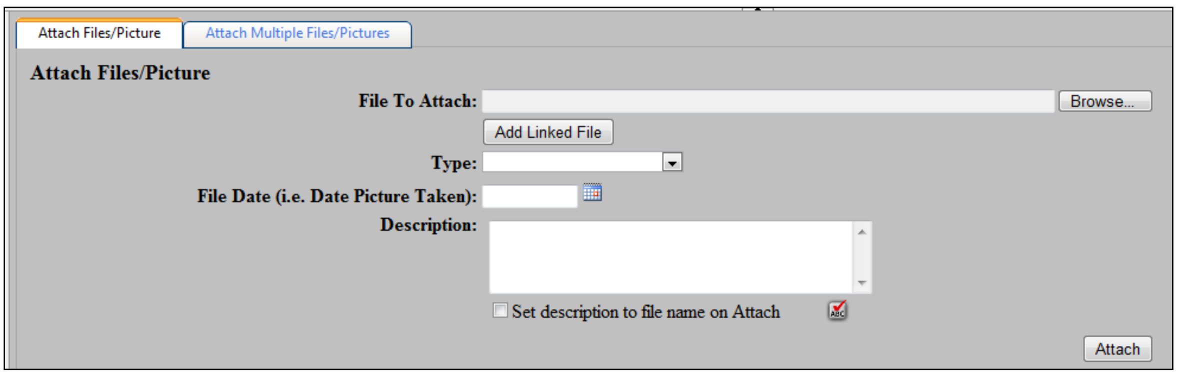

Figure 19.1.2.1. Upload Rating Calculations to SIIMS

19.1.2.2 Load Rating Report

The following steps shall be used to complete the load rating form:

1. Sign the Load Rating Report using an electronic signature.
2. Print the signed copy and place it in the Load Rating binder.

19.2 LOAD RATING REPORTED BY LOCAL PUBLIC AGENCIES

Load rating can be documented in SIIMS as a stand-alone report or as part of an inspection.

19.2.1 Load Rating in a Stand-Alone Report

The items to be checked on the “Create Report” form are shown in Figure 19.1.1-1. A sample Bridge Rating Report is shown in Figure 19.1.1-2.

19.2.1.1 Load Rating Calculations

The following steps shall be used to complete the load rating calculations:

1. Although it is allowed to maintain a hard copy in the bridge file, Iowa DOT recommends uploading an electronic copy into SIIMS using “Load Rating” Type as previously shown in Figure 19.1.2.1 before finalizing the Load Rating Report.
2. Check the “Calculations Attached” box on the Load Rating Report if an electronic copy of the calculations is uploaded into SIIMS.

19.2.1.2 Load Rating Report

The following steps shall be used to complete the load rating form:

1. Print the Load Rating Report from SIIMS.
2. Sign and seal the Load Rating Report by a professional engineer.
3. Maintain the Load Rating Report in the Bridge File.

19.2.2 Load Rating as Part of an Inspection

19.2.2.1 Load Rating Calculations

The following steps shall be used to complete the load rating calculations:

1. Although it is allowed to maintain a hard copy in the bridge file, Iowa DOT recommends uploading an electronic copy into SIIMS using “Load Rating” Type as previously shown in Figure 19.1.2.1 before finalizing the Inspection Report.
2. Check the “Calculations Attached” box on the Load Rating Report if an electronic copy of the calculations is uploaded into SIIMS.

19.2.2.2 Load Rating Report

Steps in Section 19.2.1.2 of this manual should be followed.

APPENDIX A
1972 AASHTO TABLE 1.10.1

Table 1.10.1 Allowable Unit Stresses for Structural Lumber — Visually Graded
(The allowable unit stresses below are for normal loading conditions. See other provisions of Article 1.10.1 for adjustments of these tabulated allowable unit stresses)

Note: This represents only a partial listing of available species and grades. For a complete listing see the Supplement to 1971 Edition of "National Design Specification for Stress Grade Lumber and its Fastenings", NFPA

Species and commercial grade	Size classification	Allowable unit stress in pounds per square inch [1]						Modulus of elasticity "E"	Grading rules agency
		Extreme fiber in bending "F_b"		Tension parallel to grain "F_t"	Horizontal shear "F_v"	Compression perpendicular to grain "$F_{c\perp}$"	Compression parallel to grain "F_c"		
		Engineered uses (single)	Repetitive-member uses						
CALIFORNIA REDWOOD (Surfaced dry, Used at 19% max. m.c.)									
Clear Heart Structural	4" and less thick any width	2300	—	1550	145	425	2150	1,400,000	
Clear Structural		2300	—	1550	145	425	2150	1,400,000	
Select Structural	4" and less thick and wide	2050	—	1200	100	425	1500	1,400,000	
No. 1		1700	—	1000	100	425	1250	1,400,000	
No. 2		1400	—	800	80	425	1000	1,300,000	Redwood Inspection Service
No. 3		800	—	450	80	425	600	1,100,000	
Select Structural	4" and less thick 6" to 12" wide	1750	—	1200	100	425	1450	1,400,000	
No. 1		1500	—	1000	100	425	1250	1,400,000	
No. 2		1200	—	800	80	425	1000	1,300,000	
No. 3		700	—	450	80	425	600	1,100,000	
DOUGLAS FIR-LARCH (Surfaced dry or surfaced green. Used at 19% max. m.c.)									
Dense Select Structural	2" to 4" thick 2" to 4" wide	2450	—	1400	95	455	1850	1,900,000	
Select Structural		2100	—	1200	95	385	1600	1,800,000	
Dense No. 1		2050	—	1200	95	455	1450	1,900,000	West Coast Lumber Inspection Bureau and Western Wood Products Association (see footnotes 2 through 9)
No. 1		1750	—	1050	95	385	1250	1,800,000	
Dense No. 2		1700	—	1000	95	455	1150	1,700,000	
No. 2		1450	—	850	95	385	1000	1,700,000	
No. 3		800	—	475	95	385	600	1,500,000	
Dense Select Structural	2" to 4" thick 6" and wider	2100	—	1400	95	455	1650	1,900,000	
Select Structural		1800	—	1200	95	385	1400	1,800,000	
Dense No. 1		1800	—	1200	95	455	1450	1,900,000	
No. 1		1500	—	1000	95	385	1250	1,800,000	
Dense No. 2		1450	—	950	95	455	1250	1,700,000	
No. 2		1250	—	825	95	385	1050	1,700,000	
No. 3		750	—	475	95	385	675	1,500,000	

Table No. 1.10.1 (cont'd)

Species and commercial grade	Size classification	Allowable unit stress in pounds per square inch [1]: Extreme fiber in bending "F_b" – Engineered uses (single)	Extreme fiber in bending "F_b" – Repetitive-member uses	Tension parallel to grain "F_t"	Horizontal shear "F_v"	Compression perpendicular to grain "$F_{c\perp}$"	Compression parallel to grain "F_c"	Modulus of elasticity "E"	Grading rules agency
Dense Select Structural	Beams and Stringers	1900	--	1100	85	455	1300	1,700,000	West Coast Lumber Inspection Bureau (see footnotes 2 through 9)
Select Structural		1600	--	950	85	385	1100	1,600,000	
Dense No. 1		1550	--	775	85	455	1100	1,700,000	
No. 1		1350	--	675	85	385	925	1,600,000	
Dense Select Structural	Posts and Timbers	1750	--	1150	85	455	1400	1,700,000	
Select Structural		1500	--	1000	85	385	1200	1,600,000	
Dense No. 1		1400	--	950	85	455	1200	1,700,000	
No. 1		1200	--	825	85	385	1000	1,600,000	
Select Dex	Decking	1750	2000	--	--	385	--	1,800,000	
Commercial Dex		1450	1650	--	--	385	--	1,800,000	
Dense Select Structural	Beams and Stringers	1900	--	1250	85	455	1300	1,700,000	Western Wood Products Association (see footnotes 2 through 11)
Select Structural		1600	--	1050	85	385	1100	1,600,000	
Dense No. 1		1550	--	1050	85	455	1100	1,700,000	
No. 1		1350	--	900	85	385	925	1,600,000	
Dense Select Structural	Post and Timbers	1750	--	1150	85	455	1350	1,700,000	
Select Structural		1500	--	1000	85	385	1150	1,600,000	
Dense No. 1		1400	--	950	85	455	1200	1,700,000	
No. 1		1200	--	825	85	385	1000	1,600,000	
Selected Decking	Decking	--	2000	--	--			1,800,000	
Commercial Decking		--	1650	--	--			1,700,000	
Selected Decking	Decking	--	2150			(Stresses apply at 15% moisture content)		1,900,000	
Commercial Decking		--	1800	--	--			1,700,000	
EASTERN HEMLOCK – TAMARACK (Surfaced dry or surfaced green. Used at 19% max. m.c.)									Northeastern Lumber Manufacturer Association or Northern Hardwood and Pine Manufacturers Association (see footnotes 2 through 9)
Select Structural	2" to 4" thick 2" to 4" wide	1800	--	1050	85	365	1350	1,300,000	
No. 1		1500	--	900	85	365	1050	1,300,000	
No. 2		1250	--	725	85	365	850	1,100,000	
No. 3		700	--	400	85	365	525	1,000,000	
Select Structural	2" to 4" thick 6" and wider	1550	--	1050	85	365	1200	1,300,000	
No. 1		1300	--	875	85	365	1050	1,300,000	
No. 2		1050	--	700	85	365	900	1,100,000	
No. 3		625	--	400	85	365	575	1,000,000	

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Table No. 1.10.1 (cont'd)

Species and commercial grade	Size classification	Allowable unit stress in pounds per square inch [1]: Extreme fiber in bending "F_b": Engineered uses (single)	Extreme fiber in bending "F_b": Repetitive-member uses	Tension parallel to grain "F_t"	Horizontal shear "F_v"	Compression perpendicular to grain "$F_{c\perp}$"	Compression parallel to grain "F_c"	Modulus of elasticity "E"	Grading rules agency
Select Structural	Beams and Stringers	1400	——	925	80	365	950	1,200,000	
No. 1		1150	——	775	80	365	800	1,200,000	
Select Structural	Posts and Timbers	1300	——	875	80	365	1000	1,200,000	
No. 1		1050	——	700	80	365	875	1,200,000	
Select	Decking	1500	1700	——	——	——	——	1,300,000	NeLMA
Commercial		1250	1450	——	——	——	——	1,100,000	
EASTERN SPRUCE (Surfaced dry or surfaced green. Used at 19% max. m.c.)									Northeastern Lumber Manufacturer Association or Northern Hardwood and Pine Manufacturers Association
Select Structural	2" to 4" thick 2" to 4" wide	1500	——	875	65	255	1150	1,400,000	
No. 1		1300	——	750	65	255	900	1,400,000	
No. 2		1050	——	625	65	255	700	1,200,000	
No. 3		575	——	325	65	255	425	1,100,000	
Select Structural	2" to 4" thick 6" and wider	1300	——	875	65	255	1000	1,400,000	
No. 1		1100	——	750	65	255	900	1,400,000	
No. 2		900	——	600	65	255	750	1,200,000	
No. 3		525	——	325	65	255	475	1,100,000	
Select	Decking	1250	1450					1,400,000	
Commercial		1050	1200					1,200,000	
ENGELMANN SPRUCE (Engelmann Spruce - Lodgepole Pine) (Surfaced dry or surfaced green. Used at 19% max. m.c.)									
Selected Decking	Decking	——	1300					1,200,000	Western Wood Products Association
Commercial Decking		——	1100					1,100,000	
Selected Decking	Decking	——	1400	(Stresses apply at 15% moisture content)				1,300,000	
Commercial Decking		——	1150					1,200,000	
HEM-FIR (Surfaced dry or surfaced green. Used at 19% max. m.c.)									West Coast Lumber Inspection Bureau and Western Wood Products Association (see footnotes 2 through 9)
Select Structural	2" to 4" thick 2" to 4" wide	1650	——	975	75	245	1300	1,500,000	
No. 1		1400	——	825	75	245	1000	1,500,000	
No. 2		1150	——	675	75	245	800	1,400,000	
No. 3		625	——	375	75	245	500	1,200,000	
Select Structural	2" to 4" thick 6" and wider	1400	——	950	75	245	1150	1,500,000	
No. 1		1200	——	800	75	245	1000	1,500,000	
No. 2		1000	——	650	75	245	850	1,400,000	
No. 3		575	——	375	75	245	550	1,200,000	

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Table No. 1.10.1 (cont'd)

Species and commercial grade	Size classification	Extreme fiber in bending "F_b": Engineered uses (single)	Extreme fiber in bending "F_b": Repetitive-member uses	Tension parallel to grain "F_t"	Horizontal shear "F_v"	Compression perpendicular to grain "$F_{c\perp}$"	Compression parallel to grain "F_c"	Modulus of elasticity "E"	Grading rules agency
		Allowable unit stress in pounds per square inch							
Select Structural No. 1	Beams and Stringers	1250 1000	–– ––	750 525	70 70	245 245	900 750	1,400,000 1,400,000	West Coast Lumber Inspection Bur.
Select Structural No. 1	Posts and Timbers	1200 975	–– ––	800 650	70 70	245 245	950 850	1,400,000 1,400,000	(see footnotes 2 through 9)
Select Dex Commercial Dex	Decking	1400 1150	1600 1300	–– ––	–– ––	245 245	–– ––	1,500,000 1,400,000	
Select Structural No. 1	Beams and Stringers	1250 1050	–– ––	850 700	70 70	245 245	900 775	1,400,000 1,400,000	Western Wood Products Association
Select Structural No. 1	Posts and Timbers	1200 975	–– ––	800 650	70 70	245 245	950 850	1,400,000 1,400,000	
Selected Decking Commercial Decking	Decking	–– ––	1600 1300					1,500,000 1,400,000	(see footnotes 2 through 11)
Selected Decking Commercial Decking	Decking	–– ––	1750 1450	(Stresses apply at 15% moisture content)				1,600,000 1,500,000	
IDAHO WHITE PINE (Surfaced dry or surfaced green. Used at 19% max. m.c.)									
Selected Decking Commercial Decking	Decking	–– ––	1400 1150					1,400,000 1,300,000	Western Wood Products Association
Selected Decking Commercial Decking	Decking	–– ––	1500 1250	(Stresses apply at 15% moisture content)				1,500,000 1,300,000	
LODGEPOLE PINE (Surfaced dry or surfaced green. Used at 19% max. m.c.)									
Selected Decking Commercial Decking	Decking	–– ––	1450 1200					1,300,000 1,200,000	Western Wood Products Association
Selected Decking Commercial Decking	Decking	–– ––	1550 1300	(Stresses apply at 15% moisture content)				1,400,000 1,200,000	
NORTHERN PINE (Surfaced dry or surfaced green. Used at 19% max. m.c.)									
Select Structural No. 1 No. 2 No. 3	2" to 4" thick 6" and wider	1400 1200 950 575	1600 1400 1100 650	950 800 650 375	70 70 70 70	280 280 280 280	1100 975 825 525	1,400,000 1,400,000 1,300,000 1,100,000	Northeastern Lumber Manufacturers Association and Northern Hardwood
Select Structural No. 1	Beams and Stringers	1250 1050	–– ––	850 700	65 65	280 280	800 725	1,300,000 1,300,000	and Pine Manufacturers Association

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Table No. 1.10.1 (cont'd)

Species and commercial grade	Size classification	Allowable unit stress in pounds per square inch: Extreme fiber in bending "F_b" – Engineered uses (single)	Extreme fiber in bending "F_b" – Repetitive-member uses	Tension parallel to grain "F_t"	Horizontal shear "F_v"	Compression perpendicular to grain "$F_{c\perp}$"	Compression parallel to grain "F_c"	Modulus of elasticity "E"	Grading rules agency
Select Structural	Posts and Timbers	1150	——	800	65	280	900	1,300,000	(see footnotes 2 through 9)
No. 1		950	——	650	65	280	800	1,300,000	
Select	Decking	1350	1550					1,400,000	NeLMA
Commercial		1150	1300					1,300,000	
PONDEROSA PINE – SUGAR PINE (Ponderosa Pine - Lodgepole Pine) (Surfaced dry or surfaced green. Used at 19% max. m.c.)									Western Wood Products Association
Selected Decking	Decking	——	1350					1,200,000	
Commercial Decking		——	1150					1,100,000	
Selected Decking	Decking	——	1450	(Stresses apply at 15% moisture content)				1,300,000	
Commercial Decking		——	1250					1,100,000	
RED PINE (Surfaced dry or surfaced green. Used at 19% max. m.c.)									National Lumber Grades Author. (A Canadian agency. See footnotes 2 through 8 and 12)
Select Structural	2" to 4" thick 6" and wider	1200	1350	800	70	280	900	1,300,000	
No. 1		1100	1150	675	70	280	825	1,300,000	
No. 2		825	950	550	70	280	675	1,200,000	
No. 3		500	550	325	70	280	425	1,000,000	
Select Structural	Beams and Stringers	1050	——	625	65	280	725	1,100,000	
No. 1 Structural		875	——	450	65	280	600	1,100,000	
Select Structural	Posts and Timbers	1000	——	675	65	280	775	1,100,000	
No. 1 Structural		800	——	550	65	280	675	1,100,000	
Select	Wall and Roof Plank	1150	1350			280		1,300,000	
Commercial		975	1100			280		1,300,000	
SITKA SPRUCE (Surfaced dry or surfaced green. Used at 19% max. m.c.)									West Coast Lumber Inspection Bur.
Select Dex	Decking	1300	1500	——	——	280	——	1,500,000	
Commercial Dex		1100	1250	——	——	280	——	1,300,000	
SOUTHERN PINE (Surfaced dry. Used at 19% max. m.c.)									Southern Pine Inspection Bureau
Selected Structural	2" to 4" thick 2" to 4" wide	2100	——	1250	90	405	1600	1,800,000	
Dense Select Structural		2450	——	1450	90	475	1850	1,900,000	
No. 1		1750	——	1000	90	405	1250	1,800,000	
No. 1 Dense		2050	——	1200	90	475	1450	1,900,000	
No. 2		1250	——	725	75	345	850	1,400,000	
No. 2 Medium Grain		1450	——	850	90	405	1000	1,600,000	

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Table No. 1.10.1 (cont'd)

Species and commercial grade	Size classification	Allowable unit stress in pounds per square inch: Extreme fiber in bending "F_b": Engineered uses (single)	Extreme fiber in bending "F_b": Repetitive-member uses	Tension parallel to grain "F_t"	Horizontal shear "F_v"	Compression perpendicular to grain "$F_{c\perp}$"	Compression parallel to grain "F_c"	Modulus of elasticity "E"	Grading rules agency
No. 2 Dense	2" to 4" thick 2" to 4" wide	1700	——	1000	90	475	1150	1,700,000	Southern Pine Inspection Bureau
No. 3		825	——	475	75	345	600	1,400,000	
No. 3 Dense		950	——	550	90	475	700	1,500,000	
Select Structural	2" to 4" thick 6" and wider	1800	——	1200	90	405	1400	1,800,000	
Dense Select Structural		2100	——	1400	90	475	1650	1,900,000	
No. 1		1500	——	1000	90	405	1250	1,800,000	
No. 1 Dense		1800	——	1200	90	475	1450	1,900,000	
No. 2		1050	——	700	75	345	900	1,400,000	
No. 2 Medium grain		1250	——	825	90	405	1050	1,600,000	
No. 2 Dense		1450	——	975	90	475	1250	1,700,000	
No. 3		725	——	475	75	345	650	1,400,000	
No. 3 Dense		850	——	575	90	475	750	1,500,000	
Dense Std. Factory	2" to 4" thick 2" to 4" wide	2000	——	1200	90	475	1450	1,900,000	
No. 1 Factory		1400	——	825	90	405	1000	1,600,000	
No. 1 Dense Factory		1650	——	975	90	475	1150	1,700,000	
No. 2 Factory		1400	——	825	90	405	1000	1,600,000	
No. 2 Dense Factory		1650	——	975	90	475	1150	1,700,000	
Dense Std. Factory	2" to 4" thick 6" and wider	1750	——	1200	90	475	1450	1,900,000	
No. 1 Factory		1250	——	825	90	405	1050	1,600,000	
No. 1 Dense Factory		1450	——	975	90	475	1250	1,700,000	
No. 2 Factory		1250	——	825	90	405	1050	1,600,000	
No. 2 Dense Factory		1450	——	975	90	475	1250	1,700,000	
Dense Structural 86	2" to 4" thick	2750	——	1850	150	475	2050	1,900,000	
Dense Structural 72		2300	——	1550	125	475	1700	1,900,000	
WESTERN CEDARS (Surfaced dry or surfaced green. Used at 19% max. m.c.)									
Select Dex	Decking	1200	1400	——	——	295	——	1,100,000	West Coast Lumber Inspection Bur.
Commercial Dex		1050	1200	——	——	295	——	1,000,000	
Selected Decking	Decking	——	1400					1,100,000	Western Wood Products Association
Commercial Decking		——	1200					1,000,000	
Selected Decking	Decking	——	1500	(Stresses apply at 15% moisture content)				1,100,000	
Commercial Decking		——	1250					1,000,000	

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FOOTNOTES FOR TABLE 1.10.1

[1]The allowable unit stresses shown are for selected species and commercial grades. For stresses for other species and commercial grades not shown, the designer is referred to the grading rules of the appropriate grading rules agency.

[2]The recommended design values shown in Table 1.10.1 are applicable to lumber that will be used under dry conditions such as in most covered structures. For 2" to 4" thick lumber the DRY surfaced size should be used. In calculating design values, the natural gain in strength and stiffness that occurs as lumber dries has been taken into consideration as well as the reduction in size that occurs when unseasoned lumber shrinks. The gain in load carrying capacity due to increased strength and stiffness resulting from drying more than offsets the design effect of size reductions due to shrinkage. For 5" and thicker lumber, the surfaced sizes also may be used because design values have been adjusted to compensate for any loss in size by shrinkage which may occur.

[3]Values for "F_b", "F_t", and "F_c" for the grades of Construction and Standard apply only to 4" widths.

[4]The values in Table 1.10.1 are based on edgewise use. For dimension 2" to 4" in thickness, when used flatwise, the recommended design values for fiber stress in bending may be multiplied by the following factors:

Width	Thickness		
	2"	3"	4"
2" to 4"	1.10	1.04	1.00
6" and wider	1.22	1.16	1.11

[5]When 2" to 4" thick lumber is manufactured at a maximum moisture content of 15 percent and used in a condition where the moisture content does not exceed 15 percent, the design values shown in Table 1.10.1 may be multiplied by the following factors:

Extreme fiber in bending "F_b"	Tension parallel to grain "F_t"	Horizontal shear "F_v"	Compression perpendicular to grain "$F_{c\perp}$"	Compression parallel to grain "F_c"	Modulus of Elasticity "E"
1.08	1.08	1.05	1.00	1.17	1.05

[6]When 2" to 4" thick lumber is designed for use where the moisture content will exceed 19 percent for an extended period of time, the values shown in Table 1.10.1 should be multiplied by the following factors:

Extreme fiber in bending "F_b"	Tension parallel to grain "F_t"	Horizontal shear "F_v"	Compression perpendicular to grain "$F_{c\perp}$"	Compression parallel to grain "F_c"	Modulus of Elasticity "E"
0.86	0.84	0.97	0.67	0.70	0.97

[7]When lumber 5" and thicker is designed for use where the moisture content will exceed 19 percent for an extended period of time, the values shown in Table 1.10.1 should be multiplied by the following factors:

Extreme fiber in bending "F_b"	Tension parallel to grain "F_t"	Horizontal shear "F_v"	Compression perpendicular to grain "$F_{c\perp}$"	Compression parallel to grain "F_c"	Modulus of Elasticity "E"
1.00	1.00	1.00	0.67	0.91	1.00

[8]The tabulated horizontal shear values shown herein are based on the conservative assumption of the most severe checks, shakes or splits possible, as if a plane were split full length. When lumber 4" and thinner is manufactured unseasoned the tabulated values should be multiplied by a factor of 0.92.

Specific horizontal shear values for any grade and species of lumber may be established by use of the following tables when the length of split or check is known:

When length of split is:	Multiply tabulated "F_V" value by: (Nominal 2" Lumber)
No split	2.00
1/2 x wide face	1.67
3/4 x wide face	1.50
1 x wide face	1.33
1-1/2 x wide face or more	1.00

When length of split on wide face is:	Multiply tabulated "F_V" value by: (3" and Thicker Lumber)
No split	2.00
1/2 x narrow face	1.67
1 x narrow face	1.33
1-1/2 x narrow face or more	1.00

[9]Stress rated boards of nominal 1", 1-1/4" and 1-1/2" thickness, 2" and wider, are permited the recommended design values shown for Select Structural, No. 1, No. 2 and No. 3 grades as shown in 2" to 4" thick, 2" to 4" wide and 2" to 4" thick, 6" and wider categories when graded in accordance with those grade requirements.

[10]For species combinations shown in parentheses, the lowest design values for any species in the combination are tabulated.

[11]When "MC15" Decking is used where the moisture content will exceed 15 percent for an extended period of time, the design values tabulated to apply at 15 percent moisture content should be multiplied by the following factors: Extreme Fiber in Bending "F_b" - 0.79; Modulus of Elasticity "E" - 0.92.

[12]National Lumber Grades Authority is the Canadian rules-writing agency responsible for preparation, maintenance and dissemination of a uniform softwood lumber grading rule for all Canadian species.

Insert new Table 1.10.1A.

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Table 1.10.1A. Allowable Unit Stresses for Structural Glued Laminated Timber, Members Stressed Principally in Bending, Loaded Perpendicular to the Wide Face of the Laminations[1 2 3] (Stresses shown below are for normal conditions of loading. See other provisions of Article 1.10.1 for adjustments of these tabulated allowable unit stresses.)

(1) Douglas Fir and Western Larch

		Allowable unit stresses					
					Compression ⊥ to Grain		
Combination Symbol	Number of Laminations	Extreme Fiber in Bending F_b[4 5]	Tension Parallel to Grain F_t	Compression Parallel to Grain F_c	Tension Face $F_{c\perp}$	Compression Face $F_{c\perp}$	Horizontal Shear F_v
DRY CONDITIONS OF USE E = 1,800,000 psi							
22F	4-10	2200	1600	1500	410	410	165
	4-10	2200	1600	1500	450	385	165
	11-20	2200	1600	1500	450	385	165
	21-30	2200	1600	1500	450	385	165
	31-40	2200	1600	1500	450	385	165
	41 or more	2200	1600	1500	450	385	165
24F	4-10	2400	1600	1500	450	385	165
	11-20	2400	1600	1500	450	385	165
	21-25	2400	1600	1500	450	385	165
	26-35	2400	1600	1500	450	385	165
	36-40	2400	1600	1500	450	385	165
	41 or more	2400	1600	1500	450	385	165
Note:	The 26F combination may not be readily available and the designer should check on availability prior to specifying. The 22F and 24F combinations are generally available from all laminators.						
26F	4-8	2600	1600	1500	450	410	165
	9-20	2600	1600	1500	450	410	165
	21-25	2600	1600	1500	450	410	165
	26-30	2600	1600	1500	450	410	165
	31-34	2600	1600	1500	450	410	165
	35-40	2600	1600	1500	450	410	165
	41 or more	2600	1600	1500	450	410	165
WET CONDITIONS OF USE E = 1,600,000 psi							
22F	4-10	1600	1300	1100	275	275	145
	4-10	1600	1300	1100	305	260	145
	11-20	1600	1300	1100	305	260	145
	21-30	1600	1300	1100	305	260	145
	31-40	1600	1300	1100	305	260	145
	41 or more	1600	1300	1100	305	260	145
24F	4-10	1800	1300	1100	305	260	145
	11-20	1800	1300	1100	305	260	145
	21-25	1800	1300	1100	305	260	145
	26-35	1800	1300	1100	305	260	145
	36-40	1800	1300	1100	305	260	145
	41 or more	1800	1300	1100	305	260	145
Note:	The 26F combination may not be readily available and the designer should check on availability prior to specifying. The 22F and 24F combinations are generally available from all laminators.						
26F	4-8	2000	1300	1100	305	275	145
	9-20	2000	1300	1100	305	275	145
	21-25	2000	1300	1100	305	275	145
	26-30	2000	1300	1100	305	275	145
	31-34	2000	1300	1100	305	275	145
	35-40	2000	1300	1100	305	275	145
	41 or more	2000	1300	1100	305	275	145

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Table No. 1.10.1A (cont'd)

(2) Southern Pine

Combination Symbol		Number of Laminations	Allowable Unit Stresses: Extreme Fiber in Bending F_b [4, 5, 6]	Tension Parallel to Grain F_t	Compression Parallel to Grain F_c	Compression Perpendicular to Grain F_c	Horizontal Shear F_v
DRY CONDITIONS OF USE E = 1,800,000 psi							
18F	1	4 or more	1800	1600	1500	385	200
	2	12 or more	1800	1600	1500	385	200
20F	1	10 or more[9]	2000	1600	1500	385	200
	2	10 or more	2000	1600	1500	385	200
22F	1	6 or more[9]	2200	1600	1500	450	200
	2	14 or more	2200	1600	1500	385	200
	3	18 or more	2200	1600	1500	385	200
24F	1	4 or more	2400	1600	1500	385	200
	2	12 or more	2400	1600	1500	450	200
	3	9 or more	2400	1600	1500	385	200
Note: The 26F combination may not be readily available and the designer should check on availability prior to specifying. Other combinations listed are generally available from all laminators.							
26F	1	9 or more[7, 8]	2600	1600	1500	385	200
	2	14 or more	2600	1600	1500	450	200
	3	13 or more	2600	1600	1500	450	200
WET CONDITIONS OF USE E = 1,600,000 psi							
18F	1	4 or more	1400	1300	1100	260	175
	2	12 or more	1400	1300	1100	260	175
20F	1	10 or more[9]	1600	1300	1100	260	175
	2	10 or more	1600	1300	1100	260	175
22F	1	6 or more[9]	1800	1300	1100	300	175
	2	14 or more	1800	1300	1100	260	175
	3	18 or more	1700	1300	1100	260	175
24F	1	4 or more	1900	1300	1100	260	175
	2	12 or more	2000	1300	1100	300	175
	3	9 or more	1900	1300	1100	260	175
Note: The 26F combination may not be readily available and the designer should check on availability prior to specifying. Other combinations listed are generally available from all laminators.							
26F	1	9 or more[7, 8]	2000	1300	1100	260	175
	2	14 or more	2000	1300	1100	300	175
	3	13 or more	2100	1300	1100	300	175

FOOTNOTES FOR TABLE 1.10.1A

[1]The tabulated stresses in this table are primarily applicable to members stressed in bending due to a load applied perpendicular to the wide face of the laminations. For combinations and stresses applicable to members loaded primarily axially or parallel to the wide face of the laminations, see Table 1.10.1B.

[2]The tabulated bending stresses are applicable to members 12 inches or less in depth. For members greater than 12 inches in depth, the requirements of Article 1.10.2 on Size Factor apply.

[3]The tabulated combinations are applicable to arches, compression members, tension members and also bending members less than 16-1/4 inches in depth. For bending members 16-1/4 inches or more in depth, footnotes 4 and 5 apply.

[4]The grading restrictions as contained in AITC 301-22, 301-24 and 301-26 tension lamination requirements shall be followed for the outermost tension laminations representing 5% of the total depth of glued laminated bending members 16-1/4 inches or more in depth. For all conditions of use, AITC 301-22 is applicable to combination 22F, AITC 301-24 is applicable to combination 24F and AITC 301-26 is applicable to combination 26F. See Appendix "A" of AITC 203-70 for details of these tension lamination requirements.

[5]In addition to other requirements, the tension laminations as described in AITC 301-22, 301-24 and 301-26 are required to be dense.

[6]The next inner 5% of the outermost tension laminations are to be No. 1 Dense for the same conditions as indicated by footnote number 4.

[7]For fewer than nine (9) laminations, add one No. 1 lamination to each outer zone.

[8]For combination 26F(1), six or fewer laminations, the allowable unit stresses for tension parallel to grain and compression parallel to grain can be increased to 1800 psi and 1600 psi respectively for the dry condition of use and to 1500 psi and 1200 psi respectively for the wet condition of use.

[9]Where fewer laminations are required, a combination with a higher allowable unit stress can be selected.

Insert new Table 1.10.1B.

Table 1.10.1B

Allowable Unit Stresses for Structural Glued Laminated Timber, Members Stressed Principally in Axial Tension or Axial Compression, or a combination of Axial Loading Plus Bending Parallel to or Perpendicular to the Wide Face of the Laminations.[1] (Stresses shown below are for normal conditions of loading. See other provisions of Article 1.10.1 for adjustments of these tabulated allowable unit stresses.)

Combination Symbol	Number of Laminations	Tension Parallel to Grain F_t	Compression Parallel to Grain F_c	Extreme Fiber in Bending F When Loaded: Parallel to Wide Face[3]	Extreme Fiber in Bending F When Loaded: Perpendicular to Wide Face[2,4]	Compression Perpendicular to Grain[3] $F_{c\perp}$	Horizontal Shear F_v When Loaded: Parallel to Wide Face[3]	Horizontal Shear F_v When Loaded: Perpendicular to Wide Face[4]
(1) Douglas Fir and Western Larch		DRY CONDITIONS OF USE E = 1,800,000 psi						
1	All	1200	1500	900	1200	385	145	165
2	All	1800	1800	1500	1800	385	145	165
3	All	2200	2100	1900	2200	450	145	165
4	All	2400	2000	2100	2400	410	145	165
5	All	2600	2200	2300	2600	450	145	165
		WET CONDITIONS OF USE E = 1,600,000 psi						
1	All	950	1100	750	950	260	120	145
2	All	1400	1300	1100	1400	260	120	145
3	All	1800	1500	1450	1800	305	120	145
4	All	1900	1450	1500	1900	275	120	145
5	All	2000	1600	1600	2000	305	120	145
(2) Southern Pine		DRY CONDITIONS OF USE E = 1,800,000 psi						
1	All	1600	1400	950	1100	385	165	200
2	All	2200	1900	1700	1800	385	165	200
3	All	2600	2200	2000	2100	450	165	200
4	All	2400	2100	1950	2400	385	165	200
5	All	2600	2200	2300	2600	450	165	200
		WET CONDITIONS OF USE E = 1,600,000 psi						
1	All	1300	1000	750	850	260	145	175
2	All	1800	1400	1350	1450	260	145	175
3	All	2100	1600	1600	1700	300	145	175
4	All	1900	1500	1550	1950	260	145	175
5	All	2100	1600	1850	2100	300	145	175

FOOTNOTES FOR TABLE 1.10.1B

[1]The tabulated stresses in this table are primarily applicable to members loaded axially or parallel to the wide face of the laminations. For combinations and stresses applicable to members stressed principally in bending due to a load applied perpendicular to the wide face of the laminations, see Table 1.10.1A.

[2]It is not intended that these combinations be used for deep bending members, but if bending members 16-1/4 inches or deeper are used, the applicable AITC tension lamination requirements must be followed.

[3]The tabulated stresses are applicable to members containing three (3) or more laminations.

[4]The tabulated stresses are applicable to members containing four (4) or more laminations.

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