

Why Bridge Load Ratings are Important

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Professional Background

- 30 Years at the Illinois Department of Transportation (IDOT), mostly in Bureau of Bridges and Structures (BBS)
 - First 10 years, mainly in Design, wrote most of the IDOT BBS internal design/analysis software in VB/FORTRAN
 - Last 20 years performing load ratings or overseeing/directing load rating program for IDOT BBS
- AASHTOWare:
 - o Virtis/BrDR Task Force Chair
 - o Special Committee on AASHTOWare (SCOA) Vice-Chair
- Member of AASHTO Committee on Bridges and Structures, 2011-2022
 - T-18 - Technical Committee on Bridge Management, Evaluation and Rehabilitation (MBE Specifications)
 - T-19 - Technical Committee on Software & Technology (Vice-Chair)



National Bridge Inspection Standards (NBIS)



NBIS Regulations

- § 650.307 Bridge inspection organization responsibilities

“(e) Each State transportation department, Federal agency, and Tribal government must include a bridge inspection organization that is responsible for the following:

(8) Producing valid load ratings and when required, implementing load posting or other restrictions;”
- § 650.309 Qualifications of personnel

“(d) Load ratings must be performed by, or under the direct supervision of, a registered professional engineer.”

NBIS Regulations

- § 650.313 Inspection procedures.

(k) Load rating.

 - (1) Rate each bridge as to its safe load capacity in accordance with the incorporated articles in Sections 6 and 8, AASHTO Manual (incorporated by reference, see § 650.317).
 - (2) Develop and document procedures for completion of new and updated bridge load ratings. Load ratings must be completed as soon as practical, but no later than 3 months after the initial inspection and when a change is identified that warrants a re-rating such as, but not limited to, changes in condition, reconstruction, new construction, or changes in dead or live loads.
 - (3) Analyze routine and special permit loads for each bridge that these loads cross to verify the bridge can safely carry the load.

NBIS Regulations

- § 650.313 Inspection procedures.

(l) Load posting.

 - (1) Implement load posting or restriction for a bridge in accordance with the incorporated articles in Section 6, AASHTO Manual (incorporated by reference, see § 650.317), when the maximum unrestricted legal loads or State routine permit loads exceed that allowed under the operating rating, legal load rating, or permit load analysis.
 - (2) Develop and document procedures for timely load posting based upon the load capacity and characteristics such as annual average daily traffic, annual average daily truck traffic, and loading conditions. Posting shall be made as soon as possible but not later than 30 days after a load rating determines a need for such posting. Implement load posting in accordance with these procedures.

Controlling Docs - NBIS Regulations

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- § 650.317 Incorporation by reference

- (a) AASHTO. American Association of State Highway and Transportation Officials, 555 12th Street NW, Suite 1000, Washington, DC 20004; 1-800-231-3475; <https://store.transportation.org>.
- (1) MBE-3. "The Manual for Bridge Evaluation," Third Edition, 2018; IBR approved for § 650.305 and 650.313.:
- (2) MBE-3-I1-OL. The Manual for Bridge Evaluation, 2019 Interim Revisions [to 2018 Third Edition], copyright 2018; IBR approved for § 650.305 and 650.313.
- (3) MBE-3-I2. The Manual for Bridge Evaluation, 2020 Interim Revisions [to 2018 Third Edition], copyright 2020; IBR approved for § 650.305 and 650.313

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Controlling Docs – AASHTO MBE

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THE MANUAL FOR BRIDGE EVALUATION

3rd Edition • 2018

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Manual for Bridge Evaluation (MBE)

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The "23 Metrics"

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- Developed in 2010
- Systematic, data-driven, and risk-based oversight process for monitoring State compliance with the NBIS
- FHWA responsibility in response to the Office of Inspector General (OIG) recommendations and congressional direction

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The "23 Metrics"

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- It was determined that the NBIS can be measured by 23 metrics that can be independently assessed to determine compliance.
- Each of those 23 metrics can be traced directly to wording in the NBIS regulation at 23 CFR 650 subpart C.

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The "23 Metrics"

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- Metric #1: Bridge inspection organization: 23 CFR 650.307
- Metric #2: Qualifications of personnel—Program manager: 23 CFR 650.309(a) & 650.313(g)
- Metric #3: Qualifications of personnel—Team leader(s): 23 CFR 650.309(b) & 650.313(g)
- Metric #4: Qualifications of personnel—Load rating engineer: 23 CFR 650.309(c)
- Metric #5: Qualifications of personnel—Underwater bridge inspection diver: 23 CFR 650.309(d)
- Metric #6: Routine inspection frequency—Lower risk bridges: 23 CFR 650.311(a)
- Metric #7: Routine inspection frequency—Higher risk bridges: 23 CFR 650.311(a)
- Metric #8: Underwater inspection frequency—Lower risk bridges: 23 CFR 650.311(b)
- Metric #9: Underwater inspection frequency—Higher risk bridges: 23 CFR 650.311(b)
- Metric #10: Inspection frequency—Fracture critical member: 23 CFR 650.311(c)
- Metric #11: Inspection frequency—Frequency criteria: 23 CFR 650.311(a)(2), (b)(2), (c)(2), (d)
- Metric #12: Inspection procedures—Quality inspections: 23 CFR 650.313(a) & (b)
- Metric #13: Inspection procedures—Load rating: 23 CFR 650.313(c)
- Metric #14: Inspection procedures—Post or restrict: 23 CFR 650.313(c)
- Metric #15: Inspection procedures—Bridge files: 23 CFR 650.313(d)
- Metric #16: Inspection procedures—Fracture critical members: 23 CFR 650.313(e)(1)
- Metric #17: Inspection procedures—Underwater: 23 CFR 650.313(e) & (e)(2)
- Metric #18: Inspection procedures—Scour critical bridges: 23 CFR 650.313(e) & (e)(3)
- Metric #19: Inspection procedures—Complex bridges: 23 CFR 650.313(f)
- Metric #20: Inspection procedures—Quality Control/Quality Assessment: 23 CFR 650.313(g)
- Metric #21: Inspection procedures—Critical findings: 23 CFR 650.313(h)
- Metric #22: Inventory—Prepare and maintain: 23 CFR 650.315(a)
- Metric #23: Inventory—Timely updating of data: 23 CFR 650.315(a), (b), (c) & (d)

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The "23 Metrics"



- Metric #1: Bridge inspection organization: 23 CFR 650.307
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- Metric #3: Qualifications of personnel—Team leader(s): 23 CFR 650.309(b) & 650.313(g)
- Metric #4: Qualifications of personnel—Load rating engineer: 23 CFR 650.309(c)
- Metric #5: Qualifications of personnel—Underwater bridge inspection diver: 23 CFR 650.309(d)
- Metric #6: Routine inspection frequency—Lower risk bridges: 23 CFR 650.311(a)
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- Metric #13: Inspection procedures—Load rating: 23 CFR 650.313(c)
- Metric #14: Inspection procedures—Post or restrict: 23 CFR 650.313(c)
- Metric #15: Inspection procedures—Bridge files: 23 CFR 650.313(d)
- Metric #16: Inspection procedures—Fracture critical members: 23 CFR 650.313(e)(1)
- Metric #17: Inspection procedures—Underwater: 23 CFR 650.313(e) & (e)(2)
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- Metric #19: Inspection procedures—Complex bridges: 23 CFR 650.313(f)
- Metric #20: Inspection procedures—Quality Control/Quality Assessment: 23 CFR 650.313(g)
- Metric #21: Inspection procedures—Critical findings: 23 CFR 650.313(h)
- Metric #22: Inventory—Prepare and maintain: 23 CFR 650.315(a)
- Metric #23: Inventory—Timely updating of data: 23 CFR 650.315(a), (b), (c) & (d)

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Metric 1 – Bridge Inspection Organization



Criteria - Organizational roles and responsibilities are clearly defined and documented for each of the following aspects of the NBIS: policies and procedures, QC/QA, preparation and maintenance of a bridge inventory, bridge inspections, reports, and load ratings.

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Metric 13 – Inspection Procedures – Load Rating



Criteria - Bridges are rated for their safe load carrying capacity in accordance with the AASHTO Manual for Bridge Evaluation (MBE), for all legal vehicles and State routine permit loads.

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Metric 13 – Load Rating - Compliance



- All bridges have a NBI load rating determination.
- All sampled bridges have documentation in accordance with the MBE that supports the load rating determinations.

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Metric 13 – Load Rating – Substantial Compliance



- 100% of higher risk bridges and at least 95% of lower risk bridges have an NBI load rating determination.
- At least 90% of sampled bridges sampled have documentation in accordance with the MBE that supports the load rating determinations.
- Ratings may have minor or isolated documentation deficiencies, but these do not adversely affect the accuracy of the rating.

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Metric 13 – Load Rating – Noncompliance



- One or more Substantial Compliance criteria not met.

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Metric 13 – Load Rating – Noncompliance

Number	Metric Description	Program Year Compliance*		
		2017	2018	2019
1	Bridge Inspection Organization	C	C	C
2	Qualifications of Personnel - Program Manager	C	C	C
3	Qualifications of Personnel - Team Leader(s)	SC	C	SC
4	Qualifications of Personnel - Load Rating Engineer	C	C	C
5	Qualifications of Personnel - LW (Underwater) Bridge Inspection Diver	C	C	C
6	Inspection Frequency - Routine - Lower Risk Bridges	SC	SC	SC
7	Inspection Frequency - Routine - Higher Risk Bridges	SC	SC	SC
8	Inspection Frequency - Underwater - Lower Risk Bridges	C	C	C
9	Inspection Frequency - Underwater - Higher Risk Bridges	C	C	C
10	Inspection Frequency - Fracture Critical Member	C	C	C
11	Inspection Frequency - Frequency Criteria	C	C	C
12	Inspection Procedures - Quality Inspections	SC	C	SC
13	Inspection Procedures - Load Rating	C	CC(1)	CC
14	Inspection Procedures - Post or Restraint	C	CC(1)	CC
15	Inspection Procedures - Bridge Files	CC(1)	CC	CC(1)
16	Inspection Procedures - Fracture Critical Members	C	C	C
17	Inspection Procedures - Underwater	C	C	C
18	Inspection Procedures - Scour Critical Bridges	SC	CC(1)	CC
19	Inspection Procedures - Complex Bridges	SC	SC	C
20	Inspection Procedures - QC and QA	C	C	C
21	Inspection Procedures - Critical Findings	C	C	C
22	Inventory - Prepare and Maintain	C	C	C
23	Inventory - Timely Updating of Data	SC	C	C

*Compliance Highlights and Definitions
 C - Compliance - Adheres to NBIS regulations.
 SC - Substantial Compliance - Adheres to NBIS regulations with minor deficiencies. Deficiencies to be corrected within 12 months unless related to issues that would more efficiently be corrected during the next inspection.
 CC - Conditional Compliance - Taking corrective action with FHWA-approved plan of corrective action (PCA).
 CC(1) - FHWA initially identified this metric status as noncompliance and, upon submission of a PCA, FHWA recharacterized the metric status to conditional compliance.

Metric 13 – Load Rating – Noncompliance


12	Inspection Procedures - Quality Inspections	SC	C	SC
13	Inspection Procedures - Load Rating	C	CC(1)	CC
14	Inspection Procedures - Post or Restraint	C	CC(1)	CC

CC - Conditional Compliance - Taking corrective action with FHWA-approved plan of corrective action (PCA).
 CC(1) - FHWA initially identified this metric status as noncompliance and, upon submission of a PCA, FHWA recharacterized the metric status to conditional compliance.

* An approved Plan of Corrective Action (PCA) is required from a state DOT to go from "Noncompliant" to "Conditionally Compliant".

Metric 13 – Load Rating - Noncompliance

- Noncompliance =



Metric 13 – Load Rating - Noncompliance

- Non-Compliance =




Metric 13 – Load Rating - Noncompliance

Non-Compliance =


- Elevation
- Explaining
- EMBARRASSMENT

(Future scrutiny, i.e. AUDITS, i.e. non-engineers involved)



Load Rating

But always remember - The real reason to perform load ratings is to avoid this:



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Every DOT's responsibility:

- **Protect lives**
- **Protect infrastructure**

This responsibility can't be abdicated or passed on to someone else.

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Load Rating Equation Michael Baker INTERNATIONAL

$$RF = \frac{(C - DL)}{(LL + IM)}$$

Where:
 RF = Rating Factor
 C = Capacity
 DL = Dead Load
 LL = Live Load
 IM = Impact

LL CAPACITY
/ *LIVE LOAD*

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Live Load Michael Baker INTERNATIONAL

Design

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Legal Loads

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Legal Loads - "EV"s (Emergency Vehicles)

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Legal Loads

AASHTO Legal Loads

- Some states can simply use the AASHTO legal loads to envelope all of their state's legal loads.

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Legal Loads

State Legal Loads

Attachment E to 14.7000 January 9, 2021

IOWA LEGAL TRUCKS DIAGRAMS

Typical legal loads (in Kips)
(Wheel and axle loads are shown in Kips)

- States (like Iowa) may have many legal loads (besides AASHTO) to evaluate in order to envelope all the state's legal loads.

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Posting

- MBE 6A.8.2 "When the maximum legal load under state law exceeds the safe load capacity of a bridge, restrictive load posting shall be required."
- States may be OK with some postings (usually local)
- Interstates a BIG NO-NO
- May ask for solution:
 - Refined analysis, i.e. "sharpen the pencil"
 - Quick/easy repair/retrofit options
- Politics can get involved
 - Force a LA to do something
 - Truckers/lawmakers
 - Stay out of it, stick to numbers

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Software over the Years

- Excel
- In-House
- BARS/LARS/BARS7(PennDOT)
- BRASS(WYDOT)
- Merlin-Dash
- CONSPAN
- MDX
- GTSTRUDL/STAAD
- BDS
- 3D/FEM (MIDAS, SAP2000, LUSAS, etc.)
- AASHTOWare Virtis/BrR

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Software over the Years

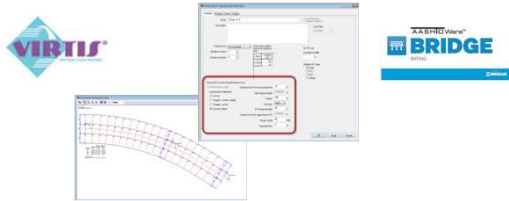
- As PCs started making their way into DOTs in the 1990s, analysis software soon followed.
- Commercial (off the shelf) software was available, but the analysis was up to the programmer. State DOTs using the software could become frustrated with slow/lack of response from developer.
- With relatively easy programming languages like BASIC and FORTRAN, some DOTs were able to write their own programs.
- Over time, DOT programmers would retire, and Operating Systems and resulting programming languages would become more complicated, leaving DOT-developed software harder to maintain.

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AASHTOWare Bridge Rating (BrR)

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- Virtis (later BrR) was a product of “AASHTOWare”, a DOT-led collaborative effort to develop a load ratings software package.
- A Task Force directs the contractor (Currently ProMiles) and is guided by the User Group.



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AASHTOWare Bridge Rating (BrR)

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- More accountability to the users for bug fixes and enhancements
- Inherent need to follow the MBE and any updates to MBE results in automatic updates to the software
- Structure database, no individual data files
- Has been developed for over 25 years and counting, experienced software programmers
- FHWA accepted



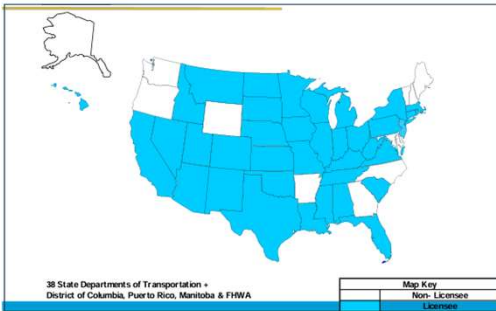
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AASHTOWare Bridge Rating Licensees

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Some Final Thoughts

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From a state DOT to their legislature:

Decisions involving bridge maintenance, retrofitting, strengthening, widening, and replacement rely heavily on complete and accurate load rating information. Additionally, load rating information is critical to our ability to safely route trucks across our state -- we currently average approximately 150,000 permits a year, all of which rely on load rating data.

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Some Final Thoughts

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- Design and Load Rating are not mutually exclusive.
- Experience in design makes great load raters but as importantly, experience in load ratings makes great designers!
- Performing load ratings helps understand the critical paths of a bridge and what is important to the owner.
- Load Rating is not “reverse design”.
 - Design “envelopes” all loads, conservative, 75 years
 - LR, especially when deterioration is present, becomes more fine tuned, specific loads, 5 years
 - Load rating is as much an “art” as a science, often multiple mitigation strategies

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Some Final Thoughts - Client Service

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- Be accurate and absolutely sure of your results.
- Crunching numbers and presenting results is just a tool in the toolbox. There may be other issues involved.
- Don’t just find the most critical location, be sure to identify all locations where load ratings below zero.
 - Maybe also locations where LR is at or just above 1.0. This helps the client identify near future repair strategies.
- Always communicate! Don’t tell the client they have a problem without looking into possible solutions/mitigation. Be proactive and offer options, so they have the whole picture.
- The client understands what potential impacts are acceptable and what’s not. Work with them and learn!

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Questions/
Discussion

