Advances in State Bridge Load Rating Processes and Practices

A Summary Report of 2024 Bridge Load Rating Peer Exchanges

FHWA-HIF-24-113
December 2024

U.S. Department of Transportation
Federal Highway Administration

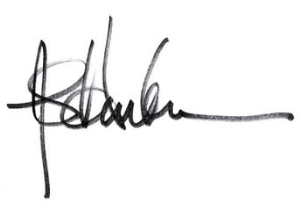
FOREWORD

From 2014 to 2019, the Federal Highway Administration (FHWA) conducted six regional bridge load rating peer exchanges, fostering knowledge sharing amongst State Departments of Transportation (DOTs) and promoting commendable practices in bridge load rating, posting, and permitting. Building on the success of these events and in response to the 2022 regulatory changes in the National Bridge Inspection Standards (NBIS), FHWA planned additional peer exchanges to continue the sharing of information and best practices in bridge load rating, posting, and overweight load permitting.

The 2024 peer exchanges, held in Salt Lake City, Utah, and Pittsburgh, Pennsylvania, brought together State DOTs and FHWA personnel to address current challenges, share innovative solutions, and advance load rating practices. A key focus was establishing consistent methods and improving efficiency, especially as aging bridges face greater demands from increased legal loads. Participants shared current practices and explored new techniques aimed at improving the accuracy and efficiency of load ratings.

This report highlights the critical role of load rating in maintaining bridge safety, and how load rating considers structural deterioration and increased loads. It also emphasizes the successful strategies State DOTs have implemented, such as advanced analysis techniques and refined assessment tools.

These peer exchanges enhanced bridge load rating practices through ongoing collaboration between State DOTs and FHWA. This report captures the insights and innovations from the 2024 peer exchanges, marking a significant step toward ensuring safer and more reliable infrastructure across the country.



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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.	
FHWA-HIF-24-113			
4. Title and Subtitle Advances in State Bridge Load Rating Processes and Practices: A Summary Report of 2024 Bridge Load Rating Peer Exchanges		**5. Report Date** December 2024 **6. Performing Organization Code**	
7. Author(s) Justin Dahlberg, Zhengyu Liu, and Brent Phares		**8. Performing Organization Report No.**	
9. Performing Organization Name and Address Bridge Engineering Center Iowa State University 2711 South Loop Drive, Suite 4700 Ames, IA 50010-8664		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** CO No. 693JJ319D000020	
12. Sponsoring Organization Name and Address Federal Highway Administration Office of Infrastructure 1200 New Jersey Avenue, SE Washington, DC 20590		**13. Type of Report and Period Covered** Final Report. 6/2023 to 12/2024 **14. Sponsoring Agency Code** FHWA-HIF/HIBS-10	
15. Supplementary Notes FHWA Task Order COR (Task Order Manager): Lubin Gao, PhD, PE FHWA Contracting Officer Representative (COR): Remy Chappetta Technical Review Panel: Ed Lutgen (Minnesota Department of Transportation), Becky Nix (Utah Department of Transportation), David Garber, Thomas Drda			
16. Abstract This report reviews State Department of Transportation (DOT) practices related to bridge load rating, posting, and permitting procedures, analyzing publicly available documents. It examines previous versions of the National Bridge Inspection Standards (NBIS) and the most recent 2022 update, alongside the AASHTO Manual for Bridge Evaluation (MBE) and its interim revisions. The review highlights both common and unique practices across States in assessing bridge load-carrying capacity, which is essential for preservation and public safety. Routine load ratings are typically based on design plans, field measurements, and inspection reports, while more advanced methods incorporate sophisticated analytical techniques like 2D and 3D finite element models. In 2024, peer exchange meetings were held in Salt Lake City, UT, and Pittsburgh, PA, where participating transportation agencies discussed five key topics: State truck size and weight limits, consideration of deterioration in bridge load rating, timely re-rating and posting, structural analysis for permit loads, and research and technology. This report summarizes the meetings and their contributions to advancing bridge load rating practices across the U.S.			
17. Key Words bridge load posting—bridge load rating—load rating practices—overweight permitting—permit loads		**18. Distribution Statement** No restrictions.	
19. Security Classification (of this report) Unclassified.	**20. Security Classification (of this page)** Unclassified.	**21. No. of Pages** 85	**22. Price** NA

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units.
Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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EXECUTIVE SUMMARY

State Department of Transportation (DOT) practices related to load rating, posting, and permitting procedures for bridges were reviewed. The review included searching for load rating policy documents from all States, and publicly available information was found for 43 States. The review also included previous NBIS versions and revisions (1996, 2004, 2009) and the most recent update, NBIS (2022), and AASHTO MBE (2018 – 3rd Ed., 2019 – Interim Revisions, 2020 – Interim Revisions). The documents were analyzed to identify common and uncommon practices and procedures.

Load rating is critically important for assessing bridges' load-carrying capacity for preservation and public safety. Load ratings are typically determined using analytical methods, with routine assessments based on design plans, field measurements, and inspection reports. More advanced load ratings involve adjusting computations for actual material properties, sometimes using sophisticated analytical techniques like 2D and 3D finite element models.

Innovative approaches like improving flexural strength calculations for concrete-steel composite bridges and refining load ratings exist, enhancing management efficiency for State DOTs. Load tests, which can reveal a bridge's actual performance, are an alternative to conventional theory-based assessments. Still, they are not yet a routine practice due to challenges like cost and standardization.

Load rating practices are continually evolving, incorporating advanced analysis techniques and innovative strategies to improve bridge assessments and enhance safety. Standardization and research are seen as crucial factors in advancing these practices further.

In April and May of 2024, meetings were held in Salt Lake City, UT, and Pittsburgh, PA., to facilitate the exchange of the participating transportation agencies' bridge load rating ideas, policies, and practices. Numerous presentations were given, and discussions were held at each meeting. The five primary topics covered include 1) State truck size and weight limits and State legal load models, 2) consideration of deterioration in bridge load rating analysis, 3) timely load rating, re-rating, posting, and closure, 4) structural analysis for routine and special permit loads, and 5) research, technology, and other topics. A summary of the meetings is provided.

PART 1
DESK SCAN

1 INTRODUCTION

This desk scan aims to identify the focused topics of interest for the peer exchanges. A similar review was conducted recently and documented in FHWA's report titled Advancing Bridge Load Rating: State of Practice and Frameworks, FHWA-HIF-22-059, December 2022; new findings and updates are recorded in this report. This scan was conducted in broad areas but is grouped into the following five categories:

1) State truck size and weight limits and State legal load models
2) Consideration of deterioration in load rating analysis
3) Timely load rating, re-rating, posting and closure
4) Structural analysis for routine and special permit loads
5) Research, technologies, and other topics of interest, such as quality management of load ratings, posting and permitting

A search was conducted for the load rating policy documents from all States. The identified documents include bridge design manuals, bridge inspection manuals, bridge load rating manuals electronically published by the respective DOTs, and memoranda. Table 1 includes the document's title containing the load rating information and the date when the document was created or most recently revised. Not all States place their load rating documents online. Among those for which information could be found online, ten States have developed a standalone manual (guideline) for bridge load rating. In contrast, most others had the relevant information as a chapter in either their bridge design manual or inspection manual. The State documents reviewed are the same as those in FHWA-HIF-22-059, though updated version reviews were completed. The documents were reviewed to identify each jurisdiction's practices and procedures for load rating, posting, and overweight permitting. It was found that almost all documents State that the load rating procedures must follow the AASHTO Manual for Bridge Evaluation (MBE), although the actual referenced version of the MBE varied. Most DOTs publish their manuals to include State-specific details in addition to the information listed in the AASHTO MBE.

State load rating policy documents vary widely in terms of comprehensiveness and detail. Some States have lengthy documents, and others have very brief documents. Where some States explicitly guide the main topics listed above, others may be silent. The following sections provide information from the policy documents that most closely provide the related information.

Other documents were reviewed, including NBIS (1996, 2004, 2009, 2022), AASHTO MBE (2018, 2019, 2020, 2022), research papers, and technical reports. The review results from the five topics listed above are summarized in Chapters 2 through 6.

Table 1 Reviewed Policy Documents

No.	State	Year and Title	Date of Publication of Last Revision
1	Alabama	Bridge Inspection Manual	October-2021
2	Alaska	Alaska Bridges and Structures Manual	March-2023
3	Arizona	Bridge Load Rating Guidelines	February-2021
4	Arkansas	Local Government Procedures for Compliance with The National Bridge Inspection Standards	September-2022
5	California	Federally Mandated Bridge Load Ratings - Report to Legislature	2021
6	Colorado	Bridge Rating Manual	2022
7	Connecticut	Bridge Load Rating Manual	March-2018
8	Delaware	Bridge Load Rating Manual	July-2021
9	Florida	Bridge Load Rating Manual	January-2023
10	Georgia	No manual available online	-
11	Hawaii	Bridge Inspection Manual	September-2020
12	Idaho	Idaho Manual for Bridge Evaluation	July-2022
13	Illinois	Structural Services Manual	June-2017
14	Indiana	Indiana Bridge Inspection Manual	May-2022
15	Iowa	Bridge Rating Manual	January-2014
16	Kansas	No manual available online	-
17	Kentucky	Kentucky Bridge Inspection Procedures Manual	February-2020
18	Louisiana	Bridge Design and Evaluation Manual	March-2016
19	Maine	Maine DOT Load Rating Guide	April-2015
20	Maryland	Office of Structures Guidelines and Procedures Memorandums	August-2018
21	Massachusetts	Bridge Inspection Handbook/ LRFD Bridge Manual Bridge Load Rating Guidelines	April-2019 January-2020
22	Michigan	Bridge Analysis Guide	2009
23	Minnesota	Bridge Load Rating and Evaluation Manual	February-2023
24	Mississippi	Bridge Safety Inspection Policy and Procedure Manual	-
25	Missouri	Bridge Inspection Rating Manual	July-2023
26	Montana	Bridge Inspection and Rating Manual	October-2018
27	Nebraska	Bridge Inspection Program Manual	March-2020

No.	State	Year and Title	Date of Publication of Last Revision
28	Nevada	Nevada Bridge Inspection Program	September-2008
29	New Hampshire	Bridge Design Manual Chapter 12	June-2019
30	New Jersey	Design Manual for Bridges and Structures, 6th Ed, 2016	2016
31	New Mexico	Bridge Procedures and Design Guide - Chapter 11	December-2008
32	New York	Bridge Inspection Manual	March-2017
33	North Carolina	No specific guidance - Bridge Manual References MBE	-
34	North Dakota	NDDOT Load Rating Manual	February-2022
35	Ohio	Bridge Design Manual Chapter 12	2020
36	Oklahoma	Not available online	-
37	Oregon	ODOT LRFR Manual	June-2018
38	Pennsylvania	Bridge Safety Inspection Manual	June-2023
39	Rhode Island	Bridge Load Rating Guidelines	September-2022
40	South Carolina	SCDOT Load Rating Guidance Document	August-2019
41	South Dakota	Load Rating Manual	July-2022
42	Tennessee	Not available online	-
43	Texas	Bridge Inspection Manual	May-2022
44	Utah	Bridge Management Manual	October-2022
45	Vermont	VTrans Structures Design Manual	2010
46	Virginia	Instructional and Informational Memorandum	December-2020
47	Washington	Bridge Design Manual	June-2022
48	West Virginia	Bridge Design Manual	2014
49	Wisconsin	WisDOT Bridge Manual Chapter 45	July-2023
50	Wyoming	Not available online	-

2 STATE TRUCK SIZE AND WEIGHT LIMITS, AND STATE LEGAL LOAD MODELS

A review of the State load rating requirements indicates that most States generally use the AASHTO design vehicles, legal vehicles, and lane-type load models indicated in the AASHTO MBE (Section 6A4.4.2.1) for design and legal load ratings. Design-load rating is performed at the inventory level corresponding to the same reliability levels as AASHTO LRFD Bridge Design Specifications and operating level corresponding to a lower-level reliability consistent with previous past load rating practices. While most States utilize all or some of the prescribed legal load models in AASHTO MBE, it is not uncommon for States to use additional State-specific legal load models in addition to or instead of those in the MBE for legal load level evaluation based on State truck size and weight limits as governed by State regulations and laws.

Included in the legal load models for evaluation are the Specialized Hauling Vehicles (SHVs), which account for single-unit trucks that have been more recently introduced by the trucking industry and are not represented by AASHTO Type 3, 3S2, and 3-3 legal vehicles. Also included in the legal load models are Emergency Vehicles that were introduced by The Fixing America's Surface Transportation (FAST) Act (Pub. L. No. 114-94) for applicable bridges as specified in the FHWA Memorandum, "Load Rating for the Fast Act's Emergency Vehicles," dated November 3, 2016. In some cases, States have adopted more restrictive SHV load models than those indicated in the MBE.

Table 2 summarizes the design and legal load models indicated in the available State policy documents.

Table 2 Design and Legal Load Models

State	Design Load Models		AASHTO Legal Load Models										State-Specific Legal Load Models	
	HS-20	HL-93	AASHTO Type 3	AASHTO Type 3-3	AASHTO Type 3S2	NRL	SU4	SU5	SU6	SU7	FAST Act EV2	FAST Act EV3	Other	Other State-specific legal modes that may create force effects greater than AASHTO
Alabama	X	X	-	-	-	-	-	-	-	-	X	X	X	ALDOT posting vehicles (Tandem axle, tri-axle truck, concrete truck, Type 3S2_AL_18 wheeler, Type 3S2_AL_6 axle)
Alaska	-	X	X	X	X	-	-	-	-	-	-	-	-	-
Arizona	X	X	X	X	X	-	X	X	X	X	X	X	-	-
Arkansas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
California	-	-	-	-	-	-	-	-	-	-	X	X	-	-
Colorado	X	X	-	-	-	X	X	X	X	X	X	X	X	Colorado Type 3, Type 3S2, Type 3-2.
Connecticut	-	X	X	X	X	-	X	X	X	X	X	X	X	CT-H20, CT-HS20, CT-L3S2, CT-L73.0
Delaware	X	X	-	-	-	-	X	X	X	X	X	X	X	S220, S335, S437, T330, T435, T540
Florida	-	X	-	-	-	-	-	-	-	-	X	X	X	SU2, SU3, SU4, C3, C4, C5, ST5
Georgia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hawaii	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Idaho	-	X	-	-	-	X	-	-	-	-	X	X	X	Idaho Type 3, Type 3S2, Idaho 3-3, Idaho 121 kip
Illinois	X	X	-	-	-	-	-	-	-	-	-	-	X	IL-PS2-21, IL-PS3-31, IL-PS4-34.75, IL-PS4-28, IL-PS5-36, IL-PS6-35.75, IL-PS6-35.75, IL-PS7-39.75, IL-PC3-31, IL-PC4-41, IL-PC5-41, IL-PD6-40
Indiana	X	X	X	X	X	X	X	X	X	X	X	X	X	H-20, Alternate Military, Lane-Type
Iowa	X	X	X	-	X	-	X	X	X	X	X	X	X	Type 4, Type 3S3A, Type 3S3B, Type 4S3, Type 3-3
Kansas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kentucky	X	X	-	-	-	-	X	X	X	X	X	X	X	Type 1, Type 2, Type 3, Type 4
Louisiana	-	X	-	X	-	X	X	X	X	X	-	-	X	LA Type 3, LA Type 3-S2, LA Type 6, LA Type 8, Lane-Type

State	Design Load Models		AASHTO Legal Load Models										State-Specific Legal Load Models	
	HS-20	HL-93	AASHTO Type 3	AASHTO Type 3-3	AASHTO Type 3S2	NRL	SU4	SU5	SU6	SU7	FAST Act EV2	FAST Act EV3	Other	Other State-specific legal modes that may create force effects greater than AASHTO
Maine	-	X	-	-	-	-	-	-	-	-	-	-	X	Maine Legal Configurations 1 through 8
Maryland	X	X	-	-	-	-	-	-	-	-	-	-	X	H-15, Type 4, Type 3S2
Massachusetts	X	X	-	-	X	-	X	X	X	X	X	X	X	H20
Michigan	X	X	X	X	X	-	-	-	-	-	-	-	X	Michigan Legal Vehicles 1 through 28
Minnesota	-	X	-	-	-	-	X	X	X	X	-	-	X	Type M3, Type M3S2-40, Type M3S3-40, Lane-Type
Mississippi	X	-	-	-	-	-	-	-	-	-	-	-	X	H-Truck, Concrete Truck, HS-Short, HS-Long
Missouri	-	-	-	-	-	-	-	-	-	-	X	X	X	H20L, MO3S2, CZSU, CZRT
Montana	X	X	X	X	X	-	X	X	X	X	-	-	-	-
Nebraska	X	-	X	X	X	-	X	X	X	X	-	-	-	-
Nevada	X	-	-	-	-	-	-	-	-	-	-	-	-	-
New Hampshire	X	X	X	X	X	-	-	-	-	-	-	-	X	NH Legal Loads, Certified Single Unit Legal Loads, Certified Multi-Unit Legal Loads
New Jersey	X	X	X	X	X	X	X	X	X	X	-	-	X	Type 3S2 NJDOT truck
New Mexico	-	X	X	X	X	-	-	-	-	-	-	-	X	NMDOT Two-Axle, NMDOT 3A, NMDOT 3B, NMDOT Four-Axle, NMDOT 5A, NMDOT 5B
New York	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Carolina	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Dakota	-	X	X	X	X	-	X	X	X	X	X	X	X	ND1, ND2
Ohio	X	X	X	X	X	-	X	X	X	X	X	X	X	2F1, 3F1, 5C1
Oklahoma	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oregon	-	X	-	X	-	-	X	X	X	X	X	X	X	OR Type 3, OR Type 3S2, OR-SU4, OR-SU5, OR-SU6, OR-SU7
Pennsylvania	X	-	-	-	-	-	-	-	-	-	-	-	-	PHL-93, ML 80, TK527
Rhode Island	-	X	X	X	X	-	X	X	X	X	X	X	X	H20, Lane-type, RIPTA Bus,

State	Design Load Models		AASHTO Legal Load Models										State-Specific Legal Load Models	
	HS-20	HL-93	AASHTO Type 3	AASHTO Type 3-3	AASHTO Type 3S2	NRL	SU4	SU5	SU6	SU7	FAST Act EV2	FAST Act EV3	Other	Other State-specific legal modes that may create force effects greater than AASHTO
South Carolina	X	X	-	X	-	-	X	X	X	X	X	X	X	SC School Bus, SC-SU2, SC-SHV1A, SC-SHV2A, SC-SHV2B, SC-SHV3A, SC-SHV3B, SC Type 3, SC Type 3S2, Lane-type
South Dakota	-	X	-	-	-	X	X	X	X	X	-	-	X	SD Type 3, SD Type 3S2, SD Type 3-2, Lane-type
Tennessee	-		-	-	-	-	-	-	-	-	-	-	-	-
Texas	X	X	-	-	-	-	X	X	X	X	X	X	-	-
Utah	X	X	X	X	X	-	X	X	X	X	X	X	-	-
Vermont	-	X	-	-	-	-	-	-	-	-	-	-	X	H-20, Vermont Standard Load Rating Trucks: 3S2, 6 axle trailer, 3 axle straight, 4 axle straight, 5 axle semi
Virginia	-	X	-	-	-	-	X	X	X	X	X	X	X	VA TYPE 3, VA TYPE 3S2
Washington	X	X	X	X	X	X	X	X	X	X	X	X	X	HS-20 LFR method, HL-93 LRFR method, Legal loads, Overload 1 (OL1), Overload 2 (OV2)
West Virginia	X	X	X	-	X	-	-	-	-	-	-	-	X	HS-25, Five West Virginia Legal Loads (H, Type 3, WV-SU4, HS and 3S2) Bridges on a CRTS Route shall be load rated for four additional trucks (WV-SU40, WV-SU45, WV-3S55, and WV-3S60)
Wisconsin	X	X	X	X	X	-	X	X	X	X	X	X	X	WisDOT Specialized Annual Permit Vehicles and Wisconsin Standard Permit Vehicle
Wyoming	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Puerto Rico	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Washington DC	X	X	X	X	X	X	-	-	-	-	X	X	X	HS-25-44

A brief review of State truck size and weight limits was also conducted to gather information on State legal load models. The NCHRP Synthesis 453 (2014), State Bridge Load Posting Processes and Practices, reviewed State legal weight limits and load models used by State DOTs in load posting. The USDOT Report to Congress (2015), Compilation of Existing State Truck Size and Weight Limit Laws, provided a comprehensive synthesis of States' truck weight limits. This information clarifies the appreciable variation among the State-legal load models, whether for gross vehicle weight, axle weight, or axle groupings. Numerous States have allowances and exemptions for various vehicle and commodity types. Table 3 shows the number of States allowing vehicles to operate above Federal truck size and weight limits.

Table 3 State Statute Exemptions from 2015 USDOT Report to Congress

Vehicle Type/Commodity	Number of States with Exemptions
Aggregate Products (rock, sand, gravel, road base, etc.)	15
Agricultural/Farm Products & Commodities	41
Construction Equipment/ Highway Machinery	28
Emission Reduction Equipment	40
Fire Trucks	29
Government-owned Vehicles	16
Implements of Husbandry	20
Snow Plows	10
Solid Waste/Rubbish/Trash	28
Timber Products & Commodities	22
Tow Trucks	22

3 CONSIDERATION OF DETERIORATION IN LOAD RATING ANALYSIS

Load ratings completed by the States are typically determined by analytical methods based on information provided in bridge plans and supplemented by information gathered from field inspections, testing, or both. AASHTO MBE (Article 6.1.2, 3rd Edition, 2018, incorporated by reference in 23 CFR 650.317) requires the consideration of deterioration of structural members in load rating calculations. The MBE (Article 6.1.2, 3rd Edition, 2018, incorporated by reference in 23 CFR 650.317) states that where steel is corroded, concrete deteriorated, or timber decayed, the remaining cross-sectional area must be determined as closely as reasonably possible. However, the guidance provided in the MBE is not all-inclusive, and consideration should be given to special characteristics such as particular member type, material, and rate of deterioration that should be noted and accounted for.

The most common accommodation of deterioration in load rating is a reduction in section resistance. The predominant theme among the States is to incorporate the results of the bridge inspections into the reduction of section capacity if it is determined that the element condition has changed from a previous condition state. The method in which the reduced section capacity is defined varies among the States and bridge types but generally includes reducing the section size proportionate to the observed deterioration during analysis.

Most States generally indicate that bridges are to be re-load rated based on the most recent inspection report. When signs of distress or a change in condition are revealed, particularly to primary load-carrying members, an appropriate judgment should be made to reduce live load-carrying capacities by properly modeling the deterioration (e.g., reduction of cross-sectional areas, reduction of material strength, etc.). Only sound material should be considered when determining the nominal resistance of the deteriorated section.

State DOTs mainly use commercial software to calculate the rating factor for most bridge structures with certain deterioration types. As just one example, for a steel beam bridge, the remaining section of the tension or compression flange and web can be accounted for by inputting the remaining thickness in the software. Although existing software provides convenience for the load rating of common bridges, the software may be limited for certain types of bridges due to their unique configurations, materials, and deterioration types.

AASHTO MBE (Article 6A.4.2.3, 3rd Edition) includes a condition factor to reduce the resistance in the rating factor equation. The condition factor accounts for the increased uncertainties and variabilities present in structures with deterioration and increased rate of future deterioration; it is used in addition to accounting for section losses. The condition factor is considered optional based on an agency’s load rating practice. A factor is assigned to deteriorated members based on the severity of the deterioration (e.g., fair = 0.95, poor = 0.85). Where condition information is only collected and recorded as NBI condition ratings, a condition rating of 5 is considered fair, and 4 or lower is considered poor.

More refined load ratings consist of routine computations adjusted for actual material properties as determined from field sampling and material tests. These load ratings may also use refined methods of analysis, such as two-dimensional (2D) grillage models or three-dimensional (3D) finite element models (FEMs). Efforts to determine the material properties of in-service bridges have been made when the information is limited or does not exist.

A few States offer more explicit instructions for when load ratings are updated based on condition ratings. Excerpts from the manuals of these States are provided in Table 4.

Table 4 Consideration of Deterioration in Load Rating Analysis

State	Excerpts from Source Document(s)
Delaware	Load ratings are also required when a bridge inspection reveals deterioration and/or damage that warrants a structural analysis to ascertain the impact to the strength and/or serviceability to an element of the bridge or the entire bridge. This correlates to an NBI Deck, Super, or Culvert Condition Rating of a 4 or less. 1.9 Load Rating Requirements, DelDOT Bridge Load Rating Manual, 2021
Illinois	IDOT policies for load rating deteriorated bridges are as follows: • Perform load rating when "Deck Condition" (ISIS Item 58) rating drops to "3" or less, and for subsequent drops in the condition rating. • Perform load rating when "Superstructure Condition" (ISIS Item 59), "Substructure Condition" (ISIS Item 60), or "Culvert Condition" (ISIS Item 62) rating drops to "4" or less, and for subsequent drops in the condition rating. • After an initial load rating due to deterioration, continue load rating at an interval determined by the Bureau of Bridges and Structures based on bridge type and anticipated deterioration rate. This interval shall not exceed 10 years. 4.3.2.2.2 Structural Deterioration, IDOT Structural Services Manual, 2017
Indiana	For bridges with a minor increase in deterioration or newly discovered minor damage or deterioration, a load analysis shall be performed. At a minimum, a load rating considering deterioration shall be on file for each bridge with a deck condition rating (NBIS Item 58), superstructure condition rating (NBIS Item 59), or culvert condition rating (NBIS Item 61) of 4 or less. Additionally, if there is a loss of bearing area or a substructure condition rating (NBIS Item 60) of 3 or less, consideration should be given to reducing the load rating. 3-9.01(03) Deterioration, INDOT Bridge Inspection Manual, 2022
Washington	For LFR Method: In cases where there is deterioration in a member, the cross section shall be reduced based on the inspection report. For cases where deterioration in members is described in general terms, reduce resistance factors of member by 0.10 for Bridge Management System (BMS) Condition State of 3, and reduce resistance factors by 0.20 for BMS Condition State of 4. The engineer should consider the quantity of each element in a fair or poor condition state and the notes describing the condition of an element when determining the appropriate resistance factor. 13.1.2.C Resistance Factors (LFR) Method, WSDOT Bridge Design Manual, 2022

There is a need for further research in accommodating deterioration in the load rating process, particularly regarding different types of structural degradation.

4 TIMELY LOAD RATING, RE-RATING, POSTING AND CLOSURE

4.1 Load rating and re-rating

Assessing and updating the load-bearing capacity of bridges for various reasons, including safety and regulatory compliance, is important. Certain conditions may necessitate a revised load rating, including structural deterioration, configuration changes, load shifts, policy changes, damage from various causes, and material degradation.

A review of State practices indicates various reasons and triggers for re-rating bridges. In general, a revised load rating may be necessary if any of the following conditions have occurred:

- Deterioration of structural components
- Changes in configuration (due to bridge widening, bridges made continuous, etc.)
- Changes in dead loads (due to overlay application, barrier changes, utility attachments, etc.)
- Changes in live loads (due to upgraded roadway classification, overweight vehicles, etc.)
- Changes in rating or posting policy
- A change in the primary member condition rating
- Cracking in primary members
- Losses at critical connections
- Changes in traffic volume, lane striping
- Specification changes
- Issuance of overweight permits
- Soil and substructure settlement and slope stability changes
- Bridge rehabilitation that affects structural components, structural or non-structural weight
- A change in State or federal laws regulating truck weights
- Structural damage resulting from a bridge hit, ice damage, flood damage, fire damage, or another cause
- Rotated or displaced beams
- Steel section loss
- Broken welds or missing bolts
- Exposed reinforcing or prestressing steel in the critical locations
- Splitting, cracking, or rot of timber members

Note that the above list is not all-inclusive, and items may overlap. The load rating may be updated on the stored digital assets, including electronic files, computer models, etc. While the detailed procedures for updating load ratings are not always documented in State design or load-rating manuals, documented procedures are required by the NBIS (23 CFR.650.313(k)(2)), and most organizations have a standard operating procedure.

While load tests are an alternative to analytical assessments and reveal a bridge's actual performance during a load test, they are not common practice due to challenges such as cost and standardization.

For existing structures, previously completed load ratings reflect the bridge's condition at the time of load rating. Structures must be re-rated when it is determined that a change has occurred in the structure's condition or when the load ratings on file are inconsistent with the current structural condition (23 CFR 650.313(k)). Reviewing and, if necessary, updating load ratings is also performed when there is an increase to the legal weight limit of trucks using the structure (23 CFR 650.313(k)). Changes in dead load (e.g., wearing surface thickness) should also be considered when load rating.

Condition-based re-ratings usually involve modification of section properties to account for deterioration. The re-rating process is also triggered when bridge rehabilitation or modifications occur and when there is a change in construction loading, including cranes, stockpiling, or paint containment systems. Re-rating for bridge rehabilitation or modification starts with the existing load rating data file or model and accounts for bridge geometry, load distribution, and material property changes.

4.2 **Timely load rating**

NBIS (23 CFR.650.313(k)(2)) states that 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. While States regularly complete load ratings within this period, many State load rating manuals do not include this explicit instruction.

4.3 **Load posting**

The bridge owner is responsible for keeping a bridge posted if necessary (23 CFR 650.313(l)). After the load rating is completed, the posting limits are documented in the load rating report. Bridge owners must install signs following the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) (FHWA 2023) showing the maximum safe load-carrying capacity of posted bridges (23 CFR 650.313(l) and 655.603(a)). Typically, a bridge management individual from the State DOT will confirm that the proper signs have been installed within a certain number of days of distributing the load posting documents (Hearn 2014).

The NBIS requires the posting of load limits 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 (23 CFR 650.313(l)(1)). The actual practice for posting a bridge differs from State to State. These criteria primarily change with posting vehicle types, bridge types, etc. It was found that some States are standardizing and addressing consistency around signs with three silhouettes (MUTCD R12-5) while others still use a single safe posting load on the MUTCD R12-1 sign.

The 11th Edition of the MUTCD requires an additional weight limit sign, with an advisory distance or directional legend, to be located in advance of the applicable section of the highway or structure so that prohibited vehicles can detour or turn around before the limit zone (MUTCD 2023). In prior editions advanced posting signs were recommended but not required.

The Manual on Uniform Traffic Control Devices (MUTCD) 11th Edition contains new provisions for the use of weight limit signs for Specialized Hauling Vehicles (SHV) and emergency vehicles. Compliance date for the advance signs with distance or directional legend (Section 2B.64 Paragraph 14) is within five years. Additional target compliance dates established by the FHWA are listed in Section 1B.03 Paragraph 07 or Table 1B-1.

Usually, after load rating, the State bridge engineer notifies the owner of what to post and how to sign the bridge accordingly. After that, the State DOT may request images of signs from districts, local agencies or other bridge owners as verification of completion and store these images in a file for oversight review.

In some States, all local agencies inspect and load rate their own structures. For example, one State DOT monitored local agency load rating and posting through its bridge management system. Local agencies were responsible for installing load posting signs and updating the information in the State's bridge management system.

Another State DOT performed monthly data checks for load posting issues and notified agencies of potential deficiencies. Other State agencies manage the inspection and load rating of local agency bridges. One State DOT would then issue a load posting recommendation to local agencies if necessary. The responsibility then went to the bridge owner to post the bridge with the State DOT following up to verify that the owner had posted the bridge within 30 days.

A review of State practices on load posting criteria and timing reveals that, for many States, the timing for posting a bridge after the load rating results are completed is not specified in the State load rating documents. However, it is common practice for States with a clear requirement on this timing to post a bridge within 30 days after load rating results are complete.

The NBIS 2022 final rule (23 CFR 650.313(l)(2)) states that posting shall be made as soon as possible but not later than 30 days after a load rating determines a need for such posting.

4.4 Bridge closure

Certain bridges are to be closed to traffic due to condition issues or low load ratings. NBIS instructs States to develop and document criteria for closing a bridge that considers the bridge condition and load-carrying capacity. Bridges that meet the criteria must be closed immediately. Bridges must be closed when the gross live load capacity is less than 3 tons (23 CFR 650.313(m)).

The AASHTO MBE (6A.8.1, 6B.7.1, 3rd Edition) also states that bridges not capable of carrying a minimum gross live load weight of 3 tons must be closed. However, it is also noted that a bridge owner may close the structure at any higher threshold considering the character of traffic, the likelihood of overweight vehicles, and the enforceability of weight posting.

A review of State manuals reveals that a few States have explicit instructions for bridge closure timing. For example, Idaho, Illinois, and Kentucky provide specific instruction in this case, and the excerpts from their State manuals are provided in Table 5.

Table 5 Bridge Closure Timing

State	Excerpts from Source Document(s)
Idaho	The District Engineer shall be required to perform the necessary actions to properly load post or close the structure. Bridge closure shall occur within 2 days of notification and load posting shall occur within 10 days. 6B.7.1.1, Idaho Manual for Bridge Evaluation, 2022
Illinois	When the decision is made to implement a load posting or closure, it is the responsibility of the agency with jurisdiction of the roadway carried by the bridge to erect the necessary signage and barricades as soon as possible. 4.3.5.2, IDOT Structural Services Manual, 2017
Kentucky	Allowable time frames (from the date of the recommendation from Central Office) within which action must be taken: Closures: 5 days, All Postings: 30 days 400, Kentucky Bridge Inspection Procedures Manual, 2020

5 STRUCTURAL ANALYSIS FOR ROUTINE AND SPECIAL PERMIT LOADS

5.1 Permit evaluation

When a truck exceeds legal weight limits, States may issue an overload permit to allow the truck to use the bridge or roadway under certain, limited conditions.

NBIS (23 CFR 650.313(k)(3)) requires analyzing routine and special permit loads for each bridge that these loads cross to verify the bridge can safely carry the load. In previous versions of the NBIS, special permit loads were not explicitly addressed.

AASHTO MBE (6A.4.5.3, 3rd Edition) specifies two permit types for vehicles weighing more than legally established limits: routine and special. The permits typically specify the duration for which the permit is valid and restrictions. Sometimes the permits include the allowable routes and the origination and destination.

Often, routine permits are valid for an extended amount of time, not to exceed one year, and for an unlimited number of trips. Vehicles that receive a routine permit may mix in the traffic stream and move at normal speeds.

Conversely, special permits are typically for heavier vehicles and single trips (though multiple trip permits may be granted), and may be accompanied by additional restrictions, such as the time of day the vehicle may be on the route, escort requirements, lane restrictions, speed restrictions, etc.

For the evaluation of permit decisions, it is expected that the actual permit truck or the vehicle producing the highest load effect in a class of permit vehicles operating under a single permit is used. This ensures the correct truck weight, axle configuration, and distribution of load to the axles are used for analysis.

Many States, recognizing the need to create efficiencies and expedite the permitting process, have adopted new changes in recent years. In many cases, the permitting process has become automated using operator input and designated routes. Despite advances being made, it is apparent through a review of the State practices that the methodologies used, the vehicle size, and the vehicle configuration can vary considerably between States for evaluating permit loads. This variation can be cause for confusion and frustration for operators, especially if hauling across State lines.

States that have adopted an automated permit system have indicated improved accuracy of permits issued, an increase in the number of permits issued, expedited permit issuance, and reallocation of human capital to specific permit cases. Numerous States have auto issue thresholds based on width, height, length, and weight. These thresholds vary from State to State.

5.2 Overweight permit procedures

The state of the practice of how various States handle overweight permitting procedures was reviewed. States like Colorado use Overload Color Code ratings to define a bridge's capacity for heavier loads. Iowa DOT conducts overweight and over-dimensional checks for superload permits, including considerations like vehicle speed, exclusivity, and axle extension. Wisconsin issues single-trip and annual permits for overweight vehicles with specific route and load restrictions. Nevada allows heavy transporter vehicles with over-dimensional permits and calculates bridge adequacy based on load ratings for permit vehicles. New Hampshire uses in-house software, BOPR, to identify bridges that may be affected by permit vehicles and makes determinations based on applied load effects compared to bridge capacity data.

Farrar et al. (2014) conducted a desk scan on the State DOT superload permit processes and practices to identify best practices in the superload permitting processes. The desk scan was conducted for 18 selected States. The results indicated that 78 percent of the surveyed States were in the process of adopting new changes in their permit processing, especially toward automated permitting and paperless processing.

6 RESEARCH, TECHNOLOGIES AND OTHER TOPICS OF INTEREST SUCH AS QUALITY MANAGEMENT OF LOAD RATINGS, POSTING AND PERMITTING

Load rating information is used to (1) prioritize structures for repair or replacement, (2) restrict the weight of vehicles that are allowed on a particular bridge, and (3) determine routes for permit vehicles (Chajes et al. 2000). In general, the load rating technology today is more adaptable and accurate, easier to use, less expensive, and more reliable than it was 20 years ago. Some advanced technology has been incorporated into the bridge load rating process.

6.1 Software use

Computer software is commonly used to calculate the load rating factor, with various structural analysis software packages available to provide opportunities for rating engineers to complete and update the calculation(s) quickly. Each software package has its limitations, with no one package capable of load rating all bridge types. This review found that State DOTs specify their preferred software packages for each different type of structure for consistency and efficient maintenance.

6.2 Automated permitting system

Farrar et al. (2014) indicated that, although successful pioneering practices have been conducted to improve the efficacy and uniformity of superload permitting processes, significant differences among States still exist.

Schaefer and Todd (2018) conducted a research study on State oversize-permitting and overweight-permitting practices, including automated vehicle routing and escort driver certification and identified the areas of best practices. The researchers found that, by 2018, 30 States were using automated permit systems.

6.3 Bridge testing and monitoring

Bridge testing and monitoring can be used for the bridge load rating to provide bridge behavior information for the load rating calculation or to measure the bridge capacities directly. The AASHTO MBE (8.8.2 and 8.8.3, 3rd Edition) includes two main load test techniques: 1) proof tests, which determine a lower-bound safe capacity, and 2) diagnostic tests, which validate analytical procedures. While field load tests provide valuable insights, they require traffic control and setup time and offer only a snapshot of the bridge's behavior.

Recent advancements have been made in nondestructive testing, electronic instrumentation, and data acquisition. These new technologies provide an opportunity to collect data to understand a bridge’s behavior better. However, the limitation of in-service monitoring is that the weight and classification of the truck loadings are not specifically known, which poses challenges for explicitly evaluating bridge parameters. One solution for collecting detailed data on the weight and classification of trucks is to utilize a weigh-in-motion (WIM) system.

Overall, advancements in sensor technology, data acquisition, and analytical techniques offer opportunities for improving the accuracy and efficiency of bridge load rating.

6.4 Data collection, communication, and management

Various technologies, including the Internet of Things (IoT), wireless sensor networks (WSNs), and Intelligent Transportation Systems (ITS), are being used to enhance bridge monitoring and load rating systems. IoT enables seamless integration of sensors into an information network, while WSNs, though challenged by power consumption, can eliminate wires and rely on batteries or power harvesting. Additionally, ITS devices are integrated into bridge monitoring systems to assess the impact of traffic conditions on bridge structures, facilitating data synchronization.

Another method to generate and manage data during an infrastructure's lifecycle is BIM (Lee et al. 2006). BIM is a digital representation of a facility's physical and functional characteristics. It allows for the definition, storage, sharing, and maintenance of applicable information. BIM covers geometry, spatial relationships, geographic information, quantities, and the properties of structural components. (Ackerman et al. 2017, Shim et al. 2017).

6.5 Digital twin concept

The digital twin concept, widely used in vehicle and aerospace engineering (Mayani et al. 2018), is gaining attention in bridge engineering for creating virtual models of physical structures to simulate their behavior and integrate cyber-physical aspects. Researchers have developed 3D digital twin bridge models, including damage records, environmental conditions, and structural parameters. These can be continuously updated with inspection and monitoring data to enhance maintenance tasks and explore new technologies. However, challenges include automated data capture and BIM creation, timely updating of maintenance information, and managing data uncertainty.

6.6 Quality control and quality assurance

The value of the load rating, load posting, and permitting procedures will only be as good as the quality in which they are executed. Quality control and quality assurance should be systematic and completed to ensure accuracy and consistency.

NBIS states to document the extent, interval, and responsible party for the review of inspection teams in the field, inspection reports, NBI data, and computations. Reviews are to be performed by personnel other than the individual who completed the original report or calculations. Further, the review results must be documented, including tracking the completion of actions identified in the procedures. Lastly, the QC and QA review findings must be addressed (23 CFR 650.313(p)(1)-(4)).

The AASHTO MBE (6.1.8, 3rd Edition) adds that a registered professional engineer shall be responsible for the bridge-capacity evaluation. Others with specialized expertise in complex or unique bridges may be necessary. The load rating should be sufficiently documented and include field inspection reports, material and load test data, all supporting computations, and a clear statement of all assumptions used in calculating the load rating. Computer input files should be retained for future use.

A review of the State manuals indicates that many States have written load rating QA/QC procedures. For quality control, the rating analyses are to be reviewed by an independent individual who may perform a review for reasonableness and general conformity with the State's load rating practices or perform independent calculations to verify the initial rating results.

The State of Delaware lists key points for reviewers to check for quality control, including the following. In Delaware, any discrepancies must be discussed and resolved between the load rater and the load rating reviewer.

1. Load Rating Assumptions
2. Type of Structural Model Utilized
3. Selection of points or nodes to be analyzed
4. Identification & Application of Dead Loads
5. Bridge Geometric & Lane Configuration
6. Material Properties
7. Cross-Section Geometry
8. Rebar Sizing & Spacing
9. Span Length Selection
10. Dynamic Impact Reduction Factor
11. Inclusion of all Design, Legal, and Permit Vehicles
12. Average Annual Daily Truck Traffic Determination
13. Live Load Distribution Calculation
14. Selection of Legal & Permit Live Load Factors
15. Structure Condition Factor
16. Material & System Resistance Factor Selection
17. General Documentation & Comments in Input Data Files and Load Rating Report
18. Completeness of Load Rating Forms

Delaware selects a minimum of 5% of bridge load ratings completed in the current calendar year as part of the quality assurance review. The bridge load ratings consist of a representative sample and include bridges that have been load rated by each load rater or consultant. In addition to the 5% QA review, the bridge management engineer will review all load ratings indicating a change in the current posting restriction for a bridge or if the bridge is in poor condition.

7 DESK SCAN SUMMARY

Many differences and similarities were observed during the desk scan in the State's processes and practices with respect to the focus areas presented previously.

Most States use the AASHTO design and legal load models for load rating. Some States have adopted their own State-specific legal load models to address local needs. Legal load exemptions for specific vehicles or commodities are common in many States. Specialized Hauling Vehicles (SHVs) and Emergency Vehicles (EVs) are also included in the load models.

States follow AASHTO MBE guidance to factor in structural deterioration during load rating. Deterioration is typically addressed by reducing the cross-sectional area of members based on inspection results. While there are inconsistencies across States, most use material-specific deterioration models. Refined methods like 2D or 3D models are also used for more detailed assessments.

Load ratings and re-ratings are critical for ensuring the safety and structural integrity of bridges. The need for re-rating arises from deterioration, changes in configuration, increased dead or live loads, or policy changes. Some States automate parts of this process to expedite load rating, but others face challenges, such as resource allocation.

Permit loads that exceed legal limits are subject to evaluation. Many States now automate this process, reducing manual effort and ensuring timely permit issuance. Special permits typically have additional restrictions, such as route limitations or escort requirements, and may involve refined analysis of specific bridge elements.

States are advancing the use of technology in load rating. Innovations like Weigh-In-Motion (WIM) systems, Digital Twins, and Building Information Modeling (BIM) are improving data collection, analysis, and load rating efficiency. Automated systems and sensors help streamline data acquisition and monitoring for load rating processes.

The results of the desk scan highlight the need for an exchange of information among key personnel to identify promising methods for improving the consistency and enhancing the uniformity of bridge safety in terms of live load carrying capacity determination.

PART 2

PEER EXCHANGE

8 OVERVIEW

In April 2024, a two-day meeting was held in Salt Lake City, UT. Personnel from State transportation agencies and the Federal Highway Administration were in attendance (57 total), primarily from western States. Similarly, in May 2024, a two-day meeting was held in Pittsburgh, PA. Personnel from State transportation agencies and the Federal Highway Administration were in attendance (68 total), primarily from eastern States. The attendee lists for each meeting are provided in the Appendices.

The purpose of the peer exchanges was to gather load rating engineers and other stakeholders from transportation agencies from around the United States to hear directly from others about their load rating practices, challenges, and ideas. The peer exchange also served to establish and develop relationships among load-rating peers so that future collaboration or exchange of ideas may result naturally. The objectives were to systematically address certain topics through prepared presentations and large- and small-group discussions to unveil commendable practices and contribute to improvements of State's practices.

Each meeting consisted of five sessions in which several State personnel offered a presentation respective to the topic and their State's policies and practices followed by large and small group discussions. The topics included:

Topic 1 – State Truck Size and Weight Limits and State Legal Load Models
Topic 2 – Consideration of Deterioration in Bridge Load Rating Analysis
Topic 3 – Timely Load Rating, Re-rating, Posting and Closure
Topic 4 – Structural Analysis for Routine and Special Permit Loads
Topic 5 – Research, Technology and Others

A short period for questions, answers, and discussion followed each presentation. Following the last presentation of the session, a small group breakout discussion period allowed States to discuss the policies and practices of their States and identify successes and challenges that exist in their State and others.

The following sections provide a brief overview of each presentation. The summaries are organized in the order presented and by the session topic. Note that each presenter produced a presentation based on their State's practices. The views and opinions expressed in the presentations summarized below are the presenters' and do not necessarily reflect those of FHWA or the U.S. Department of Transportation (USDOT). The contents of the presentations summarized below also do not necessarily reflect the official policy of the USDOT.

8.1 Presentation summaries from Salt Lake City, UT peer exchange

8.1.1 Topic 1 – State truck size and weight limits and State legal load models

8.1.1.1 Oregon

In his presentation titled LRFR for Older Bridges, the presenter discussed the Oregon Department of Transportation's (ODOT) transition to Load and Resistance Factor Rating (LRFR) for evaluating older bridges, particularly those built before modern design standards.

ODOT began using LRFR for all bridges in 2005, including older structures not originally designed with Load and Resistance Factor Design (LRFD) principles. The shift was driven by inspection findings in the early 2000s when over 500 reinforced concrete deck girder (RCDG) bridges exhibited diagonal-tension cracking, especially those built between 1947 and 1962.

Before the LRFR transition, ODOT relied on the 1989 AASHTO Guide Specifications for Strength Evaluation of Existing Steel and Concrete Bridges, an early version of LRFR. The Guide Specifications utilized reduced shear resistance for cracked concrete, prompting significant weight restrictions and costly repairs.

Oregon State University conducted extensive research on cracked concrete bridges, leading to the development of a comprehensive database and detailed studies on various bridge components. Field and laboratory tests validated several analysis methods, including ACI Method, AASHTO Modified Compression Field Theory (MCFT), and finite element analysis, among others. The research concluded that the MCFT method, integral to LRFD, accurately reflects the shear capacity of cracked concrete girders.

Based on research findings, ODOT adopted the MCFT method for all concrete bridge shear capacity calculations in its inventory. Despite initial intentions to use only parts of LRFR, ODOT decided to fully implement LRFR for a more consistent and comprehensive load rating approach. ODOT also increased the number of analysis points along the length of a beam and made sure they checked points of minimum and maximum shear and moment, points where there was a change in shear rebar size and/or spacing, all bar cutoff locations, and changes in geometry (e.g., end of a haunch). The presenter mentioned that currently available software does not properly perform the iterative process for shear load rating using MCFT, so ODOT does this using an in-house spreadsheet.

The presenter discussed a surface-mounted titanium bar repair method for increasing shear capacity. Vertical bars can be used to increase transverse reinforcement; longitudinal bars can be used to increase the longitudinal reinforcement where existing reinforcement was cut off too soon. The surface-mounted titanium bar repair detail is an alternate to Carbon Fiber Reinforced Polymer (CFRP) wraps and repairs.

ODOT was also noticing low rating factors for post-tensioned box girder bridges. They were observing that rating factors would drop below 1.0 near the inflection points, which was an issue when only considering tendons on the flexural tension side of the girders. ODOT developed spreadsheets and alternate procedures to include all tendons in the analyses.

Simply supported, short-span steel stringer bridges, common in Oregon, showed low rating factors for positive moment at midspan when evaluated with LRFR, largely due to lateral torsional buckling. Many of these bridges have timber or corrugated metal decks, which currently do not count as bracing for the top flange. These bridges, many of which have been in service for decades without issues, now require load posting under LRFR criteria. ODOT is conducting further research to understand why these bridges have performed well historically and to develop methods to account for their performance in load ratings. There was also discussion that using LRFR led to many steel continuous structures being controlled by lateral torsional buckling in the negative moment region over the pier.

LRFR provides a more accurate assessment of the ultimate capacity of concrete bridge members. Understanding the historical context and design philosophies is crucial for effectively applying modern load rating methods. Ongoing research aims to address the disconnection between past performance and modern load rating procedure, particularly for older steel bridges. This comprehensive approach ensures the safety and reliability of Oregon’s bridge infrastructure while addressing the unique challenges posed by older bridge designs.

8.1.1.2 Iowa

The Iowa DOT made a presentation on Iowa’s Legal Loads and Exemptions, which provided an overview of Iowa's road and bridge infrastructure, load rating processes, and legal load regulations.

Iowa has 115,679 miles of roads: 8% are managed by Iowa DOT, 77% by counties, 14% by municipalities, and 1% by other agencies. The State has 23,737 bridges: 18% are managed by Iowa DOT, 77% by counties, 5% by municipalities, and a negligible percentage by others.

The Iowa DOT oversees load rating for State bridges and provides guidance to local public agencies (LPAs) for their bridges. LPAs either perform load ratings in-house or hire consultants. Ten counties handle their own load ratings, while others rely on consultants.

Load rating tools used by Iowa DOT include LARS, CulvertCalc, and AASHTOWare BrR. Iowa is transitioning to an agency-sponsored AASHTOWare BrR license for broader use among local agencies.

Iowa Code 321.463 specifies the maximum legal loads operating on Iowa’s highway systems, including single axles to be 20,000 lbs. or less and tandem axles to be 34,000 lbs. or less. Exemptions from size, weight, and load requirements include fire apparatus, State and local road maintenance equipment, and certain agricultural and construction equipment under specific conditions. Seasonal exemptions exist for vehicles transporting agricultural products during harvest, allowing higher gross weights without permits on non-interstate highways.

Iowa's Automated Permit System (IAPS) and SUPERLOAD CE manage permit issuance. Permits are required for vehicles exceeding legal weight limits, with different rules for vehicles over 80,000 lbs. and those exceeding 200,000 lbs. Approximately 150,000 permits are issued annually, with about 10% subject to detailed bridge analysis.

Iowa has introduced several legislative changes in the past decade, adding various truck types and special permits. Research projects are underway to assess the impact of increased legal loads on bridge service life, involving structural analysis, data collection, and laboratory testing.

Iowa DOT is working on obtaining a bulk license for AASHTOWare BrR for local agencies to streamline load rating and permitting. A task force has been formed to develop standard models, secure funding, and plan for long-term support and training for local agencies.

8.1.1.3 West Virginia

The presenter from the West Virginia Department of Transportation (WVDOT) provided an overview of West Virginia's State legal load limits, exemptions, and practices related to truck size and weight and bridge load rating.

Legal load limits vary depending on the route. On interstate highways, the gross vehicle weight (GVW) is limited to 80,000 lbs., with a single axle limit of 20,000 lbs. and a tandem axle limit of 34,000 lbs. Axle group weight follows the Federal Bridge Weight Formula B. No additional tolerance is allowed or all tolerances are included in the weight limits. For US, WV, and select county routes, the GVW is limited to 80,000 lbs., with specific limits for single unit tandem (60,000 lbs.), tridem (70,000 lbs.), quadem (73,000 lbs.), and various tractor-semi trailer combinations. A tolerance of 10% is permitted. The GVW is limited to 65,000 lbs. for local service routes, with a single axle weight limit of 20,000 lbs. and a 10% tolerance. Bridges are posted at the maximum capacity (not including the 10% tolerance); the tolerance is not allowed for posted bridges.

Emergency vehicles and implements of husbandry are exempt from general size and weight limits. Coal Resource Transportation System, Commodity Permits, and Wood Truck Permits have specific weight allowances.

Routine load ratings are conducted at every inspection, including SHV load ratings, every two years using existing AASHTOWare BrR models. WVDOT performs more in-depth analyses and recreates load rating models every six years. WVDOT has a manual with full examples for modeling basic bridge types in BrR to maintain consistency of model inputs at State and district levels.

State-specific load models were stipulated and developed by State law and the Public Service Commission. These models represent vehicles creating greater load effects on bridges than the AASHTO legal load models provided in the AASHTO MBE.

Legal load ratings are performed regularly, at legal load rating level. Multiple lanes are used, if applicable, for legal loads. Routine permit loads are treated as legal loads. Special permit loads (OS/OW) are treated as single-lane loads. Non-standard gauge vehicles are addressed by revising live load distribution factors (LLDF) or by using finite element analysis (FEA). Complex analyses are outsourced to consultants.

8.1.2 Topic 2 – Consideration of deterioration in bridge load rating analysis

8.1.2.1 Wisconsin

Wisconsin DOT presented Wisconsin's protocols for handling deterioration and structural reviews in bridge management.

Load rating reviews are automatically initiated for bridges with significant changes in overburden or when National Bridge Inventory (NBI) ratings for deck, substructure, superstructure, or culverts fall to 4 or lower. Inspectors can manually trigger reviews if deterioration or defects are observed.

Reviews are conducted by qualified inspectors, the WisDOT load rating engineer, or consulting professional engineers. Reviews are to be completed within 60 days of the inspection. Methods include engineering judgment, structural calculations, or alternative options like repairs.

Documentation includes overall and element-specific notes, credentials of the professional engineer, the review method used, and any necessary attachments.

Final actions may include no action, increased inspection frequency, load rating or posting changes, recommended repairs, or immediate closures.

There are some common deterioration conditions observed during inspections. Timber structures are prone to decay and insect damage. Resistographs are used to determine section loss to reduce the size of timber elements in models. Steel structures often suffer from rust and section loss, particularly in gusset plates. Concrete structures can experience spalling, cracking, and rebar exposure. Metal culverts frequently show corrosion and deformation.

Factors considered for fire-damaged bridges include the fire source, vertical clearance, and material type. Immediate inspections focus on the extent of fire exposure and structural changes in concrete and steel. Collaboration with firefighters can provide temperature estimates to assess damage severity.

A detailed rerate list tracks the number of bridges reviewed annually, categorized by rerate triggers like the NBI condition ratings and structural review needs. Follow-up actions involve updating load rating models and the Highway Structures Information System (HSIS), and implementing recommended repairs or postings.

8.1.2.2 Nebraska

The presenter from Nebraska DOT discussed the causes, effects, and considerations for incorporating steel beam end deterioration and bearing failures into bridge load rating analysis.

Extreme weather, deicing chemicals, overloading, and deck joint failures contribute to steel beam end deterioration. Corrosion in steel bridges and insufficient reinforcement or cover to rebar in the deck exacerbate the issue. Nebraska DOT has recently observed more steel bridges with end region deterioration and beam end failures. They reached out to several other DOTs and realized there is a wide range of ways that States inspect and consider the effects of steel beam end deterioration.

Section losses in beams and other structural elements may result. Beam end deterioration may trigger temporary lane closures, load restrictions, or full closures. Severe section loss may cause bridge collapse if not promptly addressed.

As part of pre-analysis actions, load rating engineers assess the extent of deterioration, focusing on beam ends, seats, concrete pads, abutments, pier caps, and bearings, and decide whether to keep the bridge open, partially open, or closed. Restrictions may be applied to permit loads.

Bearing failure can result in a serious condition, which may conflict with existing load rating analysis assumptions and results.

Repair is the first choice, but other approaches may be considered, such as considering the support as free, distributing the load to other members, and conducting a load test.

Assessment and analysis of beam end deterioration can be a complex problem. Some suggestions were provided to improve estimation of remaining capacity. Visual estimation of section losses should be avoided when possible; it is better to physically measure and document remaining section dimensions. Inspection photos and documentation are used to evaluate remaining web thickness and calculate web section loss. Regular inspections map defects and manage deteriorations using detailed documentation and photos. Accurate measurement, documentation, and assessment of section losses in the end regions can help the load rater better estimate the actual capacity of the end region. Load path to the support should be assessed when deterioration is observed in the web. Load raters need to make sure that the analytical approach properly captures the effects of the end region deterioration on the performance of the structure.

Preventive maintenance and immediate repairs are prioritized to prevent further deterioration, especially on critical routes. This is the first choice to handle end-bearing deterioration, especially on emergency routes. Bridge deterioration models help prioritize and select projects, potentially postponing some immediate actions based on the severity.

8.1.2.3 Wyoming

The presenter from the Wyoming Department of Transportation (WYDOT) discussed the impacts of over-height vehicle hits on bridges and the subsequent considerations for load rating.

Wyoming's inventory includes 3,181 bridges over 20 ft, 10 tunnels, approximately 2,382 minor structures, 201 earth retaining structures, 223 overhead sign structures, and 304 high mast light towers.

WYDOT's team includes a program manager, project managers, project engineers, and engineering assistants. They also occasionally use consultants for load rating tasks.

Primary software used by WYDOT includes BRASS-GIRDER, BRASS-CULVERT, and BRASS-ROUTE. Other tools like RISA, LUSAS, and spreadsheets are used as needed.

Wyoming averages about four high-hit impacts per year, resulting in significant structural damage to bridges.

For steel bridges, the types of damage include necking (plate thinning), gouges, cracks and fractures, flange and web distortion, missing connections, and damaged welds. The damage can alter the steel's yield strength, tensile strength, ductility, and toughness, often increasing yield strength but reducing ductility and toughness. Damage like buckled cross-frames, torn stiffeners, and soffit spalling can affect the bracing and load distribution. WYDOT will use heat straightening depending on the severity of the damage and distortion; WYDOT will perform minor heat straightening up to two times before opting to replace a girder. WYDOT will grind near impact points, as this was found to help decrease stress concentrations by researchers (Conner et. al, 2008). WYDOT is trying to reduce the number of intermediate diaphragms and braces as these can cause punching of a girder at impact; new bracing configurations to reduce the number of braces by a factor of two are developed and reported in NCHRP Report 962 (Reichenbach et. al, 2021)

For concrete bridges, exposed laps of longitudinal reinforcement bars may not be effective. Gouges in prestressing strands are considered significant, and those strands are removed from the analysis. Broken stirrups and vertical cracks can reduce shear capacity, especially if the concrete is loose or broken.

The presenter recommended to stay conservative with load rating assumptions. Load raters should work closely with bridge inspection personnel to gather necessary measurements. Severe damage warrants lane closures above affected girders. Adjustments might be necessary to consider new barrier loads and reduce live load to adjacent girders.

8.1.3 Topic 3 – Timely load rating, re-rating, posting and closure

8.1.3.1 Montana

The presentation "Timely Load Rating, Re-Rating, Posting, and Closure" by Montana Department of Transportation (MDT) described MDT's processes and policies for managing bridge load ratings, postings, and closures.

Montana has about 4,500 National Bridge Inventory (NBI) structures, with 2,500 owned by MDT and 2,000 by other entities, plus 600 non-NBI structures.

MDT primarily uses AASHTOWare BrR for load ratings of bridges and Excel spreadsheets for load ratings of culverts.

The preferred methodology is Load and Resistance Factor Rating (LRFR); Load Factor Rating (LFR) and Allowable Stress Rating (ASR) are used if needed.

New structures, changes in bridge condition, dead loads, rehabilitation, reconstruction, changes in codes, policies, or operational conditions trigger load ratings or re-ratings. Common sources include inspections, condition reviews, and policy memos.

The MDT034 flag in the Bridge Management System (BMS, AASHTOWare BrM) is used to request and track load rating reviews. BMS sends an automatic email to the load rater, who then decides (engineering judgment) if immediate action is needed. Everything is tracked through a comments box in their BMS. Challenges include coordination with inspections to meet the 90-day requirement for rating or re-rating under 23 CFR 650.313(k)(2), quick response needs, and proper documentation. Consultants typically take extra time because of contracting mechanisms.

Legal load vehicles including special hauling vehicles (SHVs) with LFR or ASR operating rating factors below 1.0 or LRFR legal load rating factors below 1.0 trigger load postings.

Historical practice used inventory ratings, but revised policies depend on vehicle types triggering the postings. Simplified signs cover all scenarios, with standardized procedures for determination of posting loads based on calculated rating factors and safe posting levels (SPL).

Some challenges relating to load posting include the implementation for locally-owned bridges, especially when bridge owners are non-responsive. MDT developed an escalation procedure for non-responsive local bridge owners. MDT provides load posting signs and handles winter challenges with blank sign inventories and adhesive overlays. There was also confusion about postings and the applicability of posting signs. Public outreach and education are conducted through media, fact sheets, and an interactive load-posting map on MDT’s website to help address this challenge. The load-posting map is linked to BMS to automatically update information; the map also shows photographs of the actual posting signs.

Closures are triggered by load rating results or engineering judgment related to condition issues. Bridges unable to carry a minimum gross live load of three tons are closed as per MBE standards. MDT's recent practice adopts a minimum safe posting load of 5 tons before closure. Closure procedures include effective barricades and signage to ensure public safety. Counties are responsible for safe and effective closures for locally-owned bridges; the county decides on warning and detour signs. MDT has found that many barricades can be moved. When an easily movable barricade is being used, MDT will send notifications to the bridge owner. MDT is also working on rescindment procedures to reopen bridges after repairs have been made; a licensed engineer is to sign off on the repair and verify that the repair has been completed correctly.

8.1.3.2 Wisconsin

The Wisconsin Department of Transportation (WisDOT) presented strategies to refine bridge load postings, ensuring safety and compliance with modern standards.

1 in 10 Wisconsin State system bridges and 1 in 3 local system bridges were designed for loads lighter than AASHTO HS20 or HL-93 design loading. About 5.1% of local system bridges and 0.3% of State system bridges have weight limit postings, while 3.7% of local system bridges and 0.7% of State system bridges have emergency vehicle (EV) restrictions. Signs are installed for interstate bridges or bridges within a mile of access points for emergency vehicles if indicated necessary by load rating analysis. Sign installation was completed in September 2020 for interstate and October 2023 for other bridges. WisDOT created a map for load restrictions using ArcGIS and did outreach and education to ensure people knew how to access and use the map; users can also subscribe to receive updates on changes to postings in their area.

Several refinement strategies have been employed by WisDOT.

- Unknown Construction Details: Engineering judgment and physical inspections are used to establish load ratings based on MBE Article 6.1.4.
- Documented Engineering Judgment: Calculations may be adjusted using conservative assumptions for minor deviations below certain rating factors. This would only be done for bridges that are in good condition.
- Limit State Options: In determining load posting, exempt shear checks for concrete bridges showing no distress or use more accurate shear resistance estimation procedure (e.g., LRFR General, MCFT) and use plastic analysis for steel components. WisDOT has a checklist on when plastic analysis is allowed (e.g., braced top flange, 36 ksi steel).
- Single-Lane Loading: Consider single-lane loading for low ADT short-span bridges to avoid postings. Consider likelihood of two fully-loaded trucks on a low ADT bridge at the same time, e.g., a bridge near a quarry will not likely have two fully-loaded trucks on it simultaneously.
- Lane Striping and Curbs: Restrict loads to designated lanes using striping, curbs, or barriers.
- Live Load Factor Modifications: Adjust factors for emergency vehicles to reflect realistic conditions.

- Refined Analysis: Refine analysis for slabs, girders, and other structures using advanced methods like 3D modeling and load testing to improve the estimated distribution factors.

A local bridge strengthening program was implemented from 2018 to 2020, including retrofitting timber slabs, adding plates and angles to steel girders, and reinforcing concrete slabs. Costs ranged from $15/sf to $96/sf, depending on the method and material. County crews were used to perform simple repairs to strengthen bridges.

The posting evaluation process includes a load rating screening conducted using operating and inventory ratings, with thresholds set for re-rating triggers based on condition ratings. All information on load postings is built into their bridge management system. Load rating engineers enter in calculated and actual load postings and note reasons for differences if applicable. Load posting verification forms include photographs of the load posting sign.

Comprehensive documentation includes load rating summary forms, structural review notes, and final actions recommended and taken.

8.1.3.3 Arizona

The presenter from the Arizona Department of Transportation (ADOT) presented the procedures and processes for load rating, refined load rating, and load posting of bridges and culverts in Arizona.

ADOT uses AASHTOWare BrR 7.5 for rating analysis, enabling efficient updates and re-ratings. In Arizona, load rating is mandatory for new bridges and is reviewed when record drawings become available.

Re-rating is necessary when structural conditions change, such as vehicular damage, spalling in concrete, section loss, deck replacement, widening, or adding new girders. New Federal guidance or added loads (e.g., sidewalks, barriers) can also trigger re-rating.

Different engineers perform, review, and verify load ratings, ensuring accuracy before finalizing the load rating summary report.

Structures are posted based on the Operating Rating Level using Load Factor Rating (LFR) methodology. No posting is needed if the legal load operating rating factor is 1.0 or higher. Structures with an operating rating factor below 1.0 are to be load-posted, with weight limits set between inventory and operating ratings.

For concrete slab bridges with low operating ratings, a refined analysis method developed by Florida DOT is used to refine load ratings. When performing load ratings for emergency vehicles (EV2 and EV3), the live load factor may be reduced from 1.3 to 1.1 to increase the operating load factor.

ADOT's policy includes re-rating within 90 days of inspection and posting within 30 days if needed. Guidelines were provided for bridge closures due to critical findings such as structural defects or load ratings below safety thresholds. Immediate actions include closure or barricading, followed by detailed inspection reports within 48 hours.

The presenter provided case studies for specific bridges (e.g., San Francisco River Bridge, Waterman Wash Bridge) in need of load postings. The Pumroy Canyon Bridge was load tested and re-rated to remove posting restrictions and reopen to traffic.

8.1.4 Topic 4 – Structural analysis for routine and special permit loads

8.1.4.1 Utah

The Utah Department of Transportation (UDOT) presented the organizational structure, types of permits, legal load exemptions, and systems for managing oversized and overweight vehicles in Utah.

UDOT issues various permits for transportation, including:

- Annual Permits: Valid for 365 days.
- Semi-Annual Permits: Valid for 180 days.
- Single Trip Permits: Issued for one-time transportation needs.

Routine permits allow for the transport of non-divisible loads with specific weight limits:

- Single Axle: 29,500 lbs.
- Tandem Axle: 50,000 lbs.
- Tridem Axle: 61,750 lbs.
- Trunnion Axle: 60,000 lbs.
- Gross Vehicle Weight: 125,000 lbs.

Special permits refer to single trips for non-divisible loads exceeding 125,000 lbs., with axle, bridge and gross weight allowances based on the non-divisible bridge formula. A multiplier of 1.47 is applied to the Federal Bridge Formula B.

Several legal load exemptions apply to specific vehicle types:

- Tow Trucks: Exempt from weight limitations if properly registered and permitted.
- Emergency Vehicles: Can exceed weight limits up to 86,000 lbs.
- Natural Gas Vehicles: May exceed weight limits by the difference between the weight of natural gas and diesel fuel systems, up to 82,000 lbs.
- Milk Transport Vehicles: Can exceed the gross weight limit of 80,000 lbs. with a proper permit.
- Special Truck Equipment: Includes concrete pumper trucks, cranes, and well boring machines that must obtain permits if exceeding legal dimensions.

Details of the bridge calculator system used by UDOT for permitting was presented. The bridge calculator is part of their permitting system that allows input of axle spacing, tire widths, and weights; users will have green highlight if values are acceptable and red if there are issues. This bridge calculator is based on Utah Common Permit Vehicles; all bridges are evaluated for these vehicles. These common permit vehicles were developed based on Weigh-in-Motion (WIM) data from three collection sites. Around 20,000 vehicles, including 3 to 12-axle vehicles and trucks exceeding the legal load of 80,000 lbs. were analyzed as part of the development process for the five different Utah Common Permit Vehicles, which included 6, 7, 8, and two 9 axle vehicles.

UDOT uses WIM data to identify common axle configurations and calculate the mean Gross Vehicle Weight (GVW) within various axle counts. This data helps evaluate the most common axle configurations for 5 to 8-axle trucks and determine the top percentages of trucks by GVW for analysis.

8.1.4.2 Idaho

The presenter from the Idaho Transportation Department (ITD) discussed Idaho's practices regarding the quality management of load ratings, posting, and permitting. The presentation outlined the comprehensive procedures and standards ITD uses to manage and ensure the quality of bridge load ratings, postings, and permitting.

Idaho has 4,257 bridges: 1,334 State system (NBI) bridges, 2,433 local system bridges, and 490 bridges in other agencies. ITD is responsible for inspecting and load rating all State and local bridges.

The ITD Staff includes part-time engineers, EITs, an intern, and experienced design staff. The presenter stated there are challenges in filling the load rating engineer position.

Load ratings are conducted at the final design stage for State projects and post-construction for local bridges. ITD uses the Idaho's version of Manual for Bridge Evaluation, load rating summary forms, and software such as AASHTOWare BrR, with versions 7.2 and 7.5 currently being tested.

Independent verification is performed if design vehicle inventory rating factors are below 0.90 or above 1.50.

In-house and consultant load ratings follow a structured QC process involving data gathering, input verification, and review for conformance to standards. Current QA/QC forms are being revamped to improve quality, with comparisons made to practices in other States. Permits are issued for trucks over specific weight limits, with different types for annual, routine, and special permits. ITD's permitting process has evolved from manual processing to automated systems, significantly reducing the time and effort for bridge analysis and permitting.

AASHTOWare BrR is used for load rating, and the Load Rating Tool is used for quicker permitting. The Load Rating Tool processes 100 ratings per second, making it efficient for high-volume analyses.

ITD updates bridge and load rating information quarterly and conducts regular data testing and system monitoring. Tests include running standard truck models over State bridges to ensure accuracy and consistency in ratings.

8.1.4.3 Missouri

The presenter from the Missouri Department of Transportation (MoDOT) discussed MoDOT's plan to update load ratings, implement a new load posting policy, and manage consultant funding.

In March 2019, MoDOT started to revamp its load rating and posting policy. Studies conducted between 2019 and 2020 led to creating a new load rating section in MoDOT's Engineering Policy Guide (EPG 753.15), implemented in Summer 2022.

Legal load models for normal, commercial zone, and emergency vehicle loads are specified. The policy eliminates speed restrictions, using only gross weight and lane restrictions. Load postings are determined using the Load Factor Method, with posting levels calculated at 86% of the operating rating for most vehicles.

MoDOT's plan covers 10,387 State and 14,154 local bridges, and it includes nine activities:

1. Develop tracking database: Completed in 2023 to organize and track progress.
2. Solicit consultants: Selected 24 consultants for routine and large or unusual structures, completed in Summer 2023.
3. Load rating of higher priority State structures: 1,244 structures targeted, with 878 sent to consultants.
4. Load rating of lower priority State structures: 5,642 structures, with 623 sent to consultants.
5. Load rating of large or unusual State structures: 279 structures, with 52 sent to consultants.
6. Load rating of State system culverts: 3,176 structures to be updated by MoDOT resources.
7. Data collection for locally owned structures: Ongoing, with 50% of structures reviewed and 4,000 datasheets completed.
8. Load rating analysis for locally owned structures: MoDOT typically handles 300 per year, with additional consultant support.
9. Update load rating policy: Continuous updates to accommodate changes in legal weights and commercial zone boundaries.

Funding is sourced from routine and large/unusual STIP allocations. Additional local program funding includes withholding from BRO allocations.

MoDOT is ahead of schedule for large and unusual structures and local system datasheet collection. The biggest challenge is reviewing and processing consultant submittals.

8.1.5 Topic 5 – Research, technology and others

8.1.5.1 AASHTO Updates

The AASHTO Technical Committee on Safety and Evaluation presented an update on the Committee on Bridges and Structures (COBS) activities. The presentation outlined the roles, strategic plans, and ongoing research initiatives of the AASHTO COBS focused on safety and evaluation.

The Technical Committee was previously known as "T18 - Bridge Management, Evaluation, and Rehabilitation". The strategic plan aims to improve load rating approaches, streamline processes for managing overweight and oversize vehicle permits, and update the Manual for Bridge Evaluation (MBE) to meet evolving needs. The committee aims to enhance accuracy through better integration and coordination of software and to provide permitting guidance to ensure consistency in permitting across States. Also, the committee aims to improve techniques to mitigate the need for load posting through refined analysis.

Existing related NCHRP research studies include:

- NCHRP 15-54: Modifications to AASHTO Culvert Load Rating Specifications.
- NCHRP 12-110: Load Rating Provisions for Implements of Husbandry.
- NCHRP 20-05 (Topic 44-15)/Synthesis 453: State Bridge Load Posting Processes and Practices.
- NCHRP 20-68A, Scan 12-01: Advances in State DOT Superload Permit Processes and Practices.
- NCHRP 20-07/Task 410: Load Rating for FAST Act Emergency Vehicles EV-2 and EV-3.

Upcoming and ongoing related NCHRP research studies include:

- NCHRP 12-115: Guidelines for risk-based inspection and strength evaluation of suspension bridge main cable systems.
- NCHRP 12-123: Proposed guideline for load rating of segmental bridges.
- NCHRP 12-127: Load rating and posting of long-span bridges.

Relevant manuals and publications related to this committee include:

- Primary Manuals: Manual for Bridge Evaluation (MBE), Culvert and Storm Drain System Inspection Guide, and others focused on specific bridge types and inspection methods.
- Collaborative Publications: NBIS, NTIS, Bridge Inspector's Reference Manual, and more.
- Joint Publications: Specifications and guides for structural supports, internal redundancy, and built-up steel members.

The presentation emphasized the committee's focus on enhancing bridge safety and evaluation through strategic planning, ongoing research, and comprehensive documentation and guidelines.

This approach ensures that bridge management practices evolve to meet modern challenges and improve infrastructure resilience.

8.1.5.2 FHWA Updates

FHWA provided updates on policies, procedures, and significant incidents affecting bridge load rating and safety practices.

The FHWA Office of Bridges and Structures includes teams focused on structural engineering, hydraulics, geotechnical engineering, preservation, management, and safety inspection.

The new NBIS regulation became effective on June 6, 2022, incorporating the Specifications for the National Bridge Inventory (SNBI) and superseding the 1995 guide. Full implementation is expected by 2028.

FHWA also discussed the Fern Hollow Bridge collapse. The bridge in Pittsburgh collapsed on January 28, 2022, due to corrosion and section loss. The NTSB issued interim recommendations to develop a risk-based, data-driven process for identifying and prioritizing follow-up actions for bridges with uncoated weathering steel components. A final report in February 2024 cited poor maintenance, inspection quality, and incorrect load ratings as contributing factors. To document deterioration, the MBE (4.3.5.21 and 4.3.5.6.12, 3rd Edition) prescribes cleaning and remaining section measurement protocols to accurately assess structural steel components affected by corrosion.

FHWA conducts structural engineering research in construction, loads and evaluation, non-destructive evaluation, safety inspection, seismic and multi-hazard impacts, and more. Notable publications include guides on concrete bridge shear load rating, tunnel structure load rating, and truck platooning impacts on bridges.

The FHWA's 2022 National Bridge Inspection Standards (NBIS) updates emphasize the importance of accurate load rating and load posting. Key points include:

- Load ratings must be completed within three months of the initial inspection and when changes warrant re-rating. (23 CFR 650.313(k)(2))
- Procedures must be developed for completing new and updated load ratings, including analysis for routine, special permit loads, and all legal vehicles. (23 CFR 650.313(k)(2)-(3))
  Load posting should occur within 30 days of identifying the need based on load rating results. ((23 CFR 650.313(l)(2))

Several ongoing and planned research projects were highlighted.

- The impact of truck platooning on bridges, focusing on both structural safety and serviceability.

- A risk-based methodology for evaluating bridge-sized culverts, including uncertainty quantification and reliability analysis.
- The development of a Mobile Bridge Testing Lab (MBTL) for rapid deployment in diagnostic and proof load testing of bridges, aimed at improving load rating accuracy and bridge safety.

FHWA provides extensive training and resources to support bridge load rating, including:

- NHI training courses on load and resistance factor rating of highway bridges.
- Webinars, seminars, workshops, and peer exchanges.

Updates were provided regarding the FHWA NBIP metrics. Overall metric compliance has increased from 70% to 94% from 2011 to 2023. Metric 13 (load rating) has improved by 35% and Metric 14 (load posting) has improved by 15% since 2011.

8.1.5.3 WFL/CFL

The presenters from the Western Federal Lands (WFL) and Central Federal Lands (CFL) within the Federal Highway Administration presented the load rating procedures and policies used to load rate bridges owned by Federal agencies. The presentation provided comprehensive details on WFL's methodologies and software for load rating, QA/QC processes, posting criteria, and permitting procedures, ensuring safe and efficient management of bridge load capacities across federal lands.

WFL manages load ratings and overload evaluations for 465 NBI bridges and 40 NBI culverts across 11 States, including Arizona, California, and Alaska.

Utilized software includes BRASS Suite, CSiBridge, CANDE, SAP2000, and NCSPA spreadsheets with State modifications.

Load ratings are documented with detailed assumption notes and summaries of rating factors. A validation of load ratings is provided in each inspection report.

Load ratings conform to the AASHTO MBE 3rd Edition and AASHTO LRFD Design Specifications 9th Edition. Rating methods used include LRFR, assigned ratings, and engineering judgment.

A thorough QA/QC process involves line-by-line reviews and a checklist for each stage of the load rating report.

Posting recommendations are based on MBE guidelines. The owner agency is responsible for installing and maintaining posting signs.

WFL also conducts permit evaluations, processing 10-20 requests annually, with evaluations for multiple vehicle crossings. Permits include Continuous Trip Permits (CTP) and Special Trip Permits (STP), involving additional refinement and engineering judgment.

Load ratings for in-house designs use BRASS-Girder, BRASS-Culvert, LEAP Concrete, or Excel.

For load rating existing structures, summaries include ratings for various truck types, with specific inventory and operating traffic metrics. Deck ratings for timber decks and LFR for existing structures are included.

Case studies are provided for load rating of Air Force OMAD structures, focusing on the TERP B vehicle.

8.2 **Presentation summaries from Pittsburgh, PA peer exchange**

8.2.1 Topic 1 – State truck size and weight limits and State legal load models

8.2.1.1 Florida

The presenter from the Florida Department of Transportation (FDOT) provided a presentation on Florida’s load rating practices. The presentation provided an overview of the history, practices, and methodologies associated with bridge load rating in Florida, beginning with a historical timeline, highlighting significant events such as the corrosion issue on US19 over the Anclote River (1968) and various structural concerns and inspections mandated by the Federal Highway Act of 1968. The presentation detailed Florida's inventory of bridge materials, listing categories like prestressed concrete, reinforced concrete, steel, and wood or timber.

The protocols for posting and permits were presented, outlining legal truck weight limits according to Florida statutes and AASHTO. A comparison between FDOT and AASHTO standards was presented, emphasizing the variations in load and span length calculations.

Local practices and methodologies for bridge load rating were covered, noting the transition from Load Factor Rating (LFR) to Load and Resistance Factor Rating (LRFR) over the years. The evolution of software used for load rating was discussed, from the Bridge Analysis and Rating System (BARS) before 2005 to Virtis after 2006, and the open policy allowing various software applications, which encourages competition and cost-effectiveness.

The benefits of open software policies and specifying particular software, such as AASHTOWare BrR, were highlighted. BrR's consistency, capability in prestressed concrete shear calculations, and transparency about bugs were noted as significant advantages.

The completion of the Florida Turnpike's load rating by private consultants was addressed, citing both best-case scenarios, such as well-organized management and advanced tools, and worst-case anecdotes reflecting less cost efficiencies.

Segmental bridges were discussed, detailing historical performance, current practices, and future solutions like Carbon Fiber-Reinforced Plastic (CFRP) and High Strength Stainless Steel (HSSS).

8.2.1.2 Alabama

The Alabama Department of Transportation (ALDOT) presented various aspects of Alabama's laws and procedures regarding truck weights and bridge postings. The presentation provided a comprehensive overview of Alabama's regulatory framework for truck weights and dimensions, exemption policies, procedures for posting vehicles, bridge analysis, and the State's infrastructure in terms of bridges and overload permitting.

Alabama's State laws regarding trucks include:

- Weight Limits: Single Axle (20 kips), Tandem Axle (34 kips), Triaxle (42 kips), Overall Gross Weight (80 kips) following federal bridge formula.
- Dimensional Allowances: Width (8 ft. 6 in.), Height (13 ft. 6 in.), Length (40 ft. for trucks, 57 ft. with semitrailer).
- Annual Permits: Allowances for trucks exceeding standard weights and dimensions, with specific routing for weights over 100 kips.
- Single Trip Permits: Similar allowances as annual permits, with mandatory routing by ALDOT.

Some truck exemptions include an enforcement tolerance of 10% over legal limits and specific exemptions for various truck types (e.g., dump trucks, concrete mixers, agricultural vehicles) with adjusted weight limits.

Alabama's load models used for bridge rating and posting include H-Truck, Tandem Axle, Type 3, SU4, Concrete Truck, Type 3S2, 18-Wheeler, 6-axle, School Bus, EV2, and EV3. The presentation detailed the gross weights and axle configurations of those models. The number of posted and rated bridges by vehicle type was provided.

ALDOT use AASHTOWare BrR for most load ratings (other than culverts and complex bridges) and have it linked to their permit system. They use BRASS Culvert for load rating of culverts. Consultants typically help conduct a more detailed analysis for complex structures; consultants provide a spreadsheet with influence lines to help with permit analysis on these complex structures.

The Line Girder with Distribution Factor analysis method is generally used for evaluating bridges. The process for analyzing bridges for State legal loads was described.

Alabama has 9,628 State bridges and 10,203 local and other bridges. Most bridges fall into one of four categories: Stringer or Girder, Channel Beam, T-beam, and Slab.

Trends in the issuance of overload permits from 2009 to 2024 show fluctuations in the number of permits and the average maximum weights.

8.2.1.3 North Carolina

The North Carolina Department of Transportation (NCDOT) presented North Carolina's truck and weight limits and legal load models, including an overview of NCDOT's load rating policies.

NC truck weight limits include a gross vehicle weight limit of 80,000 lbs., a single axle weight limit of 20,000 lbs. and 38,000 lbs. for a tandem axle with slight allowances for specific conditions. The gross vehicle weight is also limited by the weight table found in State statute.

NCDOT developed 16 legal load configurations based on the current legislature. Legal loads can reach a gross vehicle weight of 90,000 lbs. for non-interstate traffic for certain exemptions. Axle weight limits vary based on the type of goods transported, such as agricultural products or bulk materials. For example, single axles may carry up to 22,000 lbs. for general goods and up to 26,000 lbs. for vehicles with five or more axles.

Special allowances exist for transporting specific commodities, including:

- Agricultural Products: Up to 26,000 lbs. for single axles and 44,000 lbs. for tandem axles.
- Aggregates: Gross vehicle weight limit of 69,850 lbs. with specific limits for tri-axle groups.
- Unhardened Ready-Mixed Concrete: Specific limits for different axle configurations, with gross vehicle weights up to 72,600 lbs. for four-axle vehicles.

The FHWA memo on Load Rating of Specialized Hauling Vehicles, November 15, 2013 indicates that Specialized Hauling Vehicles (SHVs) exert higher force effects than standard AASHTO routine commercial traffic legal loads. North Carolina has met conditions where its State legal loads envelope AASHTO SHVs; thus, statewide bridge load rating for these AASHTO SHVs is waived.

Load ratings are conducted for new, widened, and reconstructed structures. Re-ratings for existing bridges are necessary for structures in poor or fair condition, those with load postings of 18 tons or less, critical findings, structural configuration changes, or temporary repairs. Load ratings are performed primarily using in-house software that was developed and is maintained by NCDOT.

Structural changes that might prompt a load rating include additions of primary members, changes to member spacing, preservation work, or new permanent loads.

8.2.2 Topic 2 – Consideration of deterioration in bridge load rating analysis

8.2.2.1 Kentucky

The presenter provided an overview of the Kentucky Transportation Cabinet's (KYTC) approach to managing and rating its bridge inventory considering deterioration. The presentation emphasized the detailed procedures KYTC follows to ensure the safety and functionality of bridges while accounting for deterioration, with regular updates and transitions to improved software systems for better management.

Kentucky has approximately 14,500 structures, with around 9,000 State-owned and 5,500 managed by local public agencies (counties and cities). About 4,500 structures are currently posted or closed due to condition issues.

Kentucky has transitioned from using Bentley LARS to AASHTOWare BrR for State bridge load ratings and is in the process of doing the same for local bridges. The State is also transitioning from Bentley's Superload to Promiles for permitting.

Kentucky rates various types of vehicles, in addition to AASHTO SHVs and the FAST Act EVs, as defined in State statute.

When inspectors notify of changes in dead load or deterioration, load raters update the ratings accordingly. For prestressed beams with exposed or broken strands, and other beams with significant section loss, specific deterioration details are recorded and factored into load ratings. Truss and steel beam deterioration are documented with precise measurements and descriptions of section loss.

If deterioration is severe and not quantifiable, structures are posted based on engineering judgment and condition ratings. Criteria for posting include:

- Condition rating of 4 (Poor) may result in posting at half the roadway weight limit.
- Condition rating of 3 (Serious) results in a 3-ton posting.
- Condition rating of 2 (Critical) requires close monitoring or closure.
- Condition ratings below 2 necessitate closure.

Load ratings are updated in the software, and structures below legal load limits are posted. For structures originally designed using ASD, allowable stress is reduced to 69% of yield stress to determine the safe posting loads.

8.2.2.2 Illinois

The Illinois Department of Transportation (IDOT) made a presentation titled Consideration of Deterioration in Load Rating Analysis. The presenter detailed the processes and methodologies used by IDOT to account for deterioration in bridge load rating analyses. The presentation outlined

IDOT's systematic approach for inspection, load rating, and actions taken based on deterioration, ensuring the safety and functionality of bridges through meticulous analysis, temporary measures, and permanent repairs.

Load Rating Inspection (LRI) is initiated under specific conditions, such as when a superstructure, substructure, or culvert condition rating drops to '4' (Poor) or less or when a deck rating drops to '3' (Serious) or less. Inspections are also requested by districts for specific deterioration or upcoming rehabilitation or when events like bridge hits or fires damage structures. Major bridges, typically large or complex structures over major waterways, undergo routine inspections that are as detailed as LRI. Inspection reports include summaries of findings, condition ratings, photos, and detailed documentation of specific deterioration.

Bridge office load raters or consultants review Load Rating Reports. Depending on the member type, a section loss greater than 10% prompts detailed load rating analysis. Steel cracks, concrete shear cracks, and compromised prestressing are closely analyzed. Major bridge reports are reviewed every inspection cycle, and load ratings are updated per the same criteria.

Deterioration is accounted for using various methods based on component type and material, with detailed "Member Summary" documents for complex structures and Structure Load Rating Summary (SLRS) produced with formal rating results, load restrictions, and special inspections.

When load rating indicates a necessity of weight restriction, actions are determined by the district. These include load restrictions, temporary measures, or permanent repairs.

Temporary measures, such as lane restrictions, shoring, and wood cribbing, are implemented to quickly address critical issues, often paired with weight restrictions and regular inspections.

Permanent repairs, like slip-lining box culverts, plating steel components, cleaning and painting steel, partial beam replacements, and superstructure replacements, are more robust solutions to extend the structure's life but are costlier and more time-consuming. If repairs are not performed, subsequent LRIs are scheduled based on the condition rating and time intervals.

Various methods and tools are used to model the deterioration of steel structures, including AASHTOWare BrR for section loss in beams, truss members, gusset plates, cables, arches, and complex components. In-house spreadsheets support these analyses. Minor fatigue cracks may not be considered in load ratings if they are short, while larger cracks are accounted for by reducing the section carrying load.

For concrete structures, beams, slabs, pier caps, and columns are modeled with adjustments for rebar size and spacing to reflect section loss. Shear cracks and bearing losses are specifically analyzed using AASHTOWare BrR and in-house spreadsheets.

Conservative policies for deteriorated prestressed strands involve removing or debonding strands due to issues like spalling or cracking, directly inputted in AASHTOWare BrR models.

Ineffective keyways in deteriorated precast prestressed concrete (PPC) deck beams and deformation due to bridge hits are addressed through adjusted load distribution factors and manual section property calculations.

8.2.2.3 New York

A presentation on New York's Approach for Load Rating Corroded Beam Ends was given by the New York State Department of Transportation (NYSDOT). The presenter outlined the methodology for assessing and load rating corroded beam ends, focusing on typical failure modes and inspection procedures.

Some typical failure modes include web buckling, web crippling, web yielding, and web shear.

Web Buckling occurs when a beam's web bends sideways, forming inflection points near the top and bottom flanges. It is uncommon for localized section loss at beam ends and is more likely if section loss is uniform over the web's depth. NYSDOT does not typically perform web buckling checks for localized section loss at corroded beam ends unless the web is unstiffened.

Web crippling occurs when high compressive stress at the beam end reaction folds the web above the fillet between the web and bottom flange. It requires section loss extending several inches above the bottom flange. Bearing stiffeners or connection plates can prevent crippling directly over the support length.

Web yielding occurs when excessive beam end reaction causes stress at the junction of the flange and web and is common at corroded beam ends. It occurs over the support length when stress is transferred from a wide bottom flange to a narrow web.

Web shear occurs in cases of yielding or buckling along a vertical line of worst section loss beyond the support face. Shear failure associated with section loss is unlikely beyond one web depth distance from the face of support and is not a common failure mode due to corrosion.

Detailed inspection (Special Emphasis) is to be performed if the loss of section (LOS) is greater than 25% in critical areas.

Level 1 Load Rating is needed if:

- Unstiffened Web: Weighted Average LOS ≥ 50% or Web Slenderness Ratio (D/tw.avg) ≥ 75 (Grade 50)/90 (Grade 36).
- Stiffened Web: Weighted Average LOS ≥ 50%.

NYSDOT provides standard Excel worksheets for inspecting and load rating corroded unstiffened beam ends (rolled shape beams), stiffened beam ends (built-up beams), and beam ends with coped flanges (bolted end connections).

8.2.3 Topic 3 – Timely load rating, re-rating, posting and closure

8.2.3.1 Pennsylvania

The presentation "Timely Load Rating, Re-Rating, Posting and Closure" was given by a presenter from the Pennsylvania Department of Transportation (PennDOT).

An initial load rating is performed for each bridge carrying vehicular traffic. State bridges over 8 ft and local bridges over 20 ft must be rated per PennDOT's policy.

Re-ratings are triggered when there are changes in member conditions or loading. Re-rating is completed within 60 days of inspection to ensure timely updates in the Bridge Management System (BMS).

Load ratings are prioritized based on recommendations by inspectors or the condition rating. Bridges with a controlling condition rating of 4 (Poor) or less and load ratings older than 10 years, or condition rating of 5 (Fair) for 15 years with load ratings older than 15 years, are given high priority.

Monthly M1 reports are sent to 11 PennDOT districts, flagging bridges for re-rating and including next inspection dates. Email alerts for bridges needing re-rating are sent weekly to BMS users.

Regarding legal load models, PennDOT conducted parametric studies to verify live load effects of specific rating vehicles (e.g., TK-527, ML-80) encompass AASHTO Special Hauling Vehicles and Emergency Vehicles, negating the need for additional load ratings. PennDOT aims to replace the conservative PennDOT H20 design vehicle with a new CT38 vehicle, while ensuring the live load configuration of the CT38 conforms to legal loads allowed by the State vehicle code.

Bridge postings are based on the operating rating (OR) and Safety Load Carrying Capacity (SLC), a function of the operating rating and condition rating. Bridges with SLC less than 1.0 necessitate load posting.

Posting approval varies by route type. Interstate bridges require the PA Secretary of Transportation's approval, numbered routes and National Highway System (NHS) bridges require the PennDOT Chief Bridge Engineer's approval, and non-NHS bridges require district executive approval.

Bridges with load ratings below 3 tons are closed. PennDOT has the authority to post or close locally owned bridges if deemed unsafe under Pennsylvania's Act 44 of 1988.

8.2.3.2 Puerto Rico

The Puerto Rico Department of Transportation and Public Works (PRHTA) presented the challenges and strategies related to load rating, re-rating, posting, and closure of bridges in Puerto Rico.

Puerto Rico has 2,480 National Bridge Inventory (NBI) bridges, with 436 in poor condition and 148 classified as critical findings (CF). The cost to replace these bridges is estimated at $6.7 billion, with $396 million needed for repairs.

Load ratings are conducted per the AASHTO Manual for Bridge Evaluation (MBE) for all legal vehicles and routine permit loads. In 2010, PRHTA contracted four consultants to complete 1,500 load ratings over five years. A significant challenge is the absence of bridge drawings, necessitating an inference methodology based on similar structures. Fair or good condition bridges with low or zero load capacity led to 40 bridges undergoing proof load testing. The software transition from BRASS to AASHTOWare involved re-rating 1,000 bridges and updating the posting for 400 bridges.

Puerto Rico's legal loads are approximately 1.7 times that of AASHTO, with a maximum vehicle weight of 110 kips. Routine permits have higher weight limits for tandem and tridem axles.

Load ratings for Emergency Vehicles (EV2 and EV3) and AASHTO SHVs are ongoing, ensuring compliance with the FAST Act and other regulatory requirements such as the NBIS (23 CFR 650.313(k)). PRHTA needs to load rate 950 bridges for EVs due to their higher stress ratios compared to design loads. Parametric studies compare the force effects of SHV and EV loads to PR design loads, guiding posting requirements. Bridges with spans less than 20 ft require evaluation and posting for EVs, while spans greater than 20 ft are generally controlled by SHV 3A.

Bridges are posted according to the MBE or State law when load capacities are exceeded. A project was initiated to post load restrictions on 720 bridges, but Hurricane Maria delayed the process, which was later completed within a year. Challenges include limited in-house resources, vandalism, accidents, and adverse weather conditions.

Due to staff shortages and the lack of route selection software to avoid posted bridges, the permitting process faces challenges. PRHTA assists with load rating evaluations for loads between 75-95 tons, while the permit requester performs load ratings for loads over 95 tons. Enforcement of load restrictions and permits remains an ongoing issue.

8.2.3.3 Massachusetts

The Massachusetts Department of Transportation (MassDOT) presented MassDOT's processes and policies for managing bridge load ratings, postings, and closures.

Massachusetts has about 6,800 bridges, including 5,200 National Bridge Inventory (NBI) bridges and 1,600 Bridge Records Inventory (BRI) bridges. A bridge in Massachusetts is defined as a structure spanning 10 ft or more.

MassDOT aims to have as close to 100% of its bridge inventory modeled in AASHTOWare BrR, currently covering about 65% of the inventory.

Every new structure is to have an initial load rating performed following the initial NBIS inspection to capture unique design assumptions, methods, and relevant codes. The 2022 NBIS and SNBI introduces a more definite window of 3 months (23 CFR 650.313(k)(2)) after initial inspection to the load rating to be completed which will accelerate the process.

Load re-ratings are performed every 10 years or as needed when conditions or loading change. Re-ratings are prompted by the District Inspection Engineer or requested by multiple parties if necessary.

MassDOT primarily uses AASHTOWare BrD for design and AASHTOWare BrR for rating. Other approved software includes BRASS CULVERT, Bridge Link/PGSuper, CSI Bridge, MDX, MIDAS, Robot Structural (Autodesk), and Excel/MathCAD.

Past posting practices relied heavily on engineering judgment by a select group, whereas current practices base postings strictly on load ratings.

MassDOT's policy allows for up to 10% overstress from inventory ratings without posting, but no postings are permitted above operating ratings.

Posting signs must be installed within 30 days from determination, with immediate actions for critical findings.

Closures are considered critical findings that receive immediate review by the State bridge engineer and load rating engineer. A 3-ton rating or less automatically triggers closure. The process is streamlined to ensure timely response and action to safeguard public safety.

The initial inspection and load rating are conducted concurrently for new structures, which more closely aligns with SNBI requirements, with the initial load rating submitted with the first structural submission. For existing structures, re-ratings are justified based on additional load, condition changes, repairs, or traffic pattern alterations. Recommendations and actions are prioritized based on severity, with immediate measures taken if necessary.

MassDOT-owned structures must respond to findings within 5 days, while municipally-owned structures have a 10-day response window. Posting signs are verified within 7 days from the posting deadline to ensure compliance and safety.

8.2.4 Topic 4 – Structural analysis for routine and special permit loads

8.2.4.1 Ohio

The Ohio Department of Transportation (ODOT) presented an overview of ODOT's approach to bridge load rating, legal load limits, and permit load analysis.

Ohio has 26,960 National Bridge Inventory (NBI) bridges and 17,153 non-NBI bridges. ODOT manages 10,184 NBI bridges and 4,016 non-NBI bridges. Approximately 94% of NBI bridges can be modeled in AASHTOWare Bridge Rating (BrR), with plans to rate and update about 5,000 bridge ratings during 2024-25.

The maximum axle load for interstate systems is 20,000 lbs. for single axles and 34,000 lbs. for tandem axles. Non-interstate systems have similar limits but allow slight variations based on axle spacing. The allowable gross vehicle weight (GVW) is 80,000 lbs. on interstate and non-interstate systems.

Various Ohio Revised Code (ORC) sections detail weight provisions and exemptions for specific vehicle types, including farm, log, and coal trucks and vehicles fueled by natural gas or electric batteries. Vehicles such as fire engines have specific exemptions allowing higher weights under certain conditions.

Bridges are posted for reduced loads if the rating factor of legal loads is below 1.08. Emergency vehicles (EV2 and EV3) are considered for posting if their rating factor is below 1.00. The minimum load posting value is 3 tons; bridges unable to carry this minimum are closed. Specific weight allowances are given to vehicles hauling certain commodities, with permissible excesses up to 7.5%.

Ohio's Hauling Permitting System (OHPS), developed by ProMiles, processes oversize (OS) and overweight (OW) permits. Permits are generally processed within two days, with high efficiency in 2023 and 2024. The system ensures safe and efficient route planning based on clearance and bridge analysis.

Special hauling permits are issued for significant loads, such as those bringing equipment to the Intel chip manufacturing facility, which were up to 900,000 lbs. and 270 ft in length.

A study of non-standard gauge (NSG) axles was conducted to understand the impact of axle gauge variations on load distribution. A correction factor matrix was developed based on the worst-case scenarios among studied configurations. Correction factors help refine live load distribution analysis for NSG axles, ensuring accurate load ratings.

Load rating adjustments for deterioration and structural issues are addressed through conservative assumptions, precise calculations of remaining capacity, and shear capacity evaluation. Regular inspections and advanced analysis methods, such as refined modeling, are used to assess and mitigate deterioration impacts.

8.2.4.2 Virginia

The Virginia Department of Transportation (VDOT) presented on the Live Load Demand Checks for Permit Vehicles and described the practices and challenges associated with managing oversize and overweight (OS/OW) vehicle permits, focusing on load demand checks for permit vehicles.

VDOT processes approximately 100,000 OS/OW permit applications annually, with over 90% being self-issued.

Self-processing can be completed for permits meeting preset criteria, allowing quick issuance without extensive analysis.

For permits not meeting preset criteria, an extensive review involving a detailed bridge review to assess load ratings based on vehicle configuration and weight distribution is performed.

Managing a large roadway and bridge network with limited resources can be challenging. Establishing load ratings through refined analysis is time-consuming and resource-intensive.

Developing notional models based on traffic characteristics to envelope many permit vehicles and optimizing the permit analysis process to enhance efficiency and simplify procedures are being explored.

A study comparing created configurations with common load models (HL-93 for LRFR, HS-20 for LFR & ASR) indicated that bridges designed with an RF of 1 for inventory level rating of HL-93 may be inadequate for certain escorted permits with a load factor of 1.1.

Load factor, occupancy (single or multiple vehicle loading), and dynamic amplification affect load demand checks. Investigations into whether the dynamic load allowance is independent of vehicle configurations were inconclusive, showing variability based on specific conditions.

AASHTO LRFD Bridge Design Specifications and NCHRP Report 368 highlight conservative approaches in existing standards for dynamic amplification of heavier trucks, number of axles, and number of vehicles present.

8.2.4.3 South Carolina

The South Carolina Department of Transportation (SCDOT) presented SCDOT's process for analyzing and issuing permits for oversize and overweight vehicles.

The Oversize/Overweight (OSOW) Permit Office issues permits and recommends routes based on vehicle size and weight criteria. The Inspections, Load Ratings, and Compliance Office reviews all single trip and superload permits to ensure bridge safety.

Three types of permits can be issued.

1. Standard Multi-trip Permit: For standard gauge width vehicles up to 100,000 lbs. with legal configurations.
2. Standard Single Trip Permit: For vehicles with a gross vehicle weight (GVW) between 100,000 and 180,000 lbs. or non-legal configurations.
3. Non-Standard Permit: For vehicles with non-standard gauge widths.

To analyze overweight permits, a standard permit vehicle with a similar configuration and GVW is identified. The maximum moment and shears for the actual permit vehicle are calculated. An equivalent standard permit rating factor (RF) is computed by comparing the actual permit vehicle's moments/shears to those of the standard permit vehicle. A pass is achieved if the equivalent RF is greater than 1.0.

The current iHaul Permit Routing System, developed by Hexagon Geospatial Division, uses NBI data for automated routing but is limited to multi-trip (routine) permits and requires a manual load rating process.

There are plans to upgrade to Safehaul, interfacing with AASHTOWare BrR Load Rating Tool for faster, high-speed load ratings using precomputed data. This tool will cover approximately 95% of South Carolina's bridge inventory. The remaining 5% of the bridge inventory will be evaluated using a bridge formula weight analysis methodology, comparing a Truck Factor (TF) to a Bridge Factor (BF). A BF/TF ratio of 1.0 or greater is considered passing.

The current system is continuously evolving. The goal is to improve efficiency and accuracy in the permitting process while ensuring the safety of the bridge infrastructure.

8.2.5 Topic 5 – Research, technology and others

8.2.5.1 Indiana

The presentation "Research & Technology in Indiana" outlined the Indiana Department of Transportation's (INDOT) approach to bridge load rating, technology integration, and research initiatives with an emphasis on utilizing research and technology to support INDOT's needs in maintaining and improving bridge infrastructure, ensuring safety and efficiency in load rating and permitting processes.

Indiana has over 18,000 bridges, with INDOT owning more than 5,700. The 2023 budget included a $3.5 billion capital program for major projects like the I-69 Finish Line, North Split, and Sherman Minton Bridge.

Load rating evaluations are requested during the final stages of bridge design and after construction completion, deterioration, or collisions.

INDOT uses AASHTOWare BrR (version 7.2) with a preference for LRFR (Load and Resistance Factor Rating) methodology. Load ratings are updated regularly, and models are precomputed, with data integrated into the Oversize Overweight Permitting System (OSOWPS).

INDOT handles approximately 700 load rating requests for overweight permits annually, with 85% using LRFR methodology. Around 400,000 oversize/overweight (OSOW) vehicles are permitted to travel on the State system each year, managed in partnership with the Indiana Department of Revenue and Indiana State Police.

Permits for vehicles over 80,000 lbs. are evaluated for routing and restrictions, with a detailed manual review for vehicles over 200,000 lbs.

INDOT has developed several applications to support load rating, asset inventory inspection, optimization, permitting, and road condition monitoring. These applications ensure real-time data integration for permit reviews.

INDOT has pursued many research initiatives.

Fiber Reinforced Polymer Systems Research (SPR 4122) focuses on repairing and strengthening bridges using FRP systems, highlighting successful implementations and design considerations.

Corroded Steel Beam Bridges Research (SPR 4527 & 4635) examines the shear and bearing capacity of corroded steel beams, and proposes new repair strategies.

Load Rating Methodology Research (SPR 4429) investigates differences between LFR and LRFR methodologies, recommending modifications to resolve inconsistencies.

Live Load Distribution Factors Research (SPR 4444) explores improved distribution factors for load rating older concrete bridges, proposing modifications based on 3D finite element analysis.

Non-Destructive Testing (NDT) Research (SPR 4445) evaluates NDT methods for network-level and project-level bridge inspections, recommending aerial infrared thermography for initial assessments.

Several future research initiatives are planned.

SNBI Data Collection: INDOT plans to integrate Building Information Modeling (BIM) for bridge modeling and utilize AI to extract and validate data from bridge plans (SPR 4622 & 4927).

AI and Machine Learning: INDOT plans to develop a virtual validator to cross-validate information from various documents and models, enhancing data accuracy and reliability.

8.2.5.2 Minnesota

The Minnesota Department of Transportation (MnDOT) gave a presentation for "MN Prestressed Concrete Beam Shear Load Rating" which described the shear load rating process for prestressed concrete beam (PCB) bridges with details for future improvements. The presentation highlighted MnDOT's structured approach to maintaining the safety and integrity of its bridge infrastructure through rigorous inspection, evaluation, and continuous improvement in load rating processes.

The 12th edition of the AASHTO Standard Specifications for Highway Bridges in 1983 revised shear provisions for prestressed concrete beams, increasing minimum shear reinforcement. Approximately 500 out of 2,000 MnDOT PCB bridges were designed to pre-1983 specifications and do not meet current shear capacity provisions.

Since 2006, MnDOT has included concrete shear cracking elements in its inspection procedures. Research projects have been conducted to understand shear capacity discrepancies in PCB bridges.

The latest LRFR method is applied to re-evaluate shear load ratings. Fewer than 30 bridges fail to meet current AASHTO LRFR shear load ratings. These bridges are categorized into three groups:

- Group 1: Bridges with fewer overweight permit requests will have restrictions applied.
- Group 2: Bridges near meeting shear capacity threshold will undergo field concrete strength testing.
- Group 3: Bridges needing beam strengthening with methods such as FRP, titanium bars, or encased beam ends.

MnDOT uses the MN SUPERLOAD system, implemented in 2022, which operates in a Microsoft Azure Cloud environment. This system integrates bridge data from the Structure Information Management System (SIMS) and directly imports AASHTOWare BrR files using API for structural analysis.

MnDOT plans to update BrR files, import them into the MN SUPERLOAD for structural analysis, and perform quarterly and yearly updates.

Future enhancements include applying overweight permit load restrictions for specific roadways and adopting influence lines and surfaces for unsupported bridge types in the BrR software.

8.2.5.3 AASHTO and FHWA Updates

The AASHTO Technical Committee on Safety and Evaluation provided an overview of the AASHTO Committee on Bridges and Structures (COBS) activities, processes, and current initiatives related to bridge management, load rating, and structural evaluation.

The AASHTO ballot process was covered including how new ballot items are introduced based on research projects, industry input, or changes to existing documents. These items undergo multiple review stages for consistency, clarity, and accuracy before being finalized.

All AASHTO members review the draft ballot items, provide feedback, and participate in voting during the annual meeting. The process ensures that the changes are well-vetted and agreed upon by all States.

AASHTO's Safety and Evaluation Technical Committee focuses on improving load rating methodologies, managing overweight and oversize vehicle permits, and updating the Manual for Bridge Evaluation (MBE) to meet modern needs. This includes integrating software tools, refining analysis techniques, and enhancing consistency in permitting across States.

The committee is working on improving the link between legislated loads and actual loads through better data integration, especially with Weigh-in-Motion (WIM) systems. There is also a focus on enhancing inspectability, constructability, and the ability to accurately load rate structures to minimize unnecessary postings.

The presentation highlighted a number of NCHRP projects that have been adopted or are in progress and the publications that are developed and updated through AASHTO. The reader is referred to Section 8.1.5.1 for a listing of projects and publications.

The FHWA Office of Bridges and Structures provided an FHWA update similar to the update provided in Salt Lake City. The reader is referred back to Section 8.1.5.2 for a summary.

8.3 **Small Group Discussions**

Following the presentations for Topics 1, 2, 3, and 4, a time for small group discussions was set aside. A series of questions was provided to each group to prompt the exchange of practices, ideas, and policies. The questions are provided in Appendix B.

SUMMARY AND RECOMMENDATIONS

9 SUMMARY

9.1 State truck size and weight limits, and State legal load models

Most States utilize AASHTO design vehicles and legal load models as outlined in the AASHTO MBE for bridge load ratings. However, many States also adopt State-specific legal load models to address local truck size and weight regulations.

It is not uncommon State statutes provide truck weight exemptions for hauling certain commodities such as forest and farm products or specific vehicle types such as implements of husbandry, road machinery, fire apparatus and heavy-duty towing. Those vehicles or loads may not have defined axle configuration or weight limits, which impose challenges for appropriate bridge load rating and posting.

Legislative changes have resulted in increased allowable loads, necessitating re-evaluation and posting of bridges.

While WIM systems are increasingly used to collect truck load data, States face challenges in analyzing and utilizing truck weights in bridge design and rating.

The MUTCD provides the provisions for different types of weight limits signs such as gross vehicle weight limit R12-1 sign and the weight limit symbolic (R12-5) signs. Some States use word-only signs to limit single unit weight and combination vehicle weight. Inconsistent use of load posting signs across States can confuse truck drivers, particularly when crossing State lines.

State DOTs typically do not have difficulties to timely load post State-owned bridges, but posting of locally owned bridges are sometimes challenging.

9.2 Consideration of deterioration in load rating analysis

There are various State practices, challenges, and methodologies related to bridge load rating, particularly in the context of handling deterioration.

States incorporate deterioration into load rating calculations as required by the AASHTO Manual for Bridge Evaluation (Article 6.1.2, 3rd Edition, 2018). The process typically involves reducing section resistance based on inspection data, particularly where corrosion, decay, or other forms of deterioration are observed.

States vary in their approaches to modeling deterioration. Common methods include reducing the cross-sectional area of deteriorated elements or adjusting material properties based on field measurements. For example, steel beam section losses and concrete degradation are modeled based on actual measurements of remaining section, and condition factors are sometimes applied to adjust load ratings accordingly.

In certain situations, States perform more detailed, refined analyses using advanced techniques like two-dimensional (2D) or three-dimensional (3D) finite element models (FEMs). These methods are often employed when considering deterioration in regular load ratings results in a low rating or when a more precise understanding of the structure's capacity is needed.

While tools like AASHTOWare BrR are widely used, they may not adequately address all deterioration scenarios, particularly for unique bridge types, materials or types of deterioration.

Accurate and detailed inspections are crucial for effective load rating, especially when dealing with deteriorated structures. States emphasize the importance of thorough documentation and regular updates to load rating models.

Many States prioritize preventive maintenance and immediate repairs to manage deterioration, particularly on critical routes.

Many States collaborate with consultants and use standardized procedures to ensure consistent load rating practices. However, there is a need for further research to provide clear guidance for accommodating different types of structural deterioration in analysis.

9.3 **Timely load rating, re-rating, posting and closure**

States conduct timely bridge load ratings for safety and regulatory compliance.

Re-rating is necessitated by changes in structural components, dead and live loads, traffic volume, and other factors such as damage caused by accidents or natural disasters. The process typically involves adjusting load ratings based on updated loads, section properties, load distribution, and material properties.

Coordination with inspections to meet Federal requirements, such as completing re-ratings within 90 days of significant changes (23 CFR 650.313(k)(2)), is crucial. Challenges include the extra time for consultant contracting, proper documentation, and ensuring all necessary changes are reflected in the bridge management system.

The bridge owner is responsible for timely load postings following the completion of load rating. Typically, postings are completed within 30 days (23 CFR 650.313(l)(2)), with States having specific practices for verification and documentation.

Bridges are to be closed if they cannot carry a minimum gross live load of 3 tons, as per AASHTO and NBIS standards (23 CFR 650.313(m)). Some States have established higher minimum live loads. States have documented criteria for closing bridges, considering factors like bridge condition and load-carrying capacity.

Some States provide explicit instructions for closure timing, ranging from immediate actions to closures within a few days after the decision. Some States have procedures for re-opening of a bridge after repair or strengthening.

9.4 Structural analysis for routine and special permit loads

States issue permits for vehicles or loads exceeding legal weight limits, categorized as routine or special permits. Routine permits typically allow unlimited trips over a set period, while special permits are often for single trips with specific restrictions (e.g., time of day, lane usage).

Many States have adopted automated permit systems, leading to improved accuracy, expedited processing, and better resource allocation. However, processes and procedures for permit issuance vary significantly across States, causing potential confusion for operators, especially those crossing State lines.

States use different methodologies, including Load and Resistance Factor Rating (LRFR), Load Factor Rating (LFR), and Allowable Stress Rating (ASR). Modifications, such as dynamic allowances and live load factors, are applied based on State practices, specific bridge types or permit types.

Some States conduct refined analyses under specific conditions, such as when a bridge has significant deterioration or when managing super-heavy loads. Refined analysis is less common for routine evaluations but crucial for complex or high-impact scenarios. However, analyzing complex structures is technically challenging and time-consuming, which can delay permit processing.

Many States face challenges due to limited personnel and outdated bridge models or software. Outside pressure and the high volume of permit requests can further complicate prompt analysis.

State permit agencies typically only process and issue oversize or overweight permits for using State routes. Since those permit vehicles or loads will ultimately arrive at their final destination that is most likely off State system, coordination with local authorities remains a challenge.

States vary in their use of predefined permit trucks for load ratings and permit review. Some States have developed specific permit load models based on WIM data or historic permit records, while others are working on establishing such models.

9.5 Research, technologies and other topics of interest

States widely use structural analysis software for calculating load ratings, although no single software can handle all bridge types. States often specify preferred software packages for different structures to maintain consistency and efficiency.

Many States have implemented automated systems for permitting, improving the uniformity and effectiveness of processes. However, significant differences still exist among States in terms of processes and procedures.

Technologies such as non-destructive testing, electronic instrumentation, and data acquisition systems are being incorporated to understand bridge behavior better. For example, weigh-in-motion (WIM) systems collect detailed truck load data.

Emerging technologies like the Internet of Things (IoT), wireless sensor networks (WSNs), and Intelligent Transportation Systems (ITS) are enhancing bridge monitoring and data synchronization for load rating analysis. Building Information Modeling (BIM) and the digital twin concept are also gaining traction, providing virtual models of bridges that can be continuously updated with inspection data.

The accuracy and reliability of load ratings, postings, and permits depend heavily on the quality of their execution. Systematic QC and QA procedures are essential.

The National Bridge Inspection Standards (NBIS) mandate that load ratings must be performed by, or under the direct supervision of, a registered professional engineer (23 CFR 650.309(d)) and thoroughly documented (23 CFR 650.313(p)(2)). Independent reviews and QA checks are required to verify the accuracy of load ratings (23 CFR 650.313(p)(1)-(4)), with some States implementing detailed checklists for quality control.

Various National Cooperative Highway Research Program (NCHRP) studies are completed or ongoing to improve the national guidance related to bridge load rating.

States also actively pursue research to refine load rating methodologies, enhance software integration, solve specific challenges that sponsoring States are facing, and improve bridge infrastructure resilience.

10 RECOMMENDATIONS

There is a need for continued research, technology adoption, and standardized practices to address the evolving challenges in bridge load rating. Some recommendations for future efforts include the following:

Complete a review of State-specific permit loads and investigate the feasibility to develop a national model(s) that may help streamline bridge load rating and permitting processes. This could involve developing standardized truck configurations and load models for common vehicle types, allowing more consistency across States. Consider leveraging technology (e.g., WIM and software programs) for improved process efficiency.

Encourage States to collaborate to develop uniform guidance and to apply consistent approach in accounting for deterioration during load rating. This would ensure that all States are using the most accurate methods to model deterioration in structural evaluation. Promote research into advanced modeling techniques, such as finite element analysis (FEA), to account for structural deterioration more accurately.

Encourage States to prioritize upgrading outdated load rating analysis, models and systems. This would help improve the accuracy and efficiency for future load rating update and for analyzing and processing of overweight permits.

Organize peer exchanges, in person or virtual, which includes States and FHWA Division Offices to continue growth in this area.

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APPENDICES

A. PEER EXCHANGE AGENDAS

FHWA LOAD RATING PEER EXCHANGE – SALT LAKE CITY, UT

Wednesday, April 24, 2024		
8:00 – 8:30	**Welcome and Introductions**	
5 min	Welcome – AASHTO and FHWA	AASHTO, FHWA
5 min	Welcome – Host State	UDOT
10 min	Opening Remarks - FHWA	FHWA
10 min	Introductions	All
8:30 – 12:00	**Topic 1 – State Truck Size and Weight Limits and State Legal Load Models**	
5 min	Topic Introduction	ISU
25 min	Oregon: LRFR for Older Bridges	ODOT
25 min	Iowa: Legal Loads and Exemptions	Iowa DOT
25 min	West Virginia: Truck Size and Legal Load Limits	WVDOT
25 min	Extended Q&A/Discussion of Presentations	-
10 min	**Break and Dismissal to Separate Rooms**	-
60 min	Small Group Discussions	-
10 min	**Break and Reconvene as Large Group**	-
25 min	Large Group Reporting and Discussion	-
12:00 – 1:30	**Lunch Break**	
1:30 – 5:00	**Topic 2 – Consideration of Deterioration in Bridge Load Rating Analysis**	
5 min	Topic Introduction	ISU
25 min	Wisconsin: Deterioration and Structural Reviews	WisDOT
25 min	Nebraska: Bearing failure and end bearing deterioration considerations	NDOT
25 min	Wyoming: Load Rating Considerations of High-hit Impacts on Bridges	WYDOT
25 min	Extended Q&A/Discussion of Presentations	-
10 min	**Break and Dismissal to Separate Rooms**	-
60 min	Small Group Discussions	-
10 min	**Break and Reconvene as Large Group**	-
25 min	Large Group Reporting and Discussion	-
5:00 – 5:30	**Day 1 Recap and Dismissal**	-

FHWA LOAD RATING PEER EXCHANGE – SALT LAKE CITY, UT

Thursday, April 25, 2024		
8:00 – 11:15	**Topic 3 – Timely Load Rating, Re-rating, Posting and Closure**	
5 min	Topic Introduction	ISU
25 min	Montana: Timely load rating, re-rating, posting and closure	MTD
25 min	Wisconsin: Load Posting Refinement Strategies	WisDOT
25 min	Arizona: Load Rating, Refined Load Rating and Posting Requirement	ADOT
20 min	Extended Q&A/Discussion of Presentations	-
10 min	**Break and Dismissal to Separate Rooms**	-
55 min	Small Group Discussions	-
10 min	**Break and Reconvene as Large Group**	-
20 min	Large Group Reporting and Discussion	-
11:15 – 4:00	**Topic 4 – Structural Analysis for Routine and Special Permit Loads**	
5 min	Topic Introduction	ISU
25 min	Utah: Routine and special permit loads	UDOT
12:00 – 1:30	**Lunch Break**	
25 min	Idaho: Quality Management of Load Ratings, Posting, and Permitting	ITD
25 min	Missouri: Overview of MoDOT's Load Rating Update Project	MoDOT
20 min	Extended Q&A/Discussion of Presentations	-
10 min	**Break and Dismissal to Separate Rooms**	-
55 min	Small Group Discussions	-
10 min	**Break and Reconvene as Large Group**	-
20 min	Large Group Reporting and Discussion	-
4:00 – 5:00	**Topic 5 – Research, Technology and Others**	
5 min	Topic Introduction	ISU
15 min	AASHTO COBS S&E Update	AASHTO
20 min	FHWA Update	FHWA
20 min	Federal Agency Programs	FHWA
5:00 – 5:30	**Day 2 Recap and Closing Remarks**	-

FHWA LOAD RATING PEER EXCHANGE – PITTSBURGH, PA

Wednesday, May 8, 2024		
8:00 – 8:30	**Welcome and Introductions**	
5 min	Welcome – AASHTO and FHWA	AASHTO, FHWA
5 min	Welcome – Host State	PennDOT
5 min	Opening Remarks - FHWA	FHWA
15 min	Introductions	All
8:30 – 12:00	**Topic 1 – State Truck Size and Weight Limits and State Legal Load Models**	
-	Topic Introduction	ISU
30 min	Florida: Truck size and weight limits and State legal load models	FDOT
30 min	Alabama: Truck size and weight limits and State legal load models	ALDOT
30 min	North Carolina: State legal load models and their background	NCDOT
10 min	**Break and Dismissal to Separate Rooms**	-
50 min	Small Group Discussions	-
10 min	**Break and Reconvene as Large Group**	-
20 min	Large Group Reporting and Discussion	-
30 min	FHWA Update – Part 1	FHWA
12:00 – 1:30	**Lunch Break**	
1:30 – 4:40	**Topic 2 – Consideration of Deterioration in Bridge Load Rating Analysis**	
-	Topic Introduction	ISU
30 min	Kentucky: Consideration of deterioration in load rating analysis	KYTC
30 min	Illinois: Consideration of deterioration in load rating analysis	IDOT
30 min	New York: Approach for load rating of corroded steel beam ends	NYSDOT
10 min	**Break and Dismissal to Separate Rooms**	-
60 min	Small Group Discussions	-
10 min	**Break and Reconvene as Large Group**	-
20 min	Large Group Reporting and Discussion	-
4:40 – 5:00	**Day 1 Recap and Dismissal**	-

Thursday, May 9, 2024		
8:00 – 11:00	**Topic 3 – Timely Load Rating, Re-rating, Posting and Closure**	
-	Topic Introduction	ISU
30 min	Pennsylvania: Timely Load Rating, Re-rating, Posting and Closure	PennDOT
30 min	Puerto Rico: Challenges in load rating, posting, re-rating, and permits	PRHTA
30 min	Massachusetts: Timely Load Rating, Re-rating, Posting and Closure	MassDOT
10 min	**Break and Dismissal to Separate Rooms**	-
50 min	Small Group Discussions	-
10 min	**Break and Reconvene as Large Group**	-
20 min	Large Group Reporting and Discussion	-
11:00 – 3:40	**Topic 4 – Structural Analysis for Routine and Special Permit Loads**	
-	Topic Introduction	ISU
30 min	Ohio: Non-standard gauge permit loads	ODOT
30 min	Virginia: Live load demand checks for permit vehicles	VDOT
12:00 – 1:30	**Lunch Break**	
30 min	South Carolina: Structural Analysis for Routine and Special Permit Loads	SCDOT
10 min	**Break and Dismissal to Separate Rooms**	-
60 min	Small Group Discussions	-
10 min	**Break and Reconvene as Large Group**	-
20 min	Large Group Reporting and Discussion	-
3:40 – 5:00	**Topic 5 – Research, Technology and Others**	
-	Topic Introduction	ISU
30 min	Indiana: Research and Technology in Indiana	INDOT
30 min	Minnesota: Prestressed Concrete Beam Shear Load Rating	MnDOT
15 min	AASHTO COBS S&E Update	AASHTO
15 min	FHWA Update – Part 2	FHWA
5:00 – 5:10	**Day 2 Recap and Closing Remarks**	-

B. SMALL GROUP DISCUSSION QUESTIONS

B.1 Topic 1 – State truck size and weight limits, and State legal load models

Q1: When you determine if you need to develop State-specific load models to supplement what is in the MBE, what are the main considerations (factors such as weight limits, axle configurations, load effects, load factors) and what type of tools do you use?

Q2: How does your State manage those vehicles and loads that do not have defined weight limits or configurations (State exemptions) in State law to ensure bridge safety?

Q3: States collect traffic data including truck weight and classification information for various purposes with stationary scales at weight stations, portable scales used by law enforcement, and WIM sites. For bridge design and evaluation specifically, to what extent has your State utilized the collected weight data?

Q4: What are your main considerations, such as strength vs. service limit states and safety vs. preservation strategy, when your State posts bridges for State legal loads?

Q5: What are the major challenges your State has in terms of bridge load rating and posting in relation to State truck size and weight limits?

B.2 Topic 2 – Consideration of deterioration in load rating analysis

Q1: What load rating method do you normally use to account for deterioration? Do you apply the condition factor in Section 6A of the AASHTO MBE LRFR? How do you consider section losses at discrete locations (localized deterioration)? Do you change your analysis model to incorporate deterioration when determining load effects in addition to calculating the resistance?

Q2: In what situations would you perform a refined analysis to account for deterioration?

Q3: Normally there is no need to load rate a concrete substructure and transverse reinforced concrete deck slab without deterioration. How do you account for deterioration present in those components in bridge load rating or what degree of deterioration will trigger the load rating of the substructure and deck?

Q4: Localized deterioration may require analysis of failure mode due to local stresses. How does your State address localized deterioration in the load rating process?

Q5: How often do your load raters perform field visits to verify deterioration identified during bridge inspections or to perform additional field measurements of the deterioration?

Q6: What are the major challenges your State has regarding deterioration in bridge load rating or bridge management in general?

B.3 Topic 3 – Timely load rating, re-rating, posting and closure

Q1: How often do you load rate substructure components or bridge decks? What are the typical factors that trigger the rating of such structural components that are typically not considered in load rating analysis?

Q2: How often do you use consultant services to support your load rating program to ensure bridges are rated or re-rated promptly? What are the main factors you consider when determining the need to use consultant services?

Q3: In your State, who is responsible for conducting timely load rating or re-rating and implementing load posting recommendations and timely installation of load posting signs for 1) State-owned bridges, and 2) non-State-owned bridges?

Q4: In your State, who is responsible for the closure of 1) State-owned bridges, and 2) non-State-owned bridges?

Q5: What is/are the analysis method(s) of load rating and load posting most commonly used by your State? What are the major drivers for these choices?

Q6: What are the major challenges your State has to timely rate, post, or close bridges?

Q7: What type(s) of load posting signs does your State use and how are the safe posting loads on the signs determined?

B.4 Topic 4 – Structural analysis for routine and special permit loads

Q1: Which method(s), AASHTO LRFR, LFR, ASR, or other, do you use for the bridge analysis for overweight permit loads? Do you have any modifications or additions to the rating method in the AASHTO MBE (dynamic allowance, live load factors, multi-lane present, live load distribution – standard gauge and non-standard gauge, etc.)? If yes, what are they?

Q2: Does your State have a suite of pre-defined, common configurations of routine permit loads that have been load rated for all (or some) bridges in your inventory? How are those permit load models developed (i.e. based on permit records, WIM, industry)?

Q3: How often do you load rate substructure components or bridge decks for overweight permit loads? What are the typical factors that trigger the rating of such structural components that are typically not considered in load rating analysis? Do you use refined analysis when you conduct *load ratings for overweight permit loads? Do you have any special requirements for complex bridges and culverts?*

Q4: Which load rating levels are used as acceptance criteria for issuing overweight permits? Inventory, Operating, or an intermediate level between Inventory and Operating?

Q5: How many bridges are there in your inventory that you have computer models for and can the models be re-run (automatically called by a routing system or requested by the permit agency) for evaluation of bridges before approval of overweight permits?

Q6: What are the major challenges your State has for prompt analysis of bridges to facilitate quick review for overweight permit loads?