



BRIDGE RATING



ACEC-DOT
April 20, 2011

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State Bridge Management Unit

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BRIDGE MANAGEMENT

- National Bridge Inventory (NBI)
 - Database of the Nation's bridges (~600,000).
- Bridges located on public roads
 - Interstate Highways, U.S. highways, State, County Roads and City Streets as well as publicly-accessible on Federal lands.

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BRIDGE MANAGEMENT

- North Carolina Data
 - North Carolina Maintains ~19,500 Bridge Records
 - State Owned Structures ~18,300 Bridge Records
 - Bridges ~13,600
 - Bridge Size Pipes and Culverts ~4,700
 - Non-State Owned Structures ~1,200
 - Municipal Structures ~750
 - Government Agencies, Railroads, Private ~450

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BRIDGE MANAGEMENT

- FHWA established **National Bridge Inspection Standards** (NBIS).
- Periodic **inspection** and **evaluation** of all highway bridges subject to the NBIS.
 - Once every 2 years
- Maintain a current inventory of structures.
- Report the **data** to the FHWA annually in April.
- **Bridge Rating** is a part of the data reported.

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BRIDGE RATING CHALLENGES



- Structure Type
- Structure Condition



BRIDGE RATING CHALLENGES



- Structure Design
 - Code Evolution

- ASD / WSD
- LFD
- LRFD



BRIDGE RATING CHALLENGES



- Design Loads
 - H-15
 - HS-20
 - HL-93

- Legal Loads
 - Interstate
 - Non-Interstate



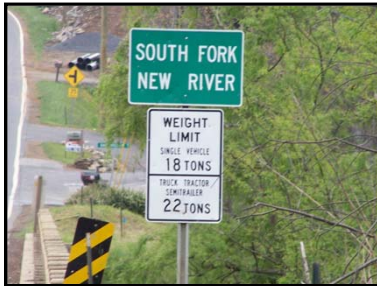
BRIDGE RATING METHODS

- Timber bridges and Truss members are rated using **WSD**.
- Existing steel and concrete bridges that were designed using the **WSD** or **LFD** method are rated using **LFR** method.
- Bridge Management Unit (BMU) performs both **Inventory** and **Operating** Ratings.
- **Bridge Posting** in North Carolina is based on the **Operating Rating**.



IMPACT of LOW BRIDGE RATING

- Bridge Posted
- Minimize Number of Posted Bridges



- Commerce
- Emergency
- School Buses

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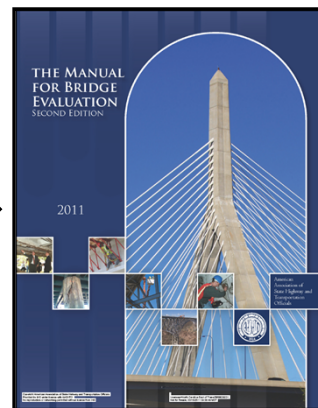
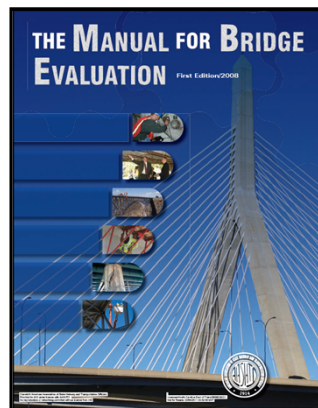
TRANSITION to LRFR

- Implementing LRFD
- Collaboration between FHWA, BMU & SDU.
 - Rating Bridges designed by LRFD?
- Bridges designed by the **LRFD** method shall be rated by the **LRFR** method.
- Rating adopted as an integral part of design.

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MANUAL for BRIDGE EVALUATION



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MANUAL for BRIDGE EVALUATION

- Replaces both the **1998 AASHTO Manual for Condition Evaluation of Bridges** and the **2003 AASHTO Guide Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges**.
- Establishes inspection procedures and evaluation practices that meet the National Bridge Inspection Standards (NBIS).

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MANUAL for BRIDGE EVALUATION

- MBE serves as a single standard for the evaluation of highway bridges of all types.
- MBE divided into eight Sections.
 - Each section discusses a distinct phase of the overall bridge inspection and evaluation program.
- MBE -- Section 6: **Load Rating**

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LRFR

- General Load-Rating Equation

$$RF = \frac{C - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_P)(P)}{(\gamma_{LL})(LL + IM)} \quad (6A.4.2.1-1)$$

- Design load rating
 - First-level assessment of bridges based on the HL-93 loading and LRFD design standards.
 - Operating and Inventory

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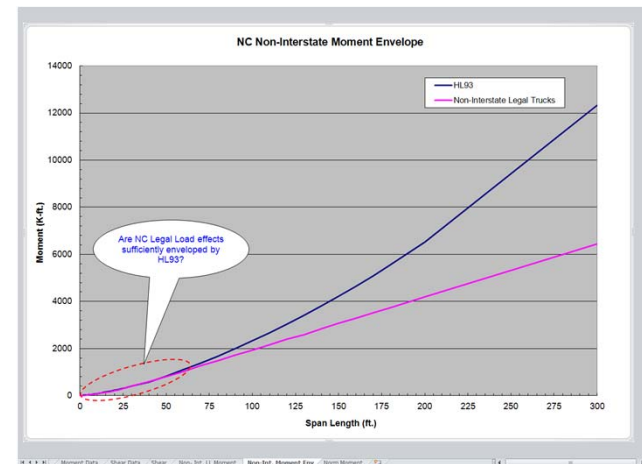
LRFR

- AASHTO legal loads and State legal load rating
 - Second-level rating that provides a single safe load capacity (for a given truck configuration).
- Rating assumes legal load force effects are enveloped by the design load (HS-20 / HL-93).
- Statutes governing NC Legal Loads are subject legislative revisions.

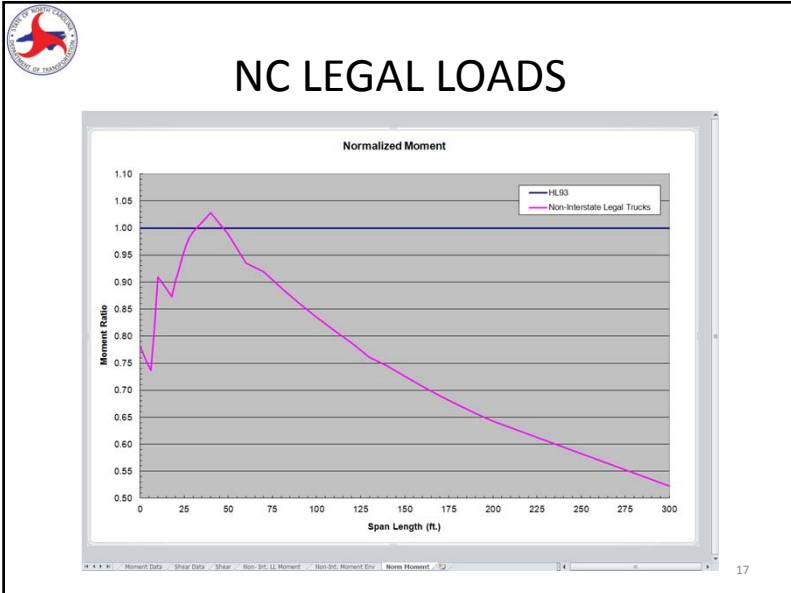
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NC LEGAL LOADS



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LRFR LOAD FACTORS

Table 6A.4.2.2-1—Limit States and Load Factors for Load Rating

Bridge Type	Limit State*	Design Load				Legal Load
		Dead Load γ_{DC}	Dead Load γ_{DW}	Inventory γ_{IL}	Operating γ_{OL}	
Steel	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1
	Strength II	1.25	1.50	—	—	—
	Service II	1.00	1.00	1.30	1.00	1.30
	Fatigue	0.00	0.00	0.75	—	—
Reinforced Concrete	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1
	Strength II	1.25	1.50	—	—	—
	Service I	1.00	1.00	—	—	—
Prestressed Concrete	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1
	Strength II	1.25	1.50	—	—	—
	Service III	1.00	1.00	0.80	—	1.00
	Service I	1.00	1.00	—	—	—
Wood	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1
	Strength II	1.25	1.50	—	—	—

* Defined in the AASHTO LRFD Bridge Design Specifications.

- ### LRFR OBSERVATIONS
- Legal Load Rating
 - Neither inventory nor operating.
 - Live load factors 1.40 – 1.80 (selected based on the truck traffic conditions at the site).
 - Service III rating for concrete bridges is optional.
 - Service III live load factor is greater than live load factor used for design.

Table 6A.4.2.2-1—Limit States and Load Factors for Load Rating

Bridge Type	Limit State*	Design Load				Legal Load
		Dead Load γ_{DC}	Dead Load γ_{DW}	Inventory γ_{IL}	Operating γ_{OL}	
Steel	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1
	Strength II	1.25	1.50	—	—	—
	Service II	1.00	1.00	1.30	1.00	1.30
	Fatigue	0.00	0.00	0.75	—	—
Reinforced Concrete	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1
	Strength II	1.25	1.50	—	—	—
	Service I	1.00	1.00	—	—	—
Prestressed Concrete	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1
	Strength II	1.25	1.50	—	—	—
	Service III	1.00	1.00	0.80	—	1.00
	Service I	1.00	1.00	—	—	—
Wood	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1
	Strength II	1.25	1.50	—	—	—

* Defined in the AASHTO LRFD Bridge Design Specifications.

- ### LRFR OBSERVATIONS
- LRFR paradigm shift
 - Probability of failure vs. reserve strength.
 - Incongruities between LRFD and LRFR.
 - Legal Load Rating < 1.0 when force effects similar /equal to HL-93.



LRFR POLICY

- Established Legal Load Live Load Factors.
- Require Service III Legal Load Rating.

Limit States and Load Factors for Load and Resistance Factor Rating (LRFR)

Bridge Type	Limit State	Dead Load	Dead Load	Design Load		Legal Load
				Inventory	Operating	
Steel	Strength I	1.25	1.50	1.75	1.35	1.40 [†]
	Service II	1.00	1.00	1.30	1.00	1.30
	Fatigue	0.00	0.00	0.75	—	—
Prestressed Concrete	Strength I	1.25	1.50	1.75	1.35	1.40 [†]
	Service III	1.00	1.00	0.80	—	0.80 [†]

[†] - Variance from the AASHTO Manual for Bridge Evaluation.



LRFR POLICY

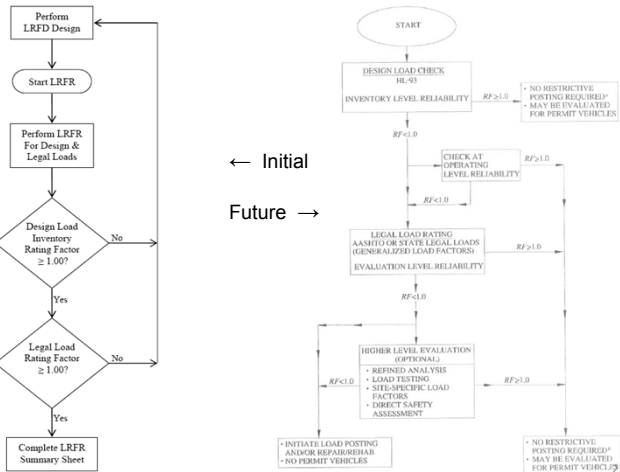
Allowable Tensile Stress in Prestressed Concrete at Service Limit State

Exposure	Girder Type	σ_{allow}	σ_{allow}
		Initial Rating ksi (MPa)	Future Rating ksi (MPa)
Non-Corrosive	Cored Slabs	0	$0.19\sqrt{f'_c}$ ($0.5\sqrt{f'_c}$)
	Box Beams	0	$0.19\sqrt{f'_c}$ ($0.5\sqrt{f'_c}$)
	I-Girders	$0.19\sqrt{f'_c}$ ($0.5\sqrt{f'_c}$)	$0.24\sqrt{f'_c}$ ($0.62\sqrt{f'_c}$)
Corrosive and Highly Corrosive	Cored Slabs	0	$0.0948\sqrt{f'_c}$ ($0.25\sqrt{f'_c}$)
	Box Beams	0	$0.0948\sqrt{f'_c}$ ($0.25\sqrt{f'_c}$)
	I-Girders	0	$0.0948\sqrt{f'_c}$ ($0.25\sqrt{f'_c}$)

[†] - As required for design, see Chapter 2 for details.



LRFR PROCESS



LRFR STANDARD SHEETS



LRFR in the FUTURE

- Maintain ASD / WSD and LFR only?
- Maintain LFR & adopt LRFR?
- Convert all Ratings to LRFR?
- None of the above?
- Some other combination / plan?

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QUESTIONS and DISCUSSION

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