BRIDGE RATING

ACEC-DOT
April 20, 2011

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State Bridge Management Unit

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Structure Design 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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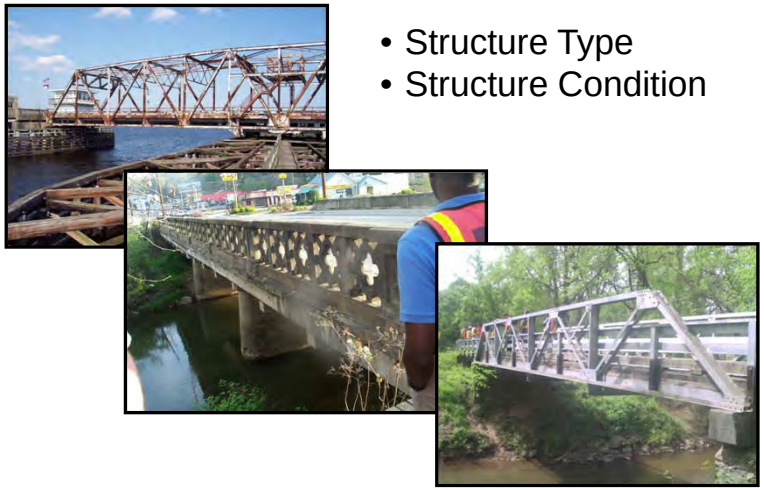
BRIDGE RATING CHALLENGES



- 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**.

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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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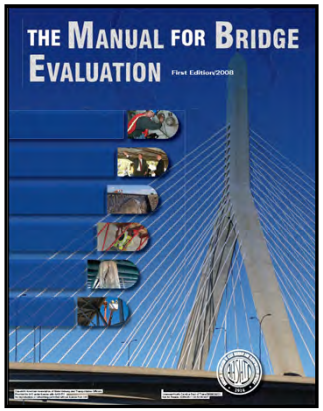
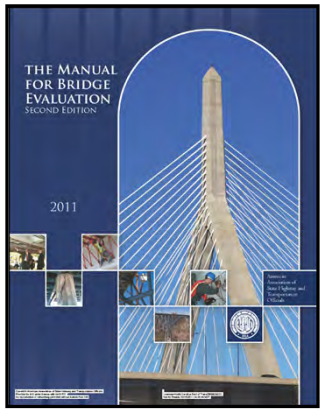
MANUAL for BRIDGE EVALUATION





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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

$$RF = \frac{C - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_P)(P)}{(\gamma_{LL})(LL + IM)}$$

(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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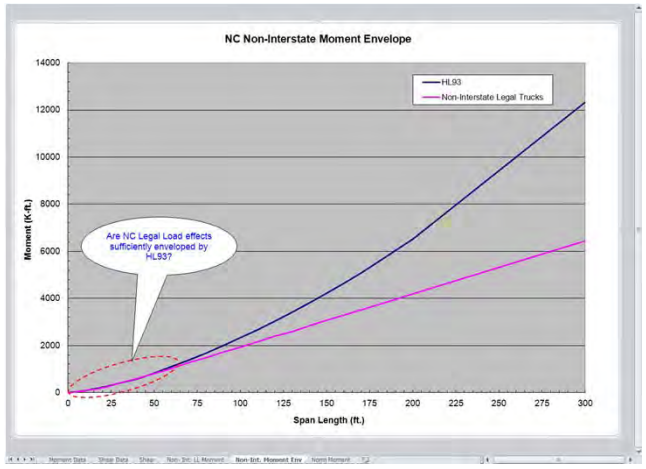
NC LEGAL LOADS



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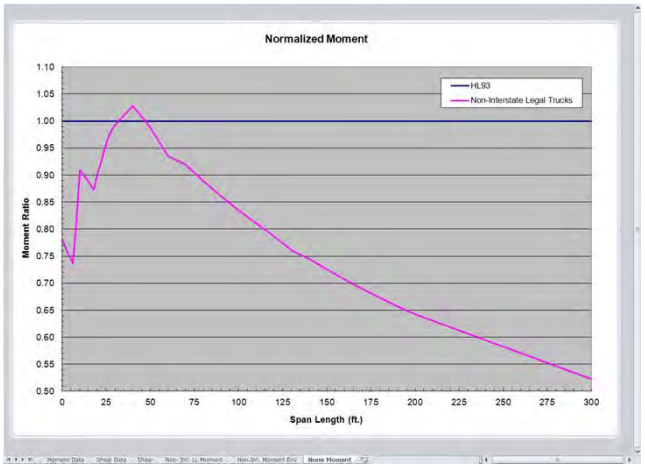
NC LEGAL LOADS



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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*	Dead Load γ_{DC}	Dead Load γ_{DW}	Design Load Inventory γ_{LL}	Design Load Operating γ_{LL}	Legal Load γ_{LL}
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*.

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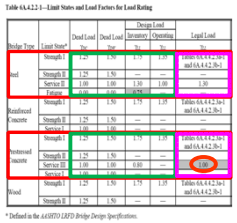
LRFR OBSERVATIONS

- 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.



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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.

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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 γ_{DC}	Dead Load γ_{DW}	Design Load Inventory γ_{LL}	Design Load Operating γ_{LL}	Legal Load γ_{LL}
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*.

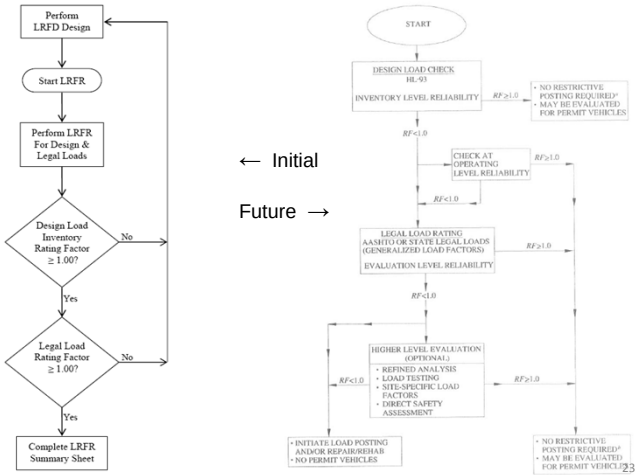
LRFR POLICY

Allowable Tensile Stress in Prestressed Concrete at Service Limit State

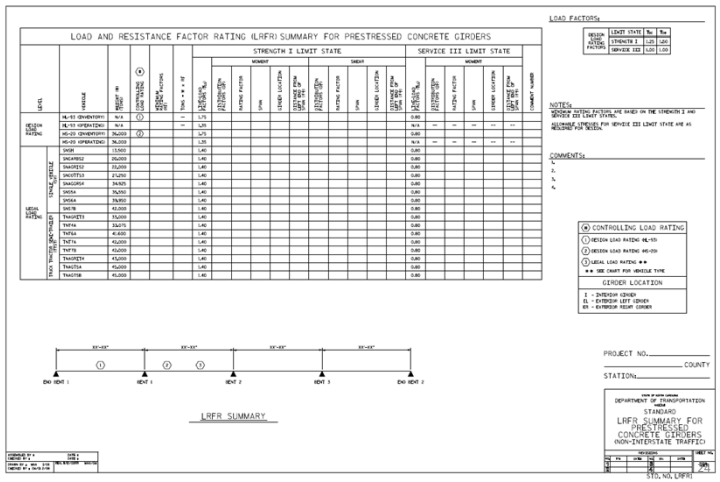
Exposure	Girder Type	σ_{allow} ‡ Initial Rating ksi (MPa)	σ_{allow} Future Rating ksi (MPa)
Non-Corrosive	Cored Slabs	0	$0.19\sqrt{f'_c}$ $(0.5\sqrt{f'_c})$
	Box Beams	0	$0.19\sqrt{f'_c}$ $(0.5\sqrt{f'_c})$
	I-Girders	$0.19\sqrt{f'_c}$ $(0.5\sqrt{f'_c})$	$0.24\sqrt{f'_c}$ $(0.62\sqrt{f'_c})$
Corrosive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