BRIDGE RATING

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ARMS-DOE
April 20, 2011

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.

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

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.
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

**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.

**MANUAL for BRIDGE EVALUATION**

- Establishes inspection procedures and evaluation practices that meet the National Bridge Inspection Standards (NBIS).
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**

**LRFR**

• General Load-Rating Equation

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

**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

**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.

**NC LEGAL LOADS**

- NC Non-Interstate Moment Envelope
- NC Interstate Moment Envelope
- Statutory Legal Loads
- Design Loads for HS-20 / HL-93
- NC Legal Loads Envelope
- Load Effects of Design Load
- NC Legal Loads Envelope
- Load Effects of Design Load
**NC LEGAL LOADS**

![Graph showing normalized moment vs. span length (ft.)]

**LRFR LOAD FACTORS**

<table>
<thead>
<tr>
<th>Bridge Type</th>
<th>Limit States</th>
<th>Dead Load</th>
<th>Dead Load</th>
<th>Design Load</th>
<th>Legal Load</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td>Y1</td>
<td>Y2</td>
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<td>Steel</td>
<td>Strength I</td>
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<tr>
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<td>Strength II</td>
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<tr>
<td></td>
<td>Service I</td>
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<tr>
<td></td>
<td>Strength II</td>
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<td>1.50</td>
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</tbody>
</table>

* 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.

- **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)

<table>
<thead>
<tr>
<th>Bridge Type</th>
<th>Limit State</th>
<th>Dead Load</th>
<th>Design Load</th>
<th>Legal Load</th>
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<tr>
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<td>Dead Load</td>
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<td>1.75</td>
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<tr>
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<td>0.75</td>
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<td>1.50</td>
<td>1.75</td>
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<tr>
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<td>Service III</td>
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<td>0.80</td>
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</tbody>
</table>

LRFR POLICY

Allowable Tensile Stress in Prestressed Concrete at Service Limit State

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Girder Type</th>
<th>Initial Rating (ksi (MPa))</th>
<th>Future Rating (ksi (MPa))</th>
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<tbody>
<tr>
<td>Non-Corrosive</td>
<td>Cored Slabs</td>
<td>0.19 $f_c$ (0.5 $f_y$)</td>
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<tr>
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<td>Box Beams</td>
<td>0.19 $f_c$ (0.5 $f_y$)</td>
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<td>I-Girders</td>
<td>0.19 $f_c$ (0.5 $f_y$)</td>
<td>0.24 $f_c$ (0.62 $f_y$)</td>
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<tr>
<td>Corrosive and</td>
<td>Cored Slabs</td>
<td>0.0948 $f_c$ (0.25 $f_y$)</td>
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<td>Highly Corrosive</td>
<td>Box Beams</td>
<td>0.0948 $f_c$ (0.25 $f_y$)</td>
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<td>I-Girders</td>
<td>0.0948 $f_c$ (0.25 $f_y$)</td>
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</tbody>
</table>

* - 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?