

# Workshop Agenda

- I. **Introductions**
- II. **Load Rating Basics**
- III. **General Equations**
- IV. **Load Rating Procedure**
- V. **Incorporating Member Distress**
- VI. **Posting, SHV's and Permitting**
- VII. **Load Rating Example #1**
  - **Simple Span Non-composite Steel**

# What is a Bridge?

- **Minnesota (Minnesota Rules 8810.8)**

**Definition:**

- **Erected over a depression or obstruction such as water, a highway or railway, etc.**
- **Has a track or passageway for carrying traffic or other moving loads**



# What is a Bridge?

- **Minnesota (Minnesota Rules 8810.8)**

**Definition:**

- Has an opening measured horizontally along center of roadway of 10 feet or more
- The opening is measured between undercopings of abutments, spring line of arches, or between extreme ends of openings for multiple boxes

# What is Load Rating?

- **The process of determining the safe live load carrying capacity of a new or an existing vehicular bridge is called its load rating.**
- **Note: load rating should not be confused with bridge condition rating which is entered into PONTIS.**

# What is Load Rating?

- **The final load rating will be the rating of the weakest point of the weakest member within the bridge.**



# What is Load Rating?

- **Live Loads are transient loads that remain in place for a relatively short time.**
  - **Cars**
  - **Busses**
  - **Trucks**
  - **Wind**
  - **Stream flow pressure**
  - **Etc**
- **Trucks usually used as Live Load for load rating of bridges**

# What is Load Rating?

- **Live load carrying capacity is based on:**
  - **Bridge inspections**
    - **Description of any structural modifications**
    - **Identify any condition changes**
    - **Measurements of any losses**
      - **Decay**
      - **Corrosion**
    - **Field measurements**

# What is Load Rating?

- **Live load carrying capacity is based on:**
  - **Engineering analysis**
    - **Applied engineering principles**
    - **Recognized formulae**
    - **Computer programs**

# What is Load Rating?

- **Live load carrying capacity is based on:**
  - **Engineering judgment**
    - **May be used to establish if substructure controls rating**
    - **May be used to establish if certain superstructure components will not control the rating**

# What is Load Rating?

- **Live load carrying capacity is based on:**
  - **Nondestructive Load tests**
    - **Maybe used when bridge cannot be accurately modeled by analysis**
    - **Owner believes a load test will provide a more realistic load capacity**

# What is Load Rating?

- **Load ratings may be subdivided into specific types depending on live load**
  - **Design load rating:** The live load model is the AASHTO design HS loading. The rating is expressed relative to a HS20 truck.
  - **Legal load rating:** Sometimes called posting rating. The live load model is one or more of the “legal trucks”.

# What is Load Rating?

- **Load ratings may be subdivided into specific types depending on live load**
  - **Annual Permit load rating:** The live load model represents a truck or class of trucks that may operate under an annual overweight permit
  - **Single Trip Permit load rating:** The live load model is the specific overweight permit truck

# What is Load Rating?

- **Load rating is expressed as a rating factor (RF) or weight in tonnage for a particular live load.**
  - **Generally a  $RF \geq 1.0$  indicates that the bridge has adequate live load carrying capacity**
  - **Generally a  $RF < 1.0$  indicates that the bridge has inadequate live load carrying capacity**
  - **A RF is always associated with a particular live load**

# Why do Ratings?

- **Minnesota Administrative Rule 8810.95 Subp.2 Ratings.**
  - Bridges must be rated to determine safe load carrying capacity and reported on a structure inventory sheet.
- **FHWA National Bridge Inspection Standards (NBIS)**
  - The MCE requires as part of every inspection cycle, bridge load ratings to be reviewed and updated

# Why do Ratings?

- **Bridge load ratings reported to the NBI weigh heavily in the determination of the Sufficiency Rating**
- **Used in preparing highway needs**
- **Used in prioritizing projects**
- **Used in distributing bridge funds to local governments**

# Why do Ratings?

- **To have a consistent summary of load carrying capacities of all state bridges**
- **Bridge load ratings are used to post bridges and for issuing load permits**
- **To monitor safety of bridges over time**
- **To help determine when rehabilitation or replacement is needed**

# When to do Ratings?

- **According to FHWA National Bridge Inspection Standards (NBIS):**
  - Ratings should be done when there is any relevant changes in condition from:
    - Maintenance or improvement work
    - Strength of members
    - Dead load
  - Ratings should be reviewed and updated following bridge inspections

# When to do Ratings?

- **Minnesota Administrative Rule 8810.95 Subp.2 Ratings.**
  - Bridge must be rerated when it is determined that a significant change has occurred in the condition of the bridge.
  - Bridge must be rerated when the allowable legal load using the bridge is increased.
  - Changes in the rating of a bridge must be indicated on the structure inventory sheet.

# When to do Ratings?

- **Increase in Dead Load**
  - Bituminous Overlay
  - Gravel
  - Increase weight of railing
  - New deck
  - New beam or girder
- **Significant changes in AASHTO specifications, state policies or federal directives.**
- **A change in law regulating truck weights**

# When to do Ratings?

- **Loss of capacity**
  - Corrosion or damage to steel structural elements resulting in section loss
  - Decay or damage to timber structural elements resulting in section loss
  - Spalling or salt related damages in concrete
  - Bridge hit by an oversize load

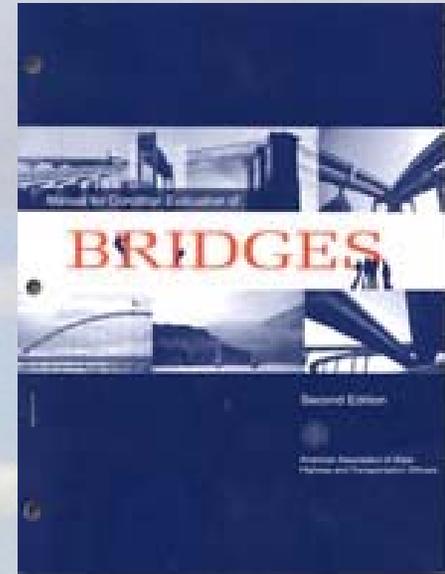
# When to do Ratings?

- **Settlement or movement of a pier or abutment**
- **Repairs or remodeling**
- **New bridges are rated before opened to traffic**



# What Code to Use?

- **FHWA National Bridge Inspection Standards (NBIS)**
  - **Adopted the AASHTO Manual for Condition Evaluation of Bridges (MCE) as a NBIS regulation**



# What Code to Use?

- **The AASHTO Manual for Condition Evaluation of Bridges (MCE)**
  - **MCE 2<sup>nd</sup> Edition with 2003 Interims**
  - **2005 Guide Specifications for MCE and Load and Resistance Factor Rating (LRFR)**
  - **New MCE soon to be released, 2008?**
    - **Part A - LRFR**
    - **Part B - Allowable Stress Rating (ASR) & Load Factor Rating (LFR)**

# What Code to Use?

- **Use AASHTO Bridge Design Specifications for all matters not covered in the MCE**
  - **2002 AASHTO Standard Specifications**
    - ASR
    - LFR
  - **AASHTO Load Resistance Factor Design (LRFD) Specifications**
    - LRFR

# What Code to Use?

- **Four rating methods are available:**
  - **Allowable Stress Rating (ASR)**
  - **Load Factor Rating (LFR)**
  - **Load and Resistance Factor Rating (LRFR)**
  - **Load Testing**

# Allowable Stress Rating (ASR)

- **Uses actual (service) loads to produce maximum stress in member**
- **Maximum stress in member not to exceed the allowable stress**
- **Allowable stress is the limiting stress of the material with an appropriate factor of safety applied**

# Allowable Stress Rating (ASR)

- Per 2003 MCE 2<sup>nd</sup> Edition, timber and masonry bridges should be evaluated using ASR.

$$\text{Maximum stress under service load} \leq \text{Allowable Stress} = \frac{\text{Yield Stress}}{\text{Factor of Safety}}$$

# Load Factor Rating (LFR)

- **Uses separate load factors (or safety factors) applied to the actual loads**
- **The magnitude of load factors reflect the uncertainty in the load calculation**
- **The effect of the factored loads are not to exceed the strength of the member**

# Load Factor Rating (LFR)

- Per 2003 MCE 2<sup>nd</sup> Edition, steel, reinforced concrete, and prestressed concrete bridges should be evaluated using LFR.

$$(\text{Strength Provided}) \times \text{SF} \geq (\text{Actual Loads}) \times \text{SF}$$

**Note: Safety Factors (SF) are called strength reduction factors and load factors. The SF for load are typically 1.3 for dead load and 2.17 for live load. The SF for strength are typically .90 for flexural strength and .85 for shear strength**

# Load Factor Rating (LFR)

- **LFR is the current standard for MnDOT**
  - **New bridges are designed using LRFD and are rated using LFR**
  - **Old rating forms not valid for steel and concrete (ASR)**

# Load & Resistance Factor Rating (LRFR)

- **Similar to LFR, but uses statistically based load and resistance factors eliminating judgment and past experience to determine factors**
- **Load and resistance factors have been calibrated by trial designs to provide a uniform level of safety**



# Load & Resistance Factor Rating (LRFR)

- **LRF method ensures that only 2 out of 10,000 bridges will have factored loads greater than the factored resistance of the bridge**

$$\text{(Strength Provided)} \times \text{SF} \geq \text{(Actual Loads)} \times \text{SF}$$

**Note: LRFR Safety Factors (SF) for load and strength are statistically based to provide a uniform level of safety**

# Load Testing

- **Is an effective means of evaluating the load rating of a bridge**
- **Bridge load testing generally consists of:**
  - **Load evaluation**
    - **Tests on load and load effects from traffic**
  - **Diagnostic load testing**
    - **Test on effects of a known load on bridge**
  - **Proof load testing (should not be used)**
    - **Test to determine maximum live load bridge can support**

# Load Testing

- **National Cooperative Highway Research Program (NCHRP) Project 12-28(13) developed a Manual for Bridge Rating Through Load Testing**
- **Manual covers:**
  - **General Load Testing Procedures**
  - **Load Test Equipment and Measurements**
  - **Diagnostic Load Tests**
  - **Proof Load Tests**

# Diagnostic Load Testing

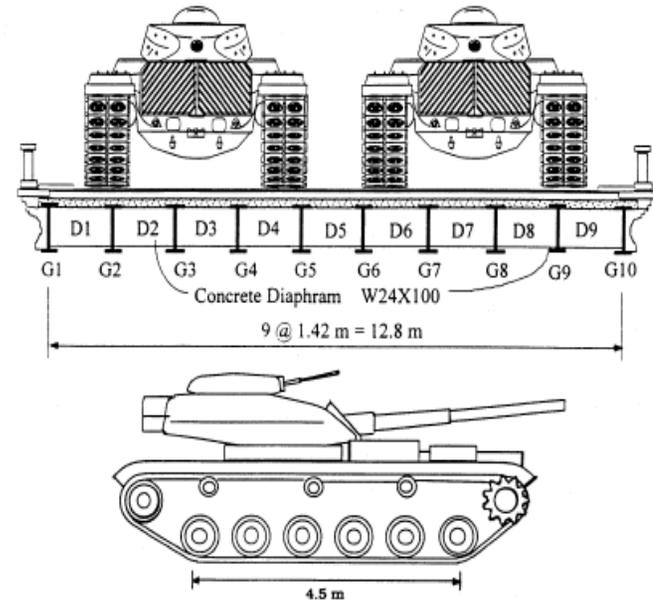
- **Some general procedures:**
  - Obtain strain responses from known load.
  - Structural behavior determined from strain data
  - Develop computer model
  - Simulate load test on computer model
  - Perform load rating on calibrated model



# Proof Load Testing

- **Using military tanks for proof load**
  - Analytical methods can under estimate the actual strength
  - Carrying capacity can be larger due to unintended composite action, contribution from sidewalks, rail and etc..

MILITARY TANKS PROOF Load Testing of Bridges 2000 Nova Award Nomination 13



Side Elevation of M-60 Tank.



# FHWA Policy on Rating Methods

- **Before October 1, 2010**
  - New LRFD bridges and replacement bridges use LFR or LRFR
- **After October 1, 2010**
  - New LRFD bridges and replacement bridges use LRFR
- **Bridges that warrant a rerating**
  - Existing rating is LRFR, rerate using LRFR

# FHWA Policy on Rating Methods

- **Bridges that warrant a rerating (cont.)**
  - No existing rating, use LRFR, LFR or ASR (for timber or masonry bridges)
  - Existing rating is LFR or ASR, rerate using LRFR, LFR or ASR (for timber or masonry bridges)
    - Non NHS bridges load rated prior to January 1, 1994, use LRFR, LFR or ASR
    - Non NHS bridges load rated after January 1, 1994, use LRFR, or LFR
  - Posting analysis can use ASR, LFR or LRFR (beyond 2010)

# Mn/DOT Policy on Rating Methods

- **Currently**
  - Design new bridges and replacement bridges using LRFD and rate LFR, but allow ASR for masonry and timber bridges
- **2008 - Mn/DOT to complete studies of LRFR**

# Mn/DOT Policy on Rating Methods

- **2009 - Mn/DOT and NHI provide LRFR training**
- **2010 - Mn/DOT to meet FHWA policy on LRFR**
- **2011 + - Rerate all bridges using LRFR**

# Who is Qualified?

- **The person charged with overall responsibility for load-rating bridges shall have:**
  - **Professional Engineer License**
  - **5-years bridge design and inspection experience**
  - **Knowledge and skills for proper evaluation**

# Who is Qualified?

- **The PE's signature of approval on the rating form holds the same level of responsibility as the Engineer's signature of approval on the bridge plans and specifications**

# Some Ratings Are Not Current

## More bridges are vulnerable

- **Of 14,921 Local Bridges and Culverts:**
  - 2,301 have not been rated for 30 years
    - Average operating rating of HS 26 or lower
  - Median age = 65 years
    - Many may need to be re-rated
  - Of 765 that are posted
    - 190 (25%) Have Not Been Rated in 30 Years and Postings May Need to be lowered



# Ideal Load Rating History

- **Bridge Built**
  - Rated at Design level
- **Gradual Corrosion**
  - Rating gradually lowered as section reduces
- **Severe Deterioration**
  - Posting at appropriate level
- **Replacement**
  - Cycle starts over again

# Statewide Bridge Rating Program Needs

- **Office of Inspector General requires FHWA to better monitor load ratings**
- **Consultant inspection findings often are recommending new bridge ratings**
- **Likely to have less posted load limits based only on engineering judgment**

# Statewide Bridge Rating Program Needs

- **New ratings are required for significant changes in condition or loading since last inspection**
- **Continued pressures from truckers may require statewide permitting, a one stop shop for all load permits in the future**
- **AASHTO introduced the new Special Hauling Vehicle (SHV) posting vehicle**

# Statewide Rating Funding Concept

- **Use federal HBRRP funds to pay for bridge ratings on the local level**
- **Possible Priorities:**
  - **First, bridges with changed conditions**
  - **Second, bridges with possible SHV limitations**

# Statewide Rating Funding Concept

- **Possible Priorities:**
  - Third, new bridge plans (by 2011, all new bridges must be rated under LRFR)
  - Fourth, rerate the remaining bridges, county roads followed by township roads
- **If County Engineers support it, the Bridge Office and State Aid could pursue.**

# Truck Trends

- **Trucks are getting heavier and increased allowable limits have created greater:**
  - **Agency costs for inspecting**
  - **Agency costs for rating**
  - **Agency costs for posting**

# Truck Trends

- **Timber Haulers:**
  - **Allowed a weight exception to 90,000 GVW for combination vehicles with 6 axles**
  - **For hauling forest products**
  - **Annual permit of \$300**
  - **Winter weight increase to 98,000 GVW**

# Truck Trends

- **Truck Size and Weight Committee**
  - **Review of truck weight laws was needed:**
    - **Truck traffic increasing**
  - **Recommendations:**
    - **A request for truck weight increases**
      - **7 axle 97,000 GVW combination vehicle**

# Truck Trends

- **Truck Size and Weight Committee**
  - **Recommendations:**
    - **Allow 4 new vehicle configurations with special permit**
      - **6 axle 90,000 GVW combination vehicle**
      - **7 axle 97,000 GVW combination vehicle**
      - **8 axle 108,000 GVW twin trailer vehicle**
      - **7 axle 80,000 GVW single-unit truck**

# Truck Trends

- **Truck Size and Weight Committee**
  - **Recommendations:**
    - **Eliminate liability exemptions for farm implements that damage roads and bridges**
    - **Eliminate requirements for seasonal harvest permits (permit allows 10% load increase)**
    - **Expand seasonal harvest allowance to include all farm crops**

# Truck Trends

- **Implements of Husbandry:**
  - **Agricultural equipment exempt from weight restrictions**
    - Grain carts (used in the fall)
    - Manure wagons (used in the spring)
    - They have no axle restrictions, can carry same load as 6 axle truck on only 2 axles



# Truck Trends

- **Increased overweight permits (truck load exceeds legal weight)**
  - **A practice that is putting additional wear and tear on our infrastructure**
  - **According to a government study, one 40-ton truck does as much damage to the road as 9,600 cars**

# Truck Trends

- **Increase high stress cycles**
  - **Higher loads create larger fatigue stresses which can result in fatigue cracking of materials**
  - **High stress cycles can lead to requirements of posting, maintenance, and/or expensive repairs**

# Bridge Rating & Related Resources

- **Mn/DOT Bridge Office Rating Section:**
  - Gary Peterson, 651-366-4507
  - Lowell Johnson, 651-366-4552
- **Mn/DOT Bridge Office Website:**
  - <http://www.dot.state.mn.us/bridge/>

# Bridge Rating & Related Resources

- **Overdimension/Overweight Permit Section**
  - <http://www.dot.state.mn.us/motorcarrier>
- **Seasonal Load Limits**
  - <http://www.mrr.dot.state.mn.us>