LOAD RATING TRAINING
Hand Calculations

Tim Keller, PE
Amjad Waheed, PE

Ohio Department of Transportation
Agenda – Day 1

8:00 am – 8:15 am  Introductions and House Keeping
8:15 am – 8:45 am  Session 1: Load Rating Basics
8:45 am – 9:30 am  Session 2: Basic Load Rating Calculations
9:30 am – 9:45 am  Break
9:45 am – 11:45 am  Session 3: Example – Load Rating Concrete Slab Bridge
11:45 am – 12:00 pm  Questions
12:00 pm – 1:00 pm  Lunch
1:00 pm – 2:30 pm  Session 4: Example – Load Rating Steel Beam Bridges
2:30 pm – 2:45 pm  Break
2:45 pm – 3:45 pm  Session 4: Example – Load Rating Steel Beam Bridges (Con’t)
3:45 pm – 4:00 pm  Questions
Agenda – Day 2

8:00 am – 8:15 am  Review of Day 1
8:15 am – 10:15 am  Session 5: Example – Prestressed Box Beam Bridge Rating
10:15 am – 10:30 am  Break
10:30 am – 12:00 pm  Session 6: Example – Concrete T-Beam Bridge Rating
12:00 pm – 1:00 pm  Lunch
1:00 pm – 2:00 pm  Session 7: Example – Precast Concrete Beam Bridge Rating
2:00 pm – 2:45 pm  Spread Sheet Demonstration
2:45 pm – 3:00 pm  Break
3:00 pm – 3:30 pm  Open Discussion on Load Rating Bridges
3:30 pm – 3:45 pm  Evaluations and Certificates
Goals for Today

1. To look inside the computer “black box” for load rating
2. To be able to perform load rating hand calculations for the following basic bridge types:
   a) Simple Span Concrete Slab
   b) Simple Span Non-composite Steel Beam
   c) Simple Span Concrete Beam
   d) Simple Span Prestressed Box Beam
<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
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<td>Questions</td>
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Session 1: Load Rating Basics

• What is Load Rating?
• Why is Load Rating Required?
• Structures that Require a Load Rating
• Load Rating Methodologies
• Load Rating Stress Levels
• Basic Truck Types ODOT uses for Load Rating
• Basic Load Rating Equations
What is Load Rating?

The safe live load carrying capacity of a highway structure is called its load rating. It is usually expressed as a rating factor (RF) or in terms of tonnage for a particular vehicle.

Load rating is different from Inspection rating
Why do we rate structures?

- Federal Highway Administration (FHWA) requires load ratings of all the structures of length 20 feet or greater in compliance with National Bridge Inspection Standards (NBIS)

- For the safety of general public and traffic using highway structures, the loading rating is performed.
Why do we rate structures?

- **OHIO Revised Code** (ORC), Section 5591.42, requires us to post warning signs where the safe load carrying capacity of a structure is ascertained and found to be less than the load limits prescribed in ORC Sections 5577.01 through 5577.12. Generally, a load rating analysis of a structure provides vital information about the load carrying capacity of a bridge to an engineer who decides whether a bridge needs to be posted or not.
Why & When Load Rating Should be Revised?

The load rating of a bridge should be revised when:

1. There is a physical change in the condition of a bridge or a structural member of the bridge.
   a) There is an alteration in the structure
   b) A new beam or a girder is added
   c) A new deck of different width, weight, or thickness is added
Why & When Load Rating Should be Revised?

d) Rusting, spalling, or damage to a beam, girder or other structural element that has resulted in section loss

e) Changes in the dead loads on the superstructure, like addition or removal of wearing surfaces, sidewalks, parapets, railings, etc

f) Structural damages in bridge members due to accidents, like a hit by a vehicle
Why & When Load Rating Should be Revised?

2. There is a request to re-evaluate the rating of a structure for a different vehicle

3. There is a change from the method of analysis used for previous rating

4. Special circumstances that require re-analysis of the structure
What is a Bridge?

According to FHWA, any structure that carries a highway load and has a total length greater than 20 ft. is a bridge.
What is a Bridge?

According to the Ohio Revised Code (5501.47), “Bridge means any structure of ten feet or more clear span or ten (10) ft. or more in diameter on, above, or below a highway, including structures upon which railroad locomotives or cars may travel.”
Load Rating Methods

Three Load Rating Methods
1. Working (Allowable) Stress Rating (WSR)
2. Load Factor Rating (LFR)
3. Load and Resistance Factor Rating (LRFR)
Load Rating Methods

Working (Allowable) Stress Rating (WSR)
  ▪ Timber bridges are still rated with WSR
  ▪ New bridge ratings should not use WSR
  ▪ Many of the bridges currently in ODOT’S BMS are rated with WSR.
  ▪ Reduces the yield stress to get allowable stress levels and treats Live Loads and Dead Loads equally.
Load Rating Methods

Load Factor Rating (LFR)

- All new load ratings should be performed using LFR.
- When updating a current load rating, it should be performed using LFR
- This course teaches LFR.
- Places load factors on Dead Loads and Live Loads and takes the capacity up to yield/ultimate/plastic for the material.
Load Rating Methods

Load and Resistance Factor Rating (LRFR)

- After Oct. 10, 2010, all bridges designed using LRFD shall be load rated using LRFR.
- We will not deal with LRFR in this course.
Load Rating Stress Levels

The load rating of each bridge on the bridge inventory is determined for:

1. Inventory Stress Level
2. Operating Stress Level
Load Rating Stress Levels

- Inventory Stress Level
  - Lower stress level
  - Design Stress Level

- Operating Stress Level
  - Higher stress level
  - ODOT uses to post bridges
  - Maximum permissible live load to which the structure may be subjected
## ODOT Bridge Posting

ODOT Bridge Posting Procedure  
Ohio Legal Loads at Operating Stress Level

<table>
<thead>
<tr>
<th>% Ohio Legal Value</th>
<th>Posted % Ohio Legal in BMS</th>
<th>Posting for Reduced Load Capacity Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;=150%</td>
<td>150%</td>
<td>NO</td>
</tr>
<tr>
<td>&gt;=100% and &lt;150%</td>
<td>Actual percentage rounded to the nearest 5 (i.e. 100, 105, 110, 115, etc.)</td>
<td>NO</td>
</tr>
<tr>
<td>&gt;=92.5% and &lt;100%</td>
<td>100%</td>
<td>NO</td>
</tr>
<tr>
<td>&lt;92.5%</td>
<td>Actual percentage rounded to the nearest 5 (starting with 90%, 85%, 80%, etc.)</td>
<td>YES</td>
</tr>
</tbody>
</table>
Truck Types Used to Load Rate Bridges in Ohio

Inventory Load Rating
1. HS 20 (truck or lane)

Operating Load Rating
1. HS 20 (truck or lane)
2. 2F1 (2 axle)
3. 3F1 (3 axle)
4. 4F1 (4 axle)
5. 5C1 (5 axle)
AASHTO HS20 Truck

Gross Vehicle Weight = 36 tons
AASHTO HS20 Lane Load

Uniform load = 640 lbs per linear foot of load lane
Plus
Concentrated Load = 18,000 lbs for Moment
= 26,000 lbs for Shear

For bending analysis on simple span bridges:
HS 20 Truck load controls for spans up to 144.8 ft. and HS 20 Lane load controls for spans greater than 144.8 ft.
Ohio Legal Loads

2F1

10k

10’

20k

GVW = 15 tons

3F1

12k

10’

17k

4’

17k

GVW = 23 tons
Ohio Legal Load (2F1)

Gross Vehicle Weight = 15 tons
Ohio Legal Load (3F1)

Gross Vehicle Weight = 23 tons
Ohio Legal Loads

4F1

12k
12k
10’

14k 14k 14k
4’ 4’ 4’

5C1

12k 12k
12k 17k 17k
12’ 4’ 31’

17k 17k 17k
4’

GVW = 27 tons
GVW = 40 tons

Load Rating Seminar 28
Ohio Legal Load (4F1)

Gross Vehicle Weight = 27 tons
Ohio Legal Load (5C1)

Gross Vehicle Weight = 40 tons
Basic Load Rating Equation

WSR: \[ RF = \frac{\text{Allowable} - \text{DL}}{\left(\text{LL} + \text{I}\right)} \]

RF = Rating Factor
DL = Dead Load
LL = Live Load
I = Impact
Basic Load Rating Equation

LFR: \[ RF = \frac{\text{Capacity} - A_1 (DL)}{A_2 (LL + I)} \]

RF = Rating Factor
DL = Dead Load
LL = Live Load
I = Impact
A_1 = Dead Load Factor
A_2 = Live Load Factor
### Factors for LFR Load Rating

<table>
<thead>
<tr>
<th>Rating Type</th>
<th>$A_1 = \text{Factor for dead loads}$</th>
<th>$A_2 = \text{Factor for live load}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory</td>
<td>1.3</td>
<td>2.17</td>
</tr>
<tr>
<td>* Design level</td>
<td>1.3</td>
<td>1.3</td>
</tr>
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Ref: AASHTO Manual for Condition Evaluation of Bridges 1994
Load Factor Rating

**Load Factor Rating**

\[ RF = \frac{\text{Capacity} - A_1 \ (DL)}{A_2 \ (LL + I)} \]

**Working Stress Rating**

\[ RF = \frac{\text{Allowable} - DL}{(LL + I)} \]

- DL = same for both
- LL+I = same for both

- Factors up DL and (LL+I)
- Capacity is at Yield/Ultimate/Plastic
- Gives higher RF

- No Factors on DL and (LL+I)
- Places a reduction on Yield Stress to get Allowable Stress
- Gives lower RF
Questions ?? ?? ??