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

General Equations

- Per the AASHTO Manual for Condition Evaluation of Bridges (MCE), the following general expression should be used in determining the load rating of a structure:

$$RF = \frac{C - A_1 D}{A_2 (L + I)}$$

General Equations

Reserve Capacity for Live Load

Maximum Design (HS) or Legal Live Load

$$RF = \frac{C - A_1 D}{A_2 (L + I)}$$

RF = Rating factor for live load capacity
C = Capacity of the member
D = Dead load effect on member
L = Live load effect on member
I = Impact Factor
A_1 = Factor for dead load
A_2 = Factor for live load

General Equations

- RF = Rating Factor for live load capacity
  - The Rating Factor (RF) is useful in understanding the factor of safety on the bridge.
  - The Rating Factor multiplied by the rating vehicle in tons gives the rating of the structure

$$RF = \frac{C - A_1 D}{A_2 (L + I)}$$

General Equations

- C = Capacity of the member
  - The nominal capacity to be used in the rating equation depends on:
    - Structural materials – Timber, concrete, or steel
    - Rating method used – ASR, LFR, or LRFR
    - Rating Level used – Inventory or Operating

$$RF = \frac{C - A_1 D}{A_2 (L + I)}$$

General Equations

- C = Capacity of the member
  - The units used for "C" depend on the member and "load effect" being checked.
  - The "load effect" is the effect of the applied load on the member
  - Typical "load effects" are axial force, vertical shear force, bending moment, axial stress, shear stress and bending stresses

Capacity of the members

- Timber (using ASR method)
  - F_B, F_V, F_C = Allowable stresses in the wood
    - Tables provided for all species, sizes, and grades of wood in AASHTO Standard Specs.
  - Timber Adjustment Factors
    - C_D = Load duration factor
    - C_F = Bending Size factor
    - C_M = Wet service factor
    - C_r = Repetitive member factor
    - C_f = Bending form factor
    - C_P = Column Stability factor

Capacity of the members

- Timber (using ASR method)
  - Inventory Level
    - $C = F_x' = F_x * C_D * C_F * C_M * C_r * C_f * C_P$
  - Operating Level
    - $C = 1.33 \times F_x'$ (Reduction from this maximum allowable stress may be warranted based on grade and condition at time of inspection)

Capacity of the members

- Concrete and Steel
  - Inventory and Operating Level (using ASR method)
    - In a FHWA Tech Memo they disallowed ASR procedure
  - Inventory and Operating Level (using LFR method)
    - $C = \phi M_n$ or ϕV_n (Found based on procedures in AASHTO Standard Specifications for Highway Bridges)
    - $\phi = 1.0$ for Steel
    - $\phi = 0.9$ for Concrete flexure
    - $\phi = 0.85$ for Concrete shear

Capacity of the members

- Steel – If F_y is unknown, use the following table for yield strength:

Year of Construction	Yield Point F_y (ksi)
Before 1905	26
1905-1936	30
1937-1963	33
1964-1989	36
1989-present	50

General Equations

- D = Dead load effect on member
  - Dead loads include self weight and any permanent external loads
  - Should be computed in accordance with the existing conditions of the member at the time of analysis

$$RF = \frac{C - A_1 D}{A_2 (L + I)}$$

General Equations

- L = Live load effect on member
  - Live loads are temporary loads that act on a structure
  - Live loads can be due to
    - Design truck (HS) and lane loading
    - Legal Trucks, Special Hauling Vehicles (SHV's)
    - Permit trucks

$$RF = \frac{C - A_1 D}{A_2 (L + I)}$$

General Equations

- L = Live load effect on member
  - For simple span bridges, live loads can typically be calculated using moment and shear tables provided
  - Live loads should be distributed to member in accordance with AASHTO Design Specs.

$$RF = \frac{C - A_1 D}{A_2 (L + I)}$$

General Equations

- I = Impact Factor
  - Impact Factor (I) is added to all live loads to account for the speed, vibration, and momentum of vehicular traffic.

$$RF = \frac{C - A_1 D}{A_2 (L + I)}$$

General Equations

- I = Impact Factor
  - The AASHTO specifications for bridge design define the impact factor as follows:

$$I = \frac{50}{(L + 125)} \leq 0.3$$ (L = Length of span)

  - Per AASHTO 3.8.1.2 – Impact is not considered for Timber members

General Equations

- A_1 = Factor for dead load
  - Allowable Stress Rating Method (ASR)
    - A_1 = 1.0 (Inventory & Operating Level)
  - Load Factor Rating Method (LFR)
    - A_1 = 1.3 (Inventory & Operating Level)

$$RF = \frac{C - A_1 D}{A_2 (L + I)}$$

General Equations

- A_2 = Factor for live load
  - Allowable Stress Rating Method (ASR)
    - A_2 = 1.0 (Inventory & Operating Level)
  - Load Factor Rating Method (LFR)
    - A_2 = 2.17 (Inventory Level)
    - A_2 = 1.3 (Operating Level)

$$RF = \frac{C - A_1 D}{A_2 (L + I)}$$

Load Rating Calculations (LFR)

- There are two levels of load ratings: (Established through different values of A_1 and A_2)
  - Inventory
  - Operating

Load Rating Calculations (LFR)

- Inventory
  - Design level of stresses
  - Incorporates existing conditions
  - Results in a live load which can safely utilize structure for an indefinite period of time

(HS-20 Truck)

$$RF = \frac{C - 1.3D}{2.17(L + I)}$$

Load Rating Calculations (LFR)

- Operating
  - Describes maximum permissible live load for bridge
  - Limited load applications
  - Loading at this level may shorten life of bridge
  - Used for Posting and permit level rating

$$RF = \frac{C - 1.3D}{1.3(L + I)}$$

Load Rating Calculations (ASR)

- The two levels of load ratings, Inventory and Operating, are established through different values of "C" or Capacity of member.

$$RF = \frac{C - 1.0D}{1.0(L + I)}$$