Bridge Impacts
An Engineer’s Perspective on Preserving Our Structures

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Load Rating

Evaluation of structures for safe load capacity and superloads (>200,000 lbs)
Why Load Rate?

- Public Safety
- State/Federal Guidelines
- Serviceability and Structure Life
Public Safety

- The top priority is to prevent failures or damage to structures that may lead to injury or death
- This is an important component for all aspects of transportation, not just structures
- Guidelines and policies are continuously changing to keep up with lessons learned from previous incidents, new technology, and industry practices
  - Recent incidents include:
    - Gusset plate failure in Minnesota
      - Resulted in a mandate to inspect and check all gusset plates in similar structures
    - Skagit River Bridge collapse in Washington
      - Resulted in updates to collecting and maintaining vertical clearance data and verifying adequate signage for low clearance
State/Federal Guidelines

- MBE (Manual for Bridge Evaluation)
  - Includes requirements for bridge management and record keeping, inspection, load rating, and more
  - Load rating is covered in Chapter 6
    - Defines load rating as the basis for determining the safe load capacity of a bridge (MBE 6.1)
    - Load ratings are used to determine the need for load posting or bridge strengthening and for overweight vehicle permit decisions (MBE 6.1)
    - Provides some allowed assumptions for typical structure types and material properties

- BDM (Bridge Design Manual)
  - WSDOT publication covering structural design and evaluation
  - Provides information not included in the MBE and/or specific to WSDOT practices.
Serviceability and Structure Life

- Structures are a taxpayer investment
- Many structures exceed their design life
- Maintenance is important
  - Deterioration is severe if not maintained
  - Emergency repairs can be costly
- Loads are getting heavier and more frequent
  - Projects (windmills, heavy girders, oil sands)
  - Can cause excessive wear on structures
Resistance Factor ($\phi$)
This factor is determined by the structure type and its condition.

Rating Factor (RF)
A value > 1.0 indicates structure is safe for load being considered.

Load Rating
Not just about the numbers!

Capacity (C)
Capacity is based on the current physical properties of the structure, it may account for deterioration or damage.

Dead Load (DL)
Dead loads are permanent loads acting on the structure.

Impact (I)
This is a standard value for all bridges. WSDOT BPO will use a lower factor if trucks are slowed down to a low speed.

Live Load (LL)
For superloads, WSDOT BPO will consider a comparable pre-defined overload truck or the actual configuration and weights submitted by the carrier.

$$RF = \frac{\phi C - \gamma dl \times DL}{\gamma ll \times LL \times I}$$
Capacity ($\varphi C$)

**Original Structure Design**

Previous standard trucks were significantly smaller than current trucks

- **H truck**
  - H15 (15 tons) 6 kips 24 kips
  - H20 (20 tons) 8 kips 32 kips

- **HS truck**
  - HS15 (27 tons) 6 kips 24 kips 24 kips
  - HS20 (36 tons) 8 kips 32 kips 32 kips

- **HL truck configurations**
  - HL93 (36 tons) + lane load
    - 8 kips 32 kips 32 kips

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8 kips 24 kips 8 kips 32 kips 24 kips 32 kips

640 lbs/ft
Capacity ($\phi_C$)

**OLD**
- Vintage 1950s era prestressed girder
  - Mild steel strength = 40,000 psi
  - PS steel strength = 250,000 psi
  - PS strand diameter = ½” or less
  - Concrete strength = 6,000 psi
  - 3.5’ section spans up to 60’

**NEW**
- Modern prestressed girder
  - Mild steel strength = 60,000 psi
  - PS steel strength = 270,000 psi
  - PS strand diameter = 0.6”
  - Concrete strength = up to 10,000 psi
  - 3.5’ section spans up to 85’
Capacity ($\varphi_C$)

NEWER

- Wide Flange prestressed girder
  - 3’ deep section spans up to 105’
Capacity ($\phi_C$)

**Current Structure Condition**

Structures are inspected regularly
- Typically every 24 months
- Verify operating configuration
- Evaluate condition
- Measure deterioration
- Recommend repairs/remediation
Live Load ($\gamma_{LL}LL$)

**Standard Trucks**

- Design truck, as defined by AASHTO (MBE Appendix C6A)
- Legal trucks, as defined by AASHTO (MBE Appendix C6A)
  - Type 3 (25 tons)
  - Type 3S2 (36 tons)
  - Type 3-3 (40 tons)
  - NRL (40 tons)
Live Load ($\gamma_{LL}LL$)

**Standard Trucks**

- Overload trucks, as defined by WSDOT (BDM Chapter 13)
  - Overload 1 (48 tons)
    - 10' 4' 12' 4'
      - 10 kips tandem
      - 43 kips tandem
  - Overload 2 (103.5 tons)
    - 10' 4' 6' 16' 4' 6' 14' 4' 6'
      - 12 kips tridem
      - 65 kips tridem
      - 65 kips tridem
      - 65 kips tridem
Superload Permit Process

- WSDOT Bridge processes superload approvals in two steps
  1. Check that load is legal in Washington
  2. Proposed route review
- Carrier is required to provide the following information:
  - Axle Spacing Report including requested weight per axle
  - Request for Approval of Oversize/Overweight Movement – *Superloads*
  - Additional information is required by Commercial Vehicle Services
Legal Load in Washington

RCW (Revised Code of Washington)

- Chapter 46.44 RCW – SIZE, WEIGHT, LOAD
  - Permit loads not to exceed:
    - 600 lbs/inch of tire width
    - 22,000 lbs/axle
    - 43,000 lbs/tandem
    - Weight allowed for any group of axles depends on axle spacing

- Typical configurations with 2- or 4-tire axles can be checked in eSnoopi
Legal Load in Washington

WSDOT Bridge Office Policy

- Configurations with 8-tire axles
  - RCW doesn’t include exceptions for loads wider than standard trucks or with more than 4-tires per axle
  - Office policy allows some additional weight for axles that have 8-tires, up to double when load is wide enough to occupy two lanes (16’-0”)

![Criteria for Additional Weight on Axles with 8 Tires]
Route Review

Initial Route Review

• Bridge Restricted List
  – Some structures have weight limits that are more stringent than RCW due to structure age or condition
    • These limits may be per axle or maximum GVW
    • Restricted List is separate from Posted List.
  – Restricted list can change at any time
    • http://www.wsdot.wa.gov/commercialVehicle/Restrictions/

![Sample Bridge Restricted List Image]
Route Review

Comprehensive Route Review

• All structures on all highways are considered
  – Specific structures may raise red flags
    • Known issue, for example:
      – Cracked steel
      – Deteriorated deck
      – Rotted timber
• Low rating factors for overload truck
• Span length compared to load length

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Route Review

Specific Structure Review

- Load configuration and number of loads is also considered
  - Large number of loads can cause additional stress and falls outside of calibrated load rating equations which are factored for one-time loads
  - Shorter & heavier loads tend to create more stress on typical structures
  - Longer & heavier loads tend to create more stress on long spans

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Route 1:
- 10' 4' 6' 16' 4' 6' 14' 4' 6'
- 12 kips, 65 kips tridem, 65 kips tridem, 65 kips tridem
- 207,000 lbs, 70 ft, 65,000 lbs tridem

Route 2:
- 14' 9' 16' 10' 10' 10' 50'+ 16'
- 18 kips, up to 65 kips tridem, up to 65 kips tridem, up to 65 kips tridem, up to 65 kips tridem
- up to 260,000 lbs, 135 ft or more, 65,000 lbs tridem

Route 3:
- 13' 10' 16' 9' 9' 9' 9' 9'
- 18 kips, 60 kips tridem, 8-tire axles at 36 kips each, 510,000 lbs
- 179 ft, 8-tire axles at 36 kips each
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Route Review

Mediation Measures

- Slow down the load to remove dynamic forces
- Weigh and measure the load to remove uncertainty
- Cross a bridge in a specific lane
- Cross a bridge with no other trucks allowed at the same time or within a specified distance
- Use detours when possible

8-tire axles at 36 kips each
Questions?

Thank You!