

Bridge Impacts

An Engineer's Perspective on Preserving Our Structures

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WSDOT Bridge Preservation Office
October 11, 2016

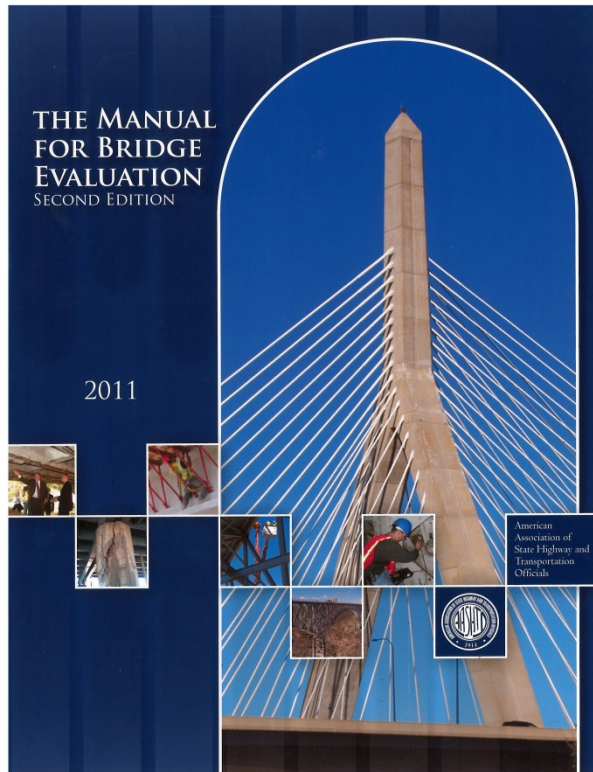
Load Rating

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



Why Load Rate?

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

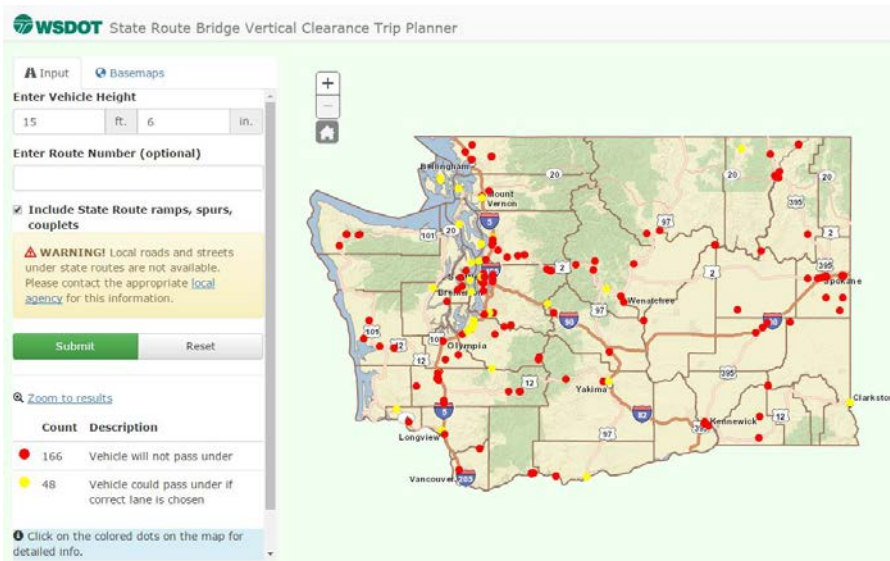


Public Safety

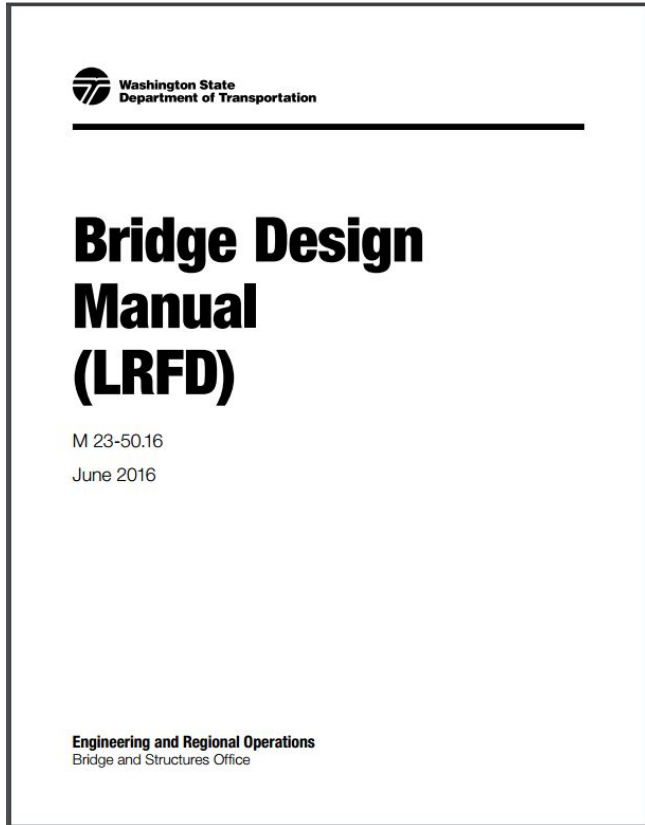


- The top priority is to prevent failures or damage to structures that may lead to injury or death
- This is an important component for all aspects of transportation, not just structures
- Guidelines and policies are continuously changing to keep up with lessons learned from previous incidents, new technology, 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 (ϕ)
This factor is determined by the structure type and its condition.

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.

$$RF = \frac{\phi C - \gamma_{dl} * DL}{\gamma_{ll} * LL * I}$$

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

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.

Load Rating

Not just about the numbers!

Capacity (ϕC)

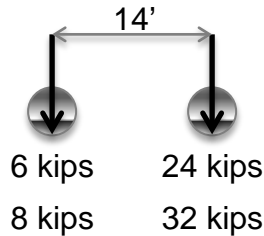
Original Structure Design

Previous standard trucks were significantly smaller than current trucks

- H truck

- H15 (15 tons)

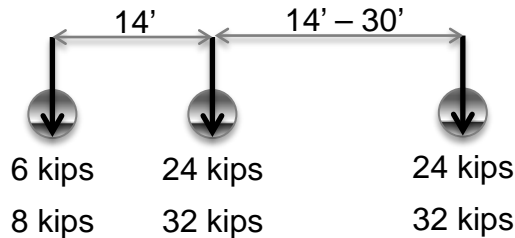
- H20 (20 tons)



- HS truck

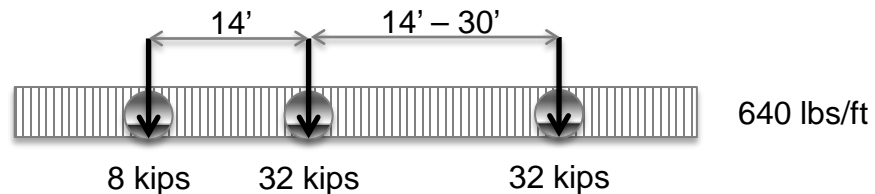
- HS15 (27 tons)

- HS20 (36 tons)



- HL truck configurations

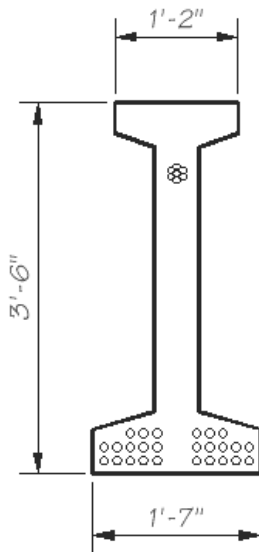
- HL93 (36 tons) + lane load



Capacity (ϕC)

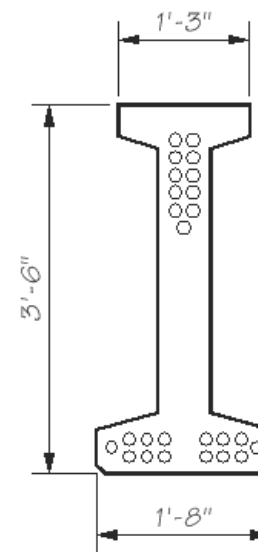
OLD

- Vintage 1950s era prestressed girder
 - Mild steel strength = 40,000 psi
 - PS steel strength = 250,000 psi
 - PS strand diameter = $\frac{1}{2}$ " or less
 - Concrete strength = 6,000 psi
 - 3.5' section spans up to 60'



NEW

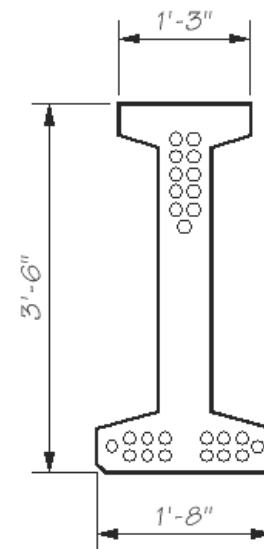
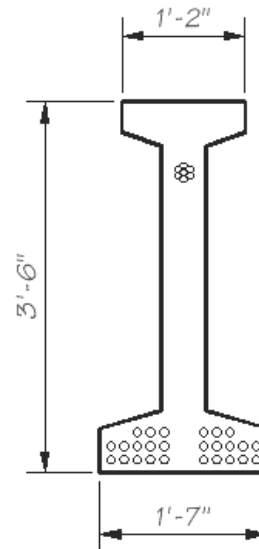
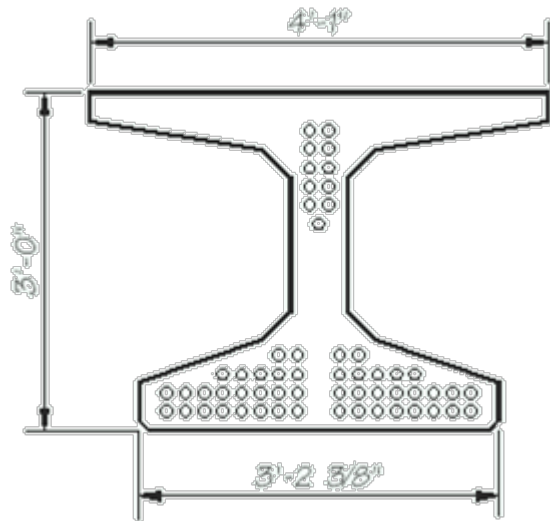
- Modern prestressed girder
 - Mild steel strength = 60,000 psi
 - PS steel strength = 270,000 psi
 - PS strand diameter = 0.6"
 - Concrete strength = up to 10,000 psi
 - 3.5' section spans up to 85'



Capacity (ϕC)

NEWER

- Wide Flange prestressed girder
 - 3' deep section spans up to 105'



Capacity (ϕC)

Current Structure Condition

Structures are inspected regularly

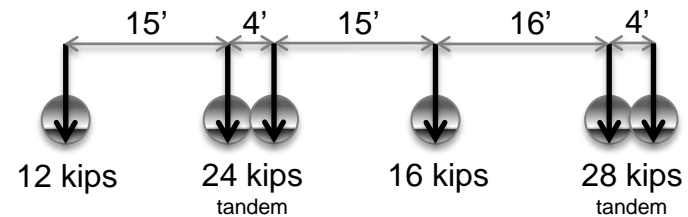
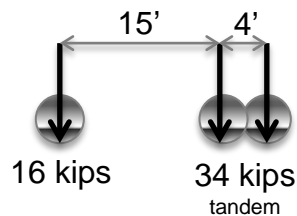
- Typically every 24 months
- Verify operating configuration
- Evaluate condition
- Measure deterioration
- Recommend repairs/remediation



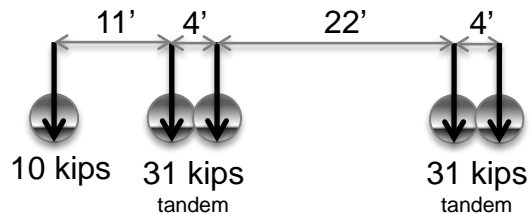
Live Load ($\gamma_{LL}LL$)

Standard Trucks

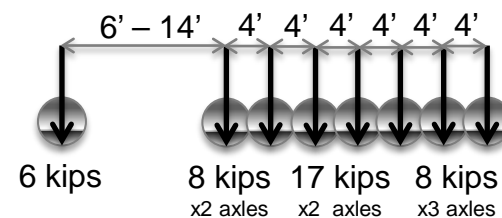
- Design truck, as defined by AASHTO (MBE Appendix C6A)
- Legal trucks, as defined by AASHTO (MBE Appendix C6A)
 - Type 3 (25 tons)
 - Type 3-3 (40 tons)



- Type 3S2 (36 tons)

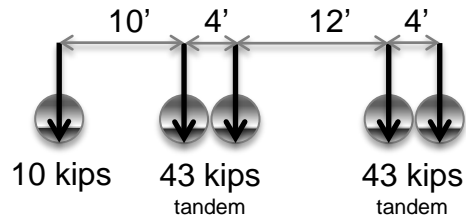


- NRL (40 tons)

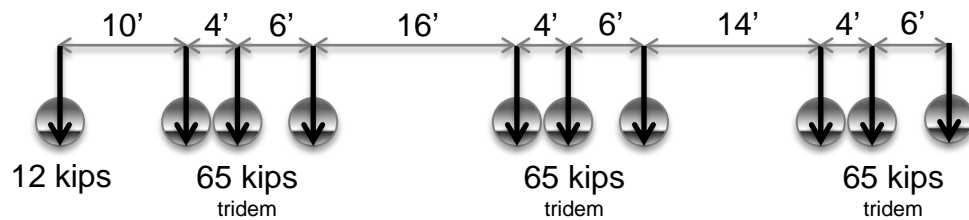


Standard Trucks

- Overload trucks, as defined by WSDOT (BDM Chapter 13)
 - Overload 1 (48 tons)



- Overload 2 (103.5 tons)



Superload Permit Process

- WSDOT Bridge processes superload approvals in two steps
 - Check that load is legal in Washington
 - 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

Washington State Department of Transportation

Request for Approval of Oversize/Overweight Movement - Superloads
Approval Form Only. Applicant MUST submit Application (DOT Form 550-021) for permit

All Sections Must Be Completed

Company Name: _____ DOT #: _____ Contact Person: _____
 Street Address: _____ Phone (with Area Code): _____ Fax (with Area Code): _____
 City: _____ State: _____ Zip Code: _____ E-mail Address: _____

Detailed Description of Non-Residue Load or Vehicle: _____

Proposed Dates of Movement: _____ Origin: _____ Destination: _____
 Total Miles: _____ Number of Loads: _____ Estimated Level Surface Speed: _____

Complete Proposed Routes of Travel. (Include beginning and ending mileposts for each highway).

Highways	Beginning MP	Ending MP	Highways	Beginning MP	Ending MP

Oversize: List weights per axle group: _____

☐ Stinger Steered/Steerable Trailer ☐ Manned Steer Trailer ☐ GVW _____ Report Number: _____
 Width: _____ Height: _____ Trailer (Load Length): _____ Front Overhang: _____ Rear Overhang: _____ Number of Axles: _____
 Signature of Person Requesting Approval: _____ Date: _____

FOR OFFICE USE ONLY

Date Received and Initials: _____ WSDOT Approval No.: _____
 Special Conditions/Requirements: _____

DOT Form 550-021
Revised 5/2005 Phone 360-704-6340 | Fax 360-704-6391 | cvgpermits@wsdot.wa.gov | www.wsdot.wa.gov/commercialvehicle

Washington State Department of Transportation

Axle Spacing Report for Overweight Permits

Commercial Vehicle Services
PO Box 47307
7345 Linderson Way SW
Olympia, WA 98512-7307
360-704-6340 / Fax 360-704-6391
www.wsdot.wa.gov/commercialvehicle

Refer to this number when applying for Overweight Special Permits (Assigned by WSDOT): _____ Report Number: _____

Name of Owner: *A Trucking Co* Contact Name: *John Doe*
 Address: *1234 Main St* City: *Olympia* State: *WA* Zip: *98506*
 Phone (Include Area Code): *360-704-6340* Fax (Include Area Code): *360-704-6391*

Description of Equipment (This section must be filled out completely)

Axle	# Tires	Size	Axle	# Tires	Size	Axle	# Tires	Size
Axle 1	2	11R22.5	Axle 7			Axle 13		
Axle 2	2	255	Axle 8			Axle 14		
Axle 3	2		Axle 9			Axle 15		
Axle 4	2		Axle 10			Axle 16		
Axle 5	2		Axle 11			Axle 17		
Axle 6	2		Axle 12			Axle 18		

Axle Spacings Which axle(s), if any, is a lift axle? *#2* Is it self-steering? ☐ Yes ☒ No

1-2	3-4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Axle Restrictions and Remarks

Note: RCW 46.44.091 requires applications to move any combination of vehicles in excess of 200,000 lbs. GVW to be submitted in writing 30 days prior to the proposed move.

WSDOT Form 550-013
5/2015

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

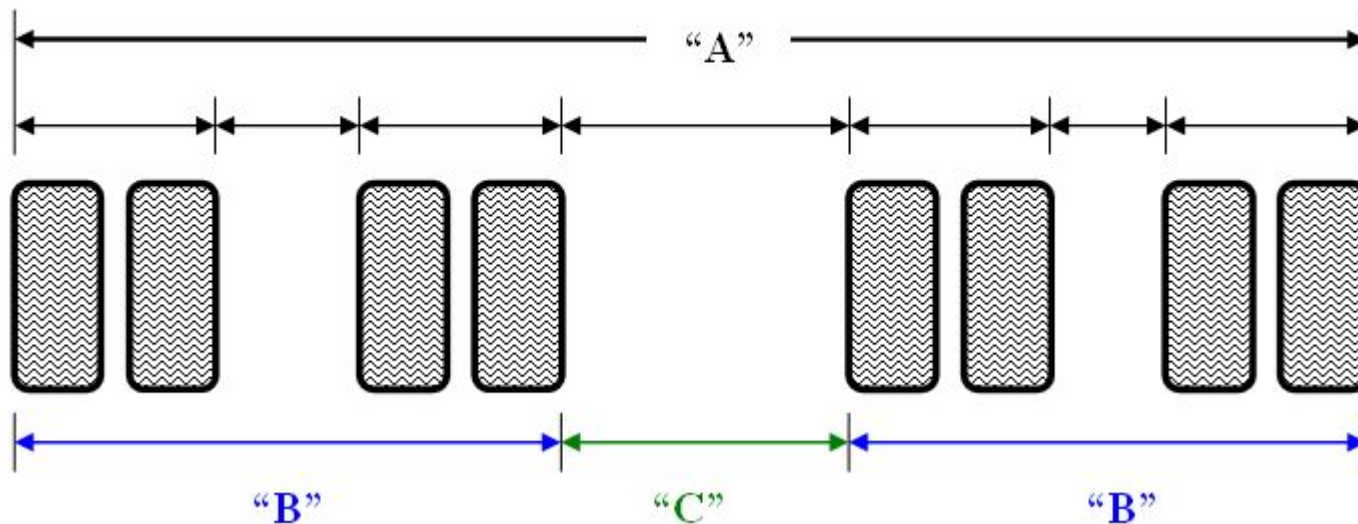
Distance in Feet Between First and Last Axles in the Group	Weight Allowed (In Pounds)
7 feet to less than 10 feet, multiply	(Feet) x 6,500
10 feet to less than 30 feet	(Feet plus 20) x 2,200
30 feet or greater	(Feet plus 40) x 1,600

- Typical configurations with 2- or 4-tire axles can be checked in eSnoopi
 - <https://secure3.wsdot.wa.gov/CommercialVehicle/Permits/public/login.aspx>

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



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/>

Oversize/Overweight Restrictions	
Printer Friendly	
I-5, MP: 18.21, Direction: N	
Date Effective:	4/27/2010 12:00 AM
Bridge Name:	East Fork Lewis River
BL max.	20000
CL max.	20000
SA max.	39000
Location:	
Name: 4.1 N Jct SR 501	
Description: I-5 NB, MP 18.21 20,000 lb per axle weight limit	
Comments:	
Limited to 20,000 lbs. per axle max. All loads over legal gross weight, must travel center lane of bridge. Loads over 20,000 lbs. per axle must use alternate route. ALTERNATE ROUTE: From Clark (360-397-2446)/Cowlitz Co (360-577-3030), Permits available 7:45AM to 5:15PM, Mon-Thurs, Closed on Fridays for gross weight up to 197,000lbs.	
All routes	

Route Review

Comprehensive Route Review

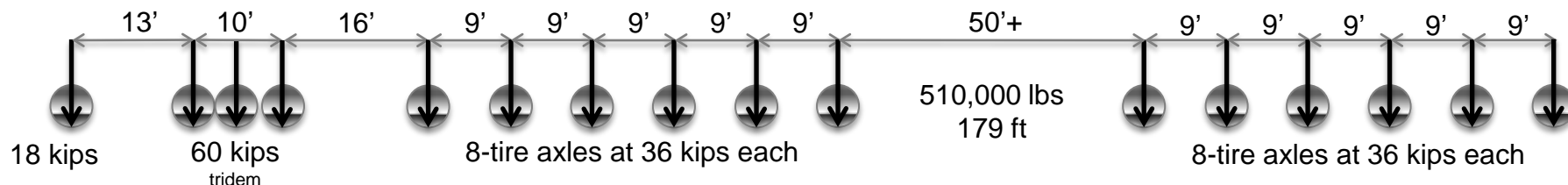
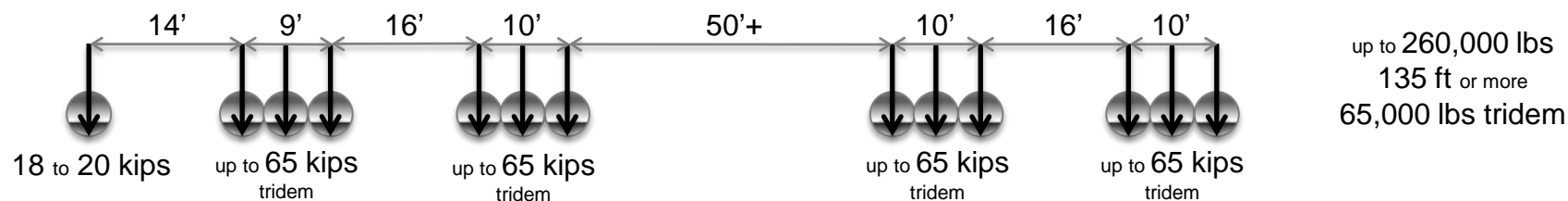
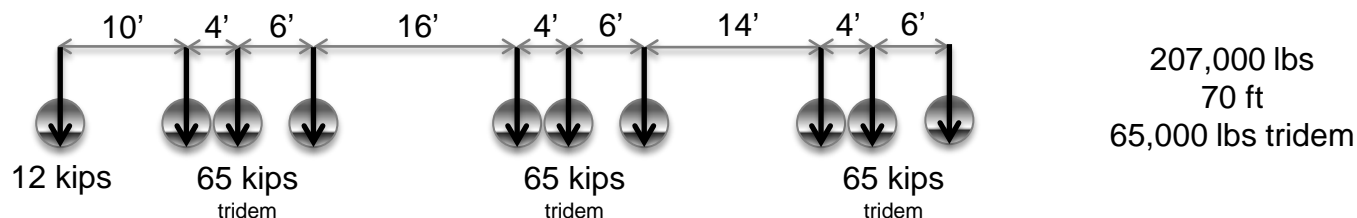
- All structures on all highways are considered
 - Specific structures may raise red flags
 - Known issue, for example:
 - Cracked steel
 - Deteriorated deck
 - Rotted timber
 - Low rating factors for overload truck
 - Span length compared to load length

bridge_no ▾	structure_id ▾	built_year ▾	traffic_flow ▾	main ▾	max_span_length ▾	alphabetic_span ▾	OL1 ▾	OL2 ▾
21/229	0003714C	1950	91.72	3	22	CS	1.24	1.09
26/114	0006047A	1959	48.28	3	69	PCB	1.35	1.04
26/115	0006047B	1959	49.07	3	41	CS	1.33	1.05
26/118	0005999A	1959	57.62	3	102	CBOX	2.17	1.51
26/119	0005999B	1959	57.69	3	49	PCB	1.4	1.27
26/121	0014470A	1995	60.93	2	127	PCB	1.88	1.11
82/257N	0012463B	1985	104.51	1	128	PCG	1.21	1
82/259.5C	00200052	1983	108.75	2	12	SCULV	10	10
82/260N	0012463F	1984	108.93	3	132	PCG	1.48	1
82/268N	0012607B	1984	114.39	1	120	PCG	1.13	1
82/275N	0012303B	1983	122.73	1	130	PCG	1.27	1
82/278N	0011608B	1980	131.58	1	110	PCB	1.27	1
90/232S	0006093A	1959	181.81	4	59	CVS	1.2	0.9
90/233S	0007621A	1965	182.83	3	44	PCB	1.62	1.17

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



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!