



Improved Load Rating of Existing Bridges for Permit Trucks

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Introduction

- ▶ Permit trucks often need bridge owners approval to cross their inventory.
- ▶ Bridge owner needs to make sure if a permit truck can safely cross a particular bridge of their inventory.
- ▶ There are two approaches for bridge owner:
 - ▶ Perform Bridge Load Rating Analysis
 - ▶ Use Bridge Formula Weights, FHWA Table
- ▶ An Improved Load Rating Method is proposed using a series of trucks to estimate the rating factor for permit trucks.

Objectives

- To develop a method to assist bridge owner to decide if a permit truck will be able to safely pass through a bridge.
- The method will be
 - Simple (table or graph)
 - Quick
 - Reliable

Presentation Outline

- Introduction
- Objectives
- Bridge Load Rating Analysis
- Bridge Formula Weights Approach
- Methodology for an Improved Load Method
- Example – California St. Overcrossing
 - Improved method vs FWHA
 - Improved method vs exact solution
- Concluding Remarks
- Questions & Answers

Bridge Load Rating

- Load rating is often performed on superstructure.
- Bridge Load Rating is performed:
 - Using a computer program (i.e., BRIDG, BRASS, etc).
 - Modal Testing of Structure.
- Bridge Load Rating can directly provide exact solution and reliable rating factors.
- Bridge Load Rating process requires a considerable time, resources and cost.

Bridge Load Rating

- Bridge Load Rating consists of following steps:
 - Model the structure
 - Model the permit truck
 - Compute nominal structure's capacity R_n
 - Compute Dead Load (D), Pre-stressed Load (S) and Live Load (L) effects

$$RF = \frac{\phi \cdot R_n - \gamma_{DL} \cdot D \pm \gamma_P \cdot S}{\gamma_L \cdot L \cdot (1 + I)}$$

- Determine rating factor (RF):

Bridge Formula Weights

- Bridge Formula Weights is provided by Federal Highway Administration (FHWA, 1994).
- Washington State Commercial Vehicle Guide 2008-2009, Appendix 4.
- Bridge Formula Weights limit the weight on groups of axles.
- The formula weights provide a conservative limit of axle weights.
- The Formula is used regardless of the bridge condition.

Bridge Formula Weights

- The weight formula can be expressed as follows:

$$W = 500 \times \left[\frac{L \times N}{N - 1} + 12 \times N + 36 \right]$$

where:

W: the maximum weight on a group of two or more axles

L: the distance in feet between the outer axles

N: is the number of axle

Improved LR Method

- New Inventory:
 - Perform load rating analysis as required for HS20, AASHTO 1-3, and OL1-2.
 - Perform additional load rating analysis for a series of trucks, which represent anticipated permit trucks to pass the Bridge.

Improved LR Method

- Inventory Load Rating:
 - Most of existing bridges in WA have been load rated.
 - The load rating analysis is readily available.
 - From the available analysis, a series of trucks can be easily added.
 - Load rating for a series of trucks will be performed to develop a reliable tool to use in load rating any permit truck.

Improved LR Method

- Similar to FHWA Table, some assumptions on truck configurations are as per following:
 - Number of axles from 2 to 9
 - Axle spacing from 4 feet to 86 feet
 - Axle weight of each axle is assumed at 100 kips
 - All axle weights are the same except for the first axle weight which is $\frac{1}{4}$ of others
- Relationship between the number of axle, the axle spacing and the axle weight can be estimated.

Example: California Street Overcrossing, Everett, WA

- 2 Span Concrete Box Girder Bridge (100':100').
- Bridge is often used for heavy trucks with different configurations due to the Port of Everett.
- It is desirable to have a handy tool to assess more realistic rating factors for those heavy trucks.

California St. Overcrossing



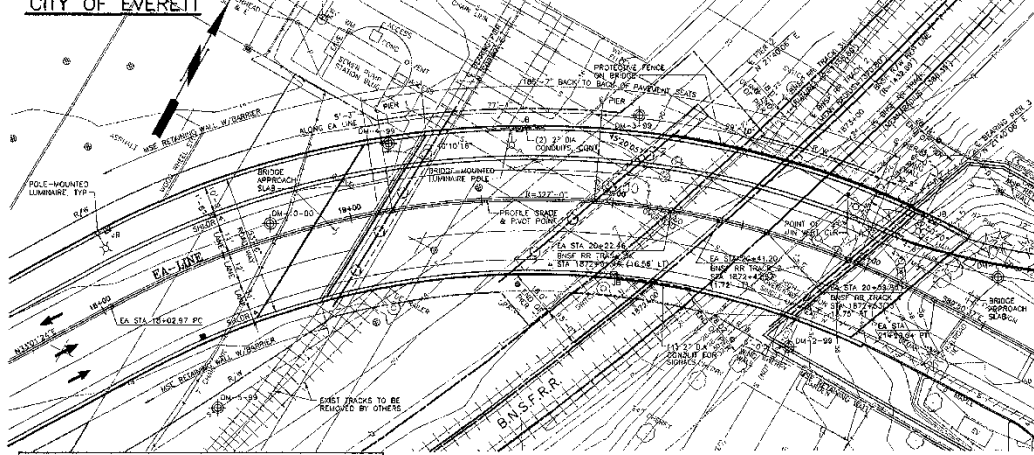
Deck View Looking East



Elevation View Looking North

C

SEC. 19, T.29N, R.5E, W.M.
CITY OF EVERETT



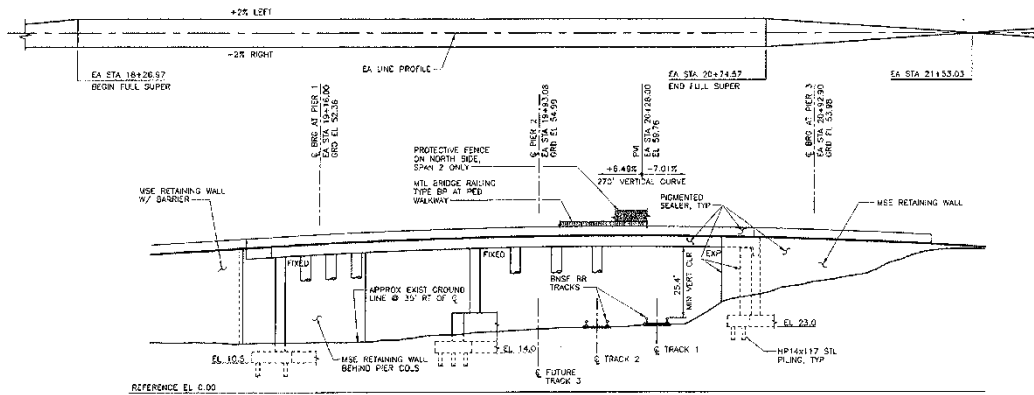
CURVE DATA				
PI STATION	Δ	RADIUS	TANGENT	CHORD TAN ANG
EA STA 18+26.57	100.00	100.00	100.00	100.00
EA STA 19+26.57	100.00	100.00	100.00	100.00
EA STA 20+26.57	100.00	100.00	100.00	100.00
EA STA 21+26.57	100.00	100.00	100.00	100.00

PLAN
1"=20'

NOTES:
1. OVERHEAD POWER AND TELEPHONE LINES AND POLES WILL BE
RELOCATED AS NOTED BY THESE SEVERAL SQUARES

ossing

Plan

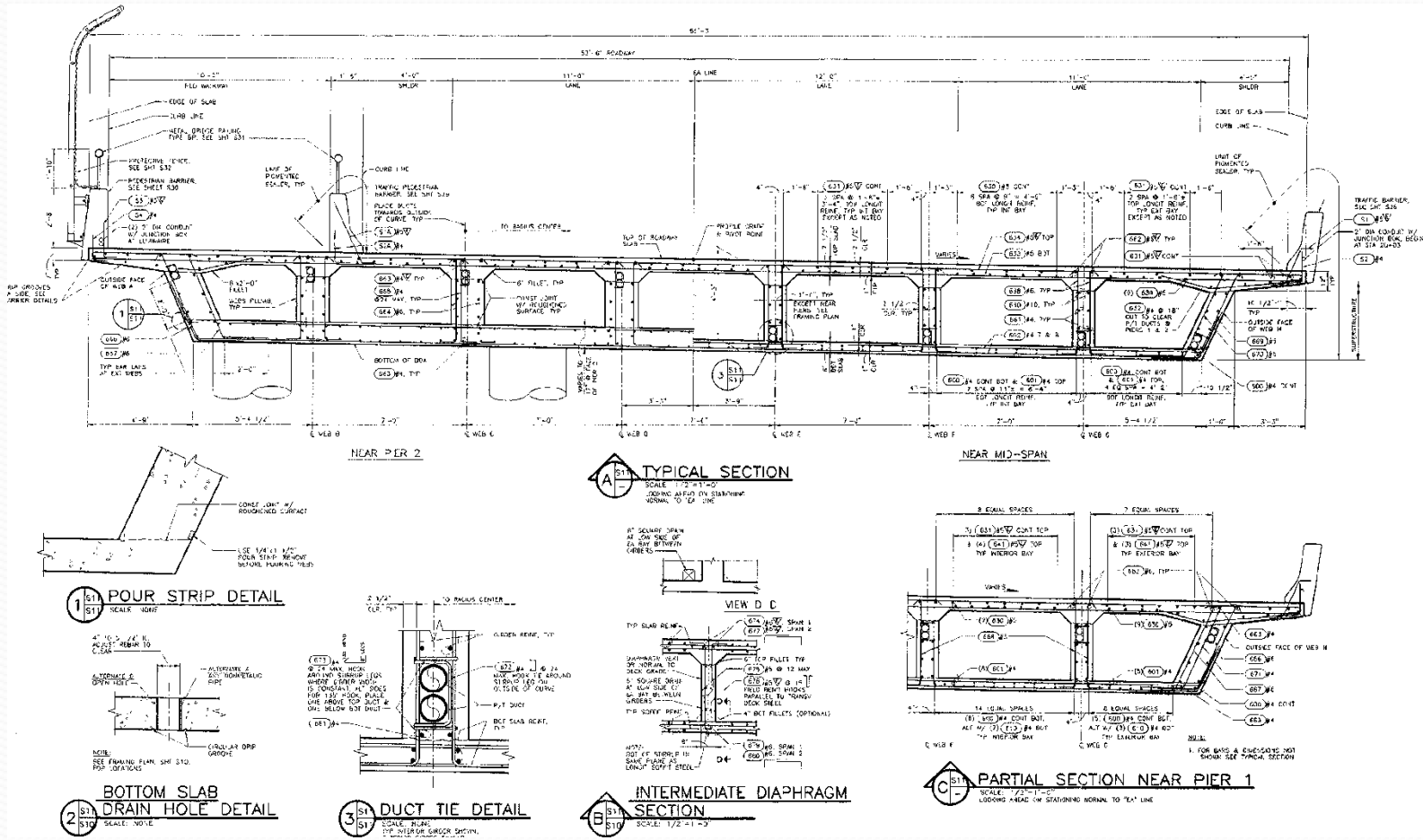


ELEVATION
1"=20'

GRADE ELEVATIONS SHOWN ARE FINISH GRADES AT TOP OF
ROADWAY SLAB ON EA-LINE AND ARE EQUAL TO PROFILE GRADE.

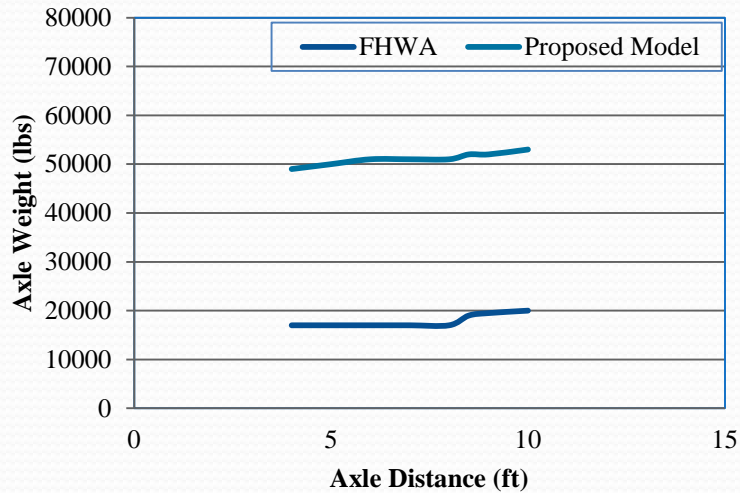
Elevation

California St. Overcrossing

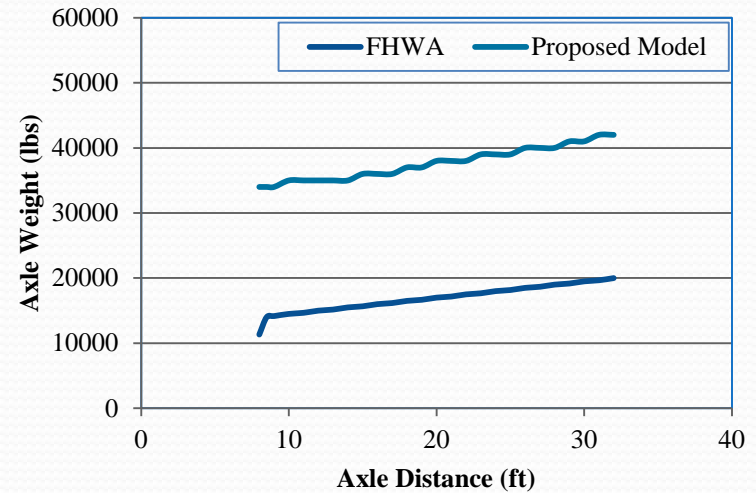


Bridge Cross Section

California St. Overcrossing

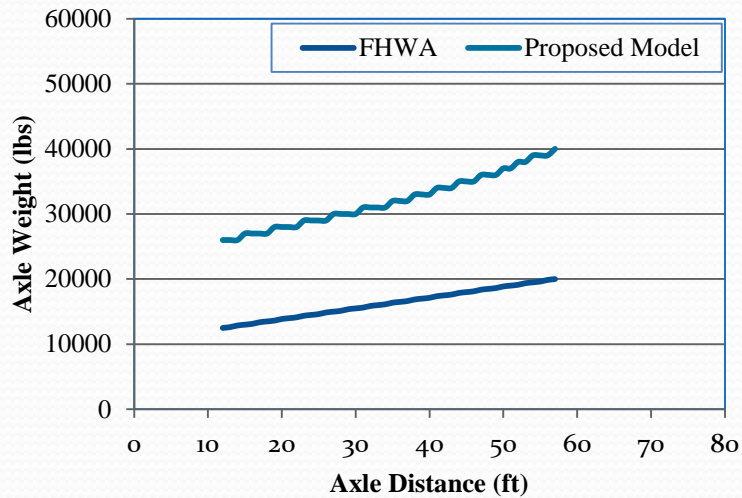


2 Axle Truck

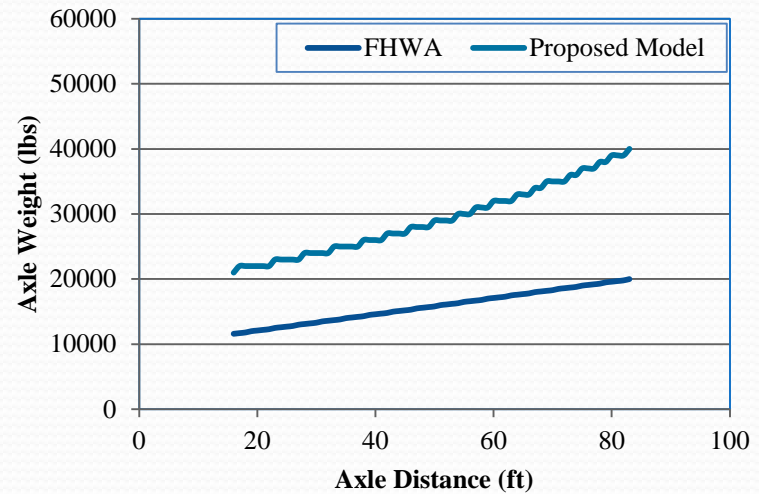


3 Axle Truck

California St. Overcrossing

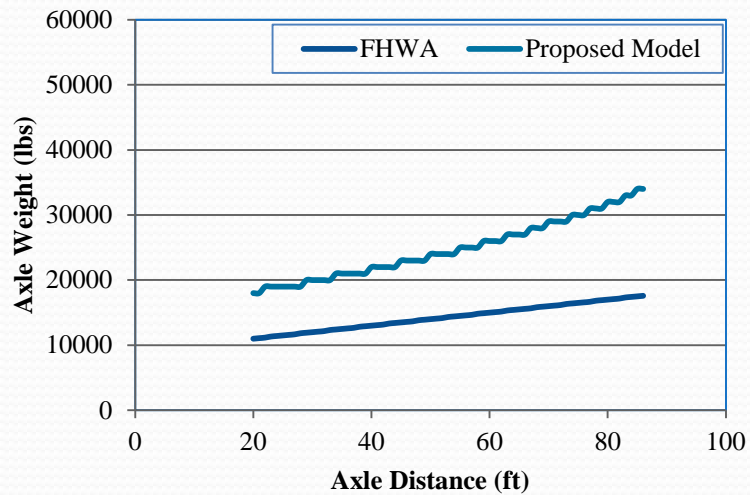


4 Axle Truck

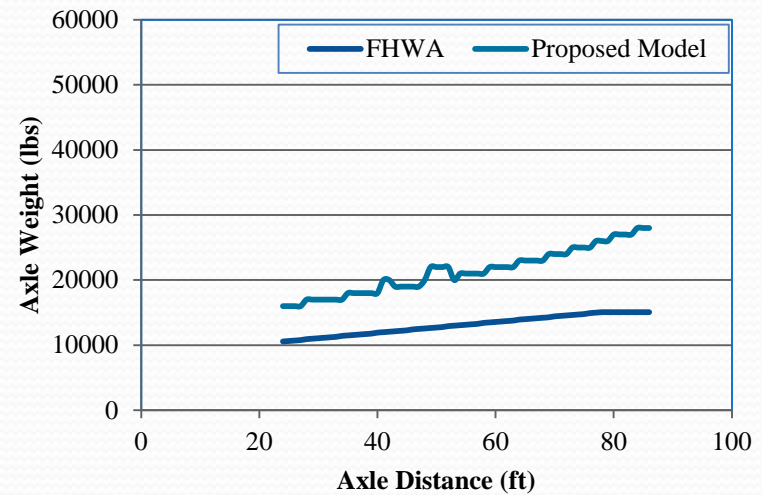


5 Axle Truck

California St. Overcrossing

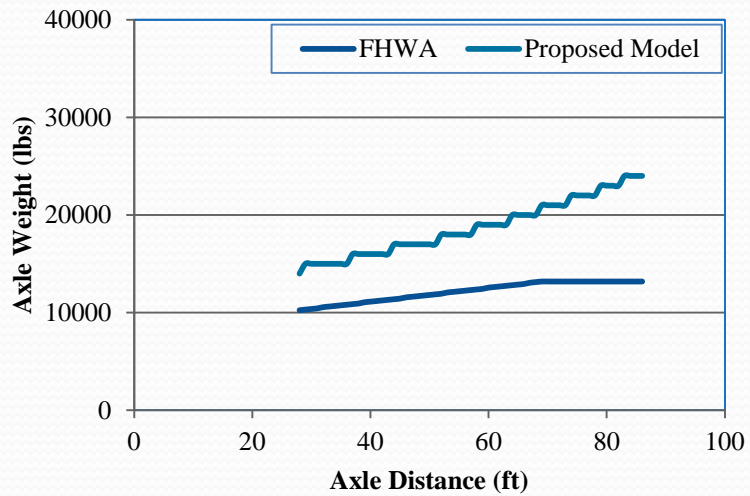


6 Axle Truck

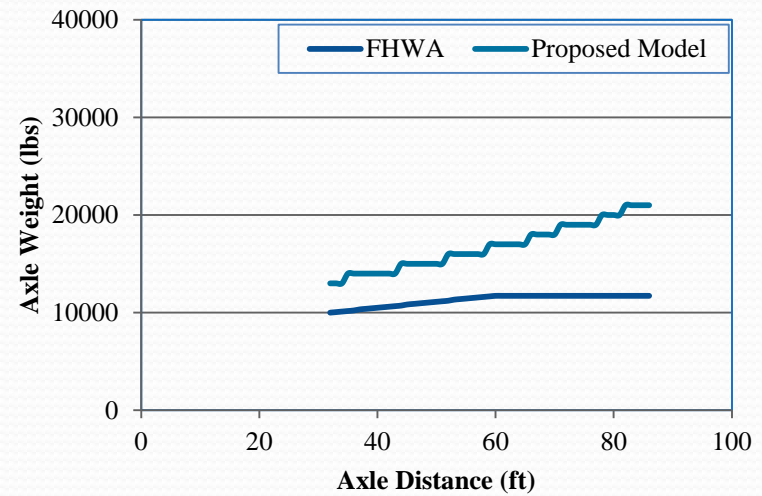


7 Axle Truck

California St. Overcrossing



8 Axle Truck

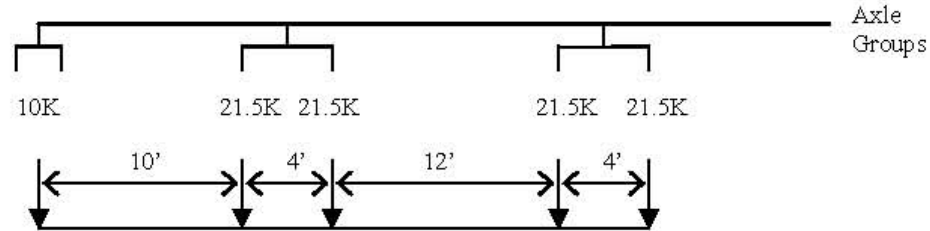


9 Axle Truck

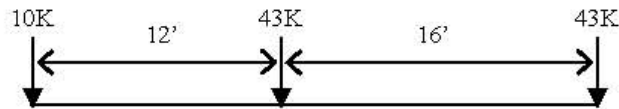
California St. Overcrossing

- FHWA Weight Formula underestimates the capacity of the Bridge
- FHWA Weight Formula does not consider the current condition of the Bridge
 - Old Bridge = New Bridge
 - Deteriorated Bridge = Good/Fair Bridge
- Overload trucks have less chance of passing a Bridge if FHWA formula is followed.

California St. Overcrossing



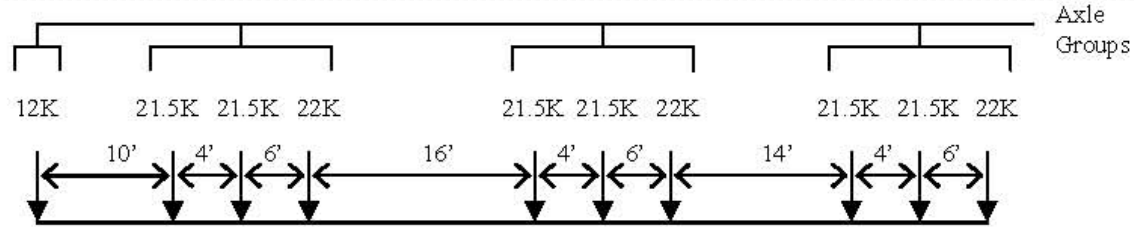
(a) OL-1 Class Truck



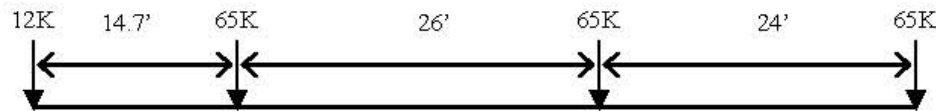
(b) Condensed OL-1 Class Truck

S23 (ft)	Axle Weight (K)
14	50
16	52
18	53
20	54
22	55
24	56
26	58
28	59
30	61

California St. Overcrossing



(a) OL-2 Class Truck



(b) Condensed OL-2 Class Truck

		S34 (ft)								
S23 (ft)		14	16	18	20	22	24	26	28	30
	14	38	39	40	40	41	42	43	43	44
	16	39	40	41	42	42	43	44	45	46
	18	40	41	41	42	43	44	45	46	46
	20	41	42	43	44	45	45	46	47	48
	22	42	42	43	44	45	46	47	48	49
	24	43	44	44	45	46	47	48	49	50
	26	43	44	45	46	47	48	49	50	52
	28	44	45	46	47	48	49	50	51	53
	30	46	47	48	49	50	51	53	54	55

Load Rating Summary



Project:	City of Everett Bridge Load Rating	Computed	JK	Date	7/30/2008
Bridge Name:	California St Overcrossing	Checked	VP	Date	8/11/2008
Bridge Number:	EVTB1	Sheet	1	of	4

BRIDGE RATING SUMMARY

Bridge Name: California St Overcrossing
 Bridge Number: EVTB1
 Span Types: Concrete Box Girder
 Bridge Length: 177' (77': 100')
 Design Load: HS25 or Two 24K axles at 4 ft.
 Rated By: JK
 Checked By: VP
 Date: 8/14/2008



Truck	RF	γ	Controlling Point
HS-20	1.5	Service	M at 52 ft from Pier 2 of Span 2, Girder H
AASHTO 1	2.07	Service	M at 53 ft from Pier 2 of Span 2, Girder H
AASHTO 2	1.72	Service	M at 35 ft from Pier 1 of Span 1, Girder H
AASHTO 3	1.64	Service	M at 35 ft from Pier 1 of Span 1, Girder H
OL-1	1.23	Service	M at 53 ft from Pier 2 of Span 2, Girder H
OL-2	0.78	Service	M at 53 ft from Pier 2 of Span 2, Girder H
HS-20 Lane	1.82	Service	M at 52 ft from Pier 2 of Span 2, Girder H

NBI Rating	RF	Tons (US)	Controlling Point
Inventory	1.21	43.56	V at Pier 2, Girder H
Operating	2.02	72.72	V at Pier 2, Girder H

Remarks: Truck load posting is NOT required

Check for OL-1

- ▶ Using Eqn. (1), the second, third and fourth axle group loads (R) are:

$$R = \sum_{i=1}^n W_i = 21.5 + 21.5 = 43 K$$

- ▶ Using Eqn. (2) the location of the weight of the axle group from the first axle in the group is:

$$d = \frac{\sum_{i=1}^n W_i d_i}{R} = \frac{21.5 \times 0 + 21.5 \times 4}{43} = 2.0'$$

- ▶ $S_{23}=16$ feet, the maximum allowable weight on an axle group is 52,000 pounds. The OL-1 truck has axle group weight of 43,000 pounds hence the truck shall be permitted to pass the Bridge.
- ▶ The minimum Rating Factor (RF) for this OL-1 class truck can be estimated from the following relationship:

$$RF = \frac{52}{43} = 1.21 \sim 1.23$$

Check for OL-2

- ▶ Using Eqn. (1), the second, third and fourth axle group loads (R) are:

$$R = \sum_{i=1}^n W_i = 21.5 + 22 + 21.5 = 65 K$$

- ▶ Using Eqn. (2) the location of the weight of the axle group from the first axle in the group is:

$$d = \frac{\sum_{i=1}^n W_i d_i}{R} = \frac{21.5 \times 0 + 21.5 \times 4 + 22 \times 10}{65} = 4.7'$$

- ▶ $S_{23}=26$ feet and $S_{34}=24$ feet, the maximum allowable weight on an axle group is 48,000 pounds. The OL-2 truck has axle group weight of 65,000 pounds hence the truck shall be permitted to pass the Bridge.
- ▶ The minimum Rating Factor (RF) for this OL-2 class truck can be estimated from the following relationship:

$$RF = \frac{48}{65} = 0.74 \sim 0.78$$

LR Factor Comparison

	HS20	AA-1	AA-2	AA-3	OL-1	OL-2
Improved Method	1.45	2.0	1.79	1.73	1.18	0.74
Exact Method	1.5	2.07	1.72	1.64	1.24	0.78
Error (%)	-3.3	-3.3	+4.1	+5.5	-4.8	-5.1

Concluding Remarks

- A method is developed to assist bridge owners to quickly assess if a permit truck can safely cross a particular bridge.
- The method uses the Rating Factor (RF) as the threshold to determine the limit axle weight.
- Permit trucks of up to nine axles of different spacing from 4'-86' are considered in the present study.
- The method can be used as a reliable and cost effective tool to load rate permit trucks with less than 5% of discrepancy compared to the exact method.
- The method provides more accurate results compared to the FHWA Table.