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Course Description

Session 4: Loads and Analysis

August 8, 2016

The load models, consisting of magnitude, configuration and application of loads, are unique to the AASHTO *LRFD Bridge Design Specifications*. This session begins with an explanation of these load models, particularly the HL-93 live load model, along with their development. The live load analysis methods, categorized as approximate and refined methods, are presented. Modern load distribution factors are discussed and compared with the traditional distribution factors of the AASHTO *Standard Specifications for Highway Bridges*. The majority of highway bridges in our nation's inventory are designed to these specifications. Finally, the guidelines for refined analysis including the finite element method (FEM) are reviewed.

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Learning Objectives

- Become familiar with the load models presented in the AASHTO *LRFD Bridge Design Specifications*.
- Become familiar with the live load analysis, both approximate and refined methods.
- Gain and understanding of the modern load distribution factors and how they compare with the traditional distribution factors of AASHTO *Standard Specifications for Highway Bridges.*
- Gain an understanding for refined analysis methods including finite element method (FEM).

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Introduction to Steel Bridge Design

Session #4: Loads and Analysis

Presented by
John Kulicki, Ph.D., P.E.
Modjeski and Masters
Mechanicsburg, PA

structural STEEL

Night School Course B1

Introduction to Steel Bridge Design

- June 6 - Session 1: Introduction to Bridge Engineering
- June 13 - Session 2: Introduction and History of AASHTO LRFD Bridge Design Specifications
- June 20 - Session 3: Steel Material Properties
- **August 8 - Session 4: Loads and Analysis**
- July 11 - Session 5: Steel Bridge Fabrication
- July 18 - Session 6: Plate Girder Design and Stability
- July 25 - Session 7: Effects of Curvature and Skew
- August 1 - Session 8: Fatigue and Fracture Design

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Lesson Agenda

- Introduction
- Loads
  - Permanent Loads
  - Transient Loads
- Limit-State Load Combinations
  - Strength
  - Service
  - Extreme-Event
  - Fatigue and Fracture
- Analysis
  - Approximate Methods
  - Refined Methods

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Basic Concepts

- Design Life - Period of time on which the statistical derivation of transient loads is based: 75 years for these Specifications.

  Assumes that bridge is maintained

- Service life – The period of time that the bridge is expected to be in operation

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Limit States

- Service Limit States - relate to stress, deformation, and cracking under regular operating conditions
- Strength Limit States - relate to strength and stability during the design life
- Extreme Event Limit States - relate to events such as earthquakes, ice load, and vehicle and vessel collision, with return periods in excess of the design life of the bridge.
- Fatigue and Fracture – covered in session 8

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Introduction

- Highway-bridge design in the USA is typically as specified in the AASHTO *LRFD Bridge Design Specifications*.
- Section 1: Introduction, defines the limit states & the LRFD limit-state function.
- Section 3: Loads and Load Factors, specifies loads, their load factors & combinations.
- Section 4: Structural Analysis and Evaluation, indicates the acceptable methods.

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Basic Equation - Load and Resistance Factor Design

$$\eta \Sigma \gamma_i Q_i \leq \phi \; R_n = R_r$$

- in which:
- η = Factor for importance, redundancy and ductility
- R_n = Nominal resistance
- Q_i = Nominal load i
- γ_i = load factor: a statistically based multiplier on force effects
- ϕ = resistance factor: a statistically based multiplier applied to nominal resistance

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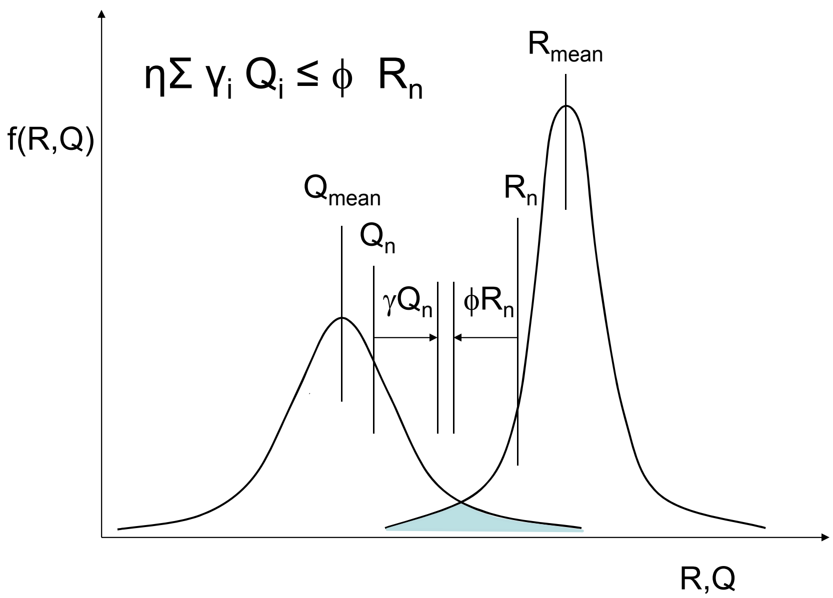
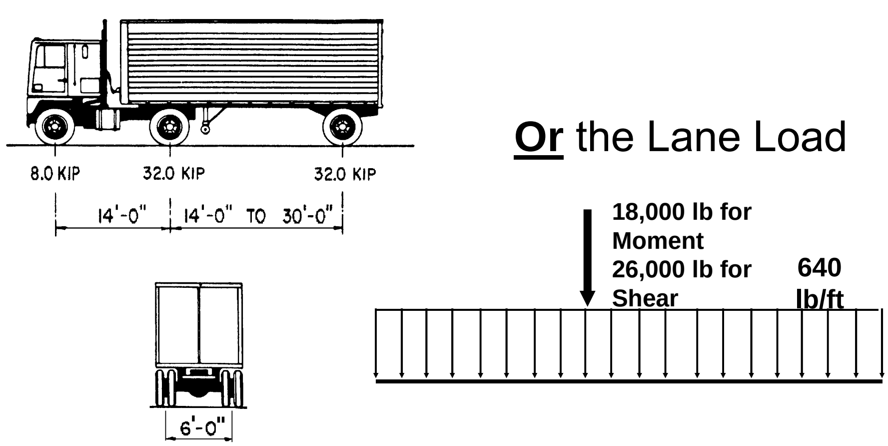


H20-S16-44 AASHTO *Standard Specifications* From Mid 40's



HL-93 NOTIONAL LIVE LOAD MODEL for Design

(<u>Hi</u>ghway <u>L</u>oad – 19<u>93</u>)

Projected for 75 Year Design Life

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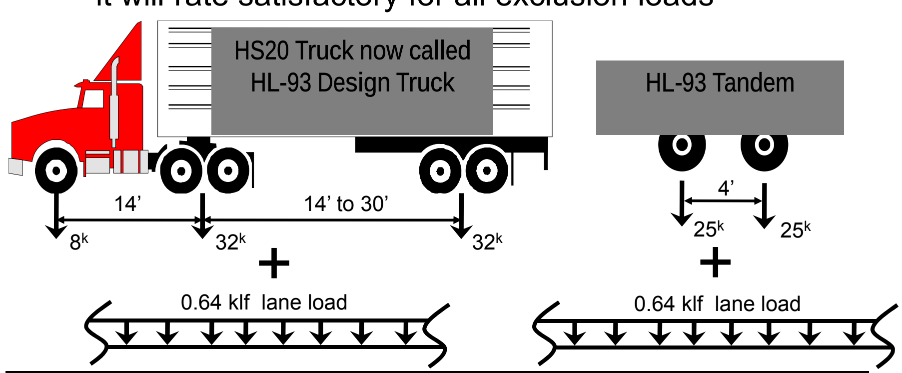
HL-93 Design Load Model

- Envelope loading for “Worst Case” exclusion loads
- If bridge is rated satisfactory with this load,
  it will rate satisfactory for all exclusion loads



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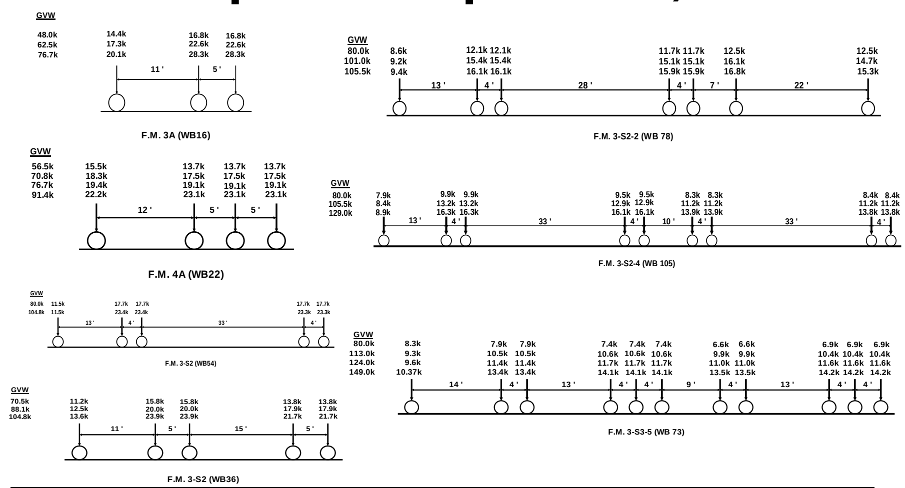
"Exclusion Loads" – Adapted from TRB Special Report 225, 1990



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Does the HS20-44 Live Load Model Represent Today's Traffic?

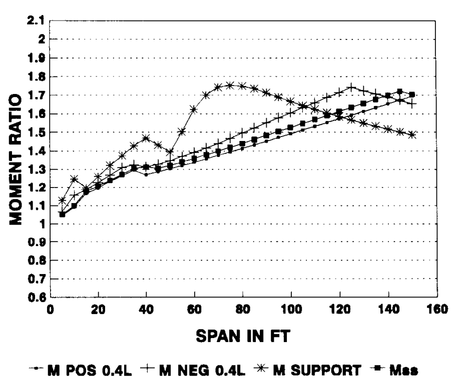

Figure C3.6.1.2.1-5 - Moment Ratios - Notional Model to HS20 (truck or lane) or two 24.0-KIP Axles at 4.0 FT

Today's truck traffic produces live load moments and shears significantly greater than those represented by the HS20-44 live load model, especially for longer spans.

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How About the HL-93?

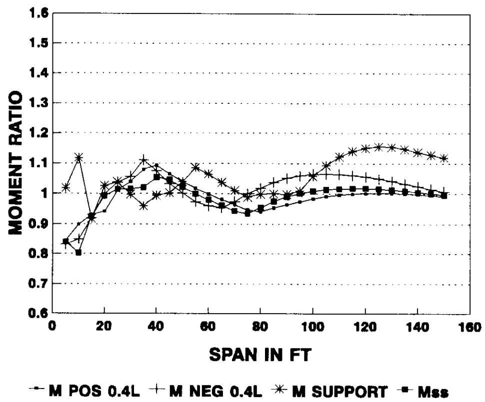

Figure C3.6.1.2.1-3 - Moment Ratios - Exclusion Vehicles to Notional Model

New "notional" live load model simulates the shear and moment effects of a group of "exclusion" vehicles currently allowed to routinely travel on highways in various states.

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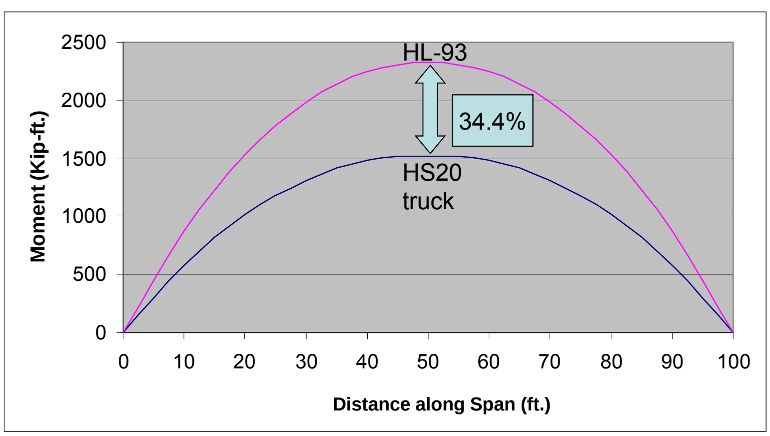
HL-93 vs. HS20 Live-Load Moment For a 100 Ft Simple Span



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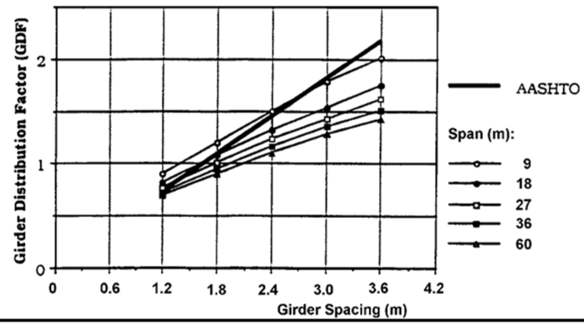
New Distribution Factors – Empirical Method of Assigning Load to Bridge Components

- Example: Multi-Lane Loading in Girder Bridge

$$g = 0.075 + \left(\frac{S}{2900}\right)^{0.6}\left(\frac{S}{L}\right)^{0.2}\left(\frac{K_g}{Lt_s^3}\right)^{0.1}$$



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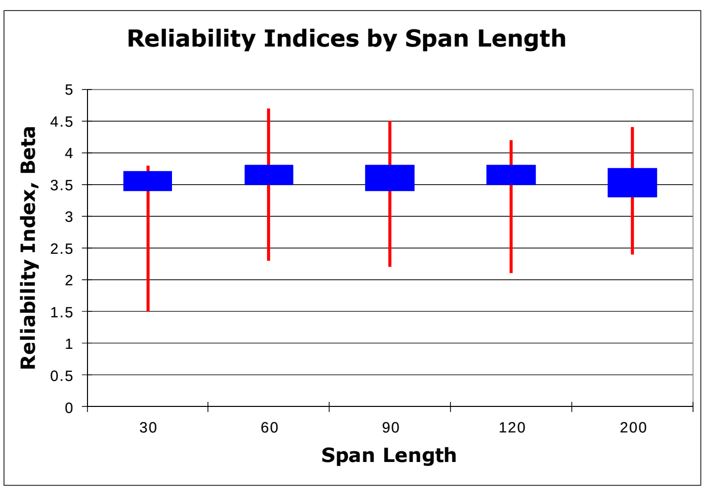

Current AASHTO LRFD Spec
Former AASHTO Standard Spec

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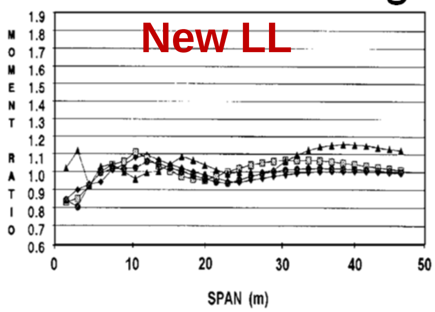
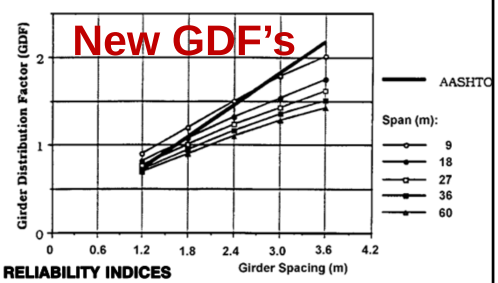
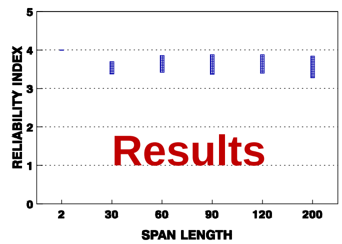
Getting It Together





RELIABILITY INDICES
PROPOSED - PRELIM

New
$\gamma's, \phi's$



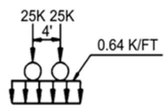
Summary of Live Load and Distribution

- What should you see in designs
  - Many designs will be similar, some won't
  - If DF was "improved," the HL 93 will be muted
  - Exterior often carries more LL
  - Shear often proportionately bigger change than moment
  - If DF unchanged, HL 93 can be a big impact

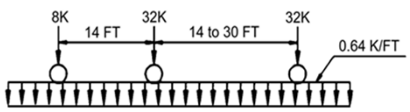
Notional Design Load – HL-93

Article 3.6.1.2

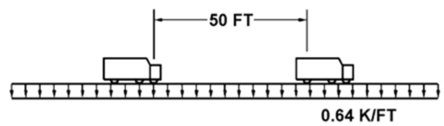
Design Tandem + Lane Load



Design Truck + Lane Load



90% of Two Design Trucks
+
90% Lane Load



- NEGATIVE MOMENT AND INTERIOR REACTIONS
- ≥ 50 FT
- FIXED WHEELBASE ON TRUCK = 14 FT

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New Design Vehicular LL

The total live load *demand* is also a function of:

- The load factor
- Load distribution - analysis
- Multiple presence – number of loaded lanes
- Dynamic load allowance (*impact*)

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Multiple Presence

Article 3.6.1.1.2

Number of Loaded Lanes	Multiple Presence Factors, *m*
1	1.20
2	1.00
3	0.85
>3	0.65

Dynamic Load Allowance, IM

Article 3.6.2.1

Component	IM
Deck Joints - All Limit States	75%
All Other Components • Fatigue and Fracture Limit State	15%
• All Other Limit States	33%

Dynamic Load Allowance, IM

- Design truck or tandem, not lane load
- Not applicable for walls with no superstructure reaction
- Not applicable for foundations completely below ground

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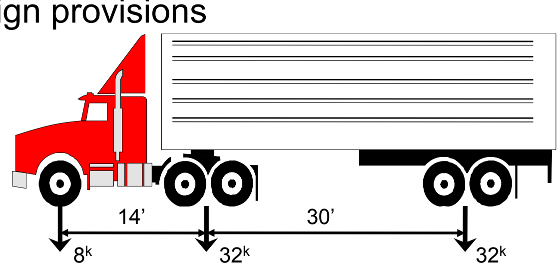
Fatigue Check Loading

Article 3.6.1.4.1

- Basic Design Truck with constant spacing of 30' between rear axles – one lane, no MPF
- Check susceptible fatigue details
- Rating process consistent with LRFD fatigue design provisions



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Load Designations

- All loads are categorized as permanent or transient to simplify the process of assigning load factors.
- Permanent loads are always present and factored by a maximum or minimum load factor.
- Transient loads are present and multiplied by a "maximum" load factor or not applied.

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Characterization of Loads

Permanent Loads

Dead Loads (Article 3.5.1)

- **DC -** dead load of structural components & nonstructural attachments
- **DW -** dead load of wearing surfaces and utilities
- **EV -** vertical pressure from dead load of earth fill

Earth Loads (Article 3.5.2)

- **EH -** horizontal earth pressure load
- **ES -** earth surcharge load
- **DD -** downdrag force

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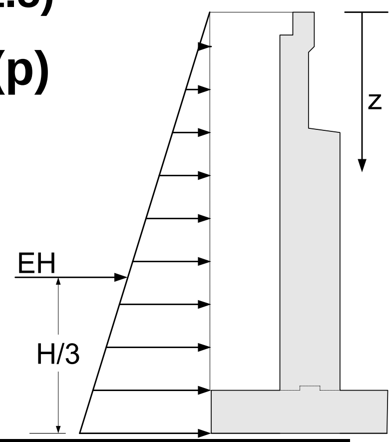
EH – horizontal earth pressure load

(Article 3.11.5)

lateral earth pressure (p)

- $p = k \gamma_s z$
- $k = k_o, k_a, \text{or } k_p$
- γ_s = unit weight of soil



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EH –horizontal earth pressure

- Permanent walls
- Temporary walls – discrete & continuous elements
- Anchored walls – single & multi-level anchors
- Mechanically Stabilized Earth walls
- Prefabricated modular walls

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ES – Surcharge Loads
(Article 3.11.6.1)

Uniform surcharge loads

- $D_p = k_s q_s$
- k_s = coefficient of earth pressure due to surcharge
- q_s = uniform surcharge applied to upper surface of active earth wedge (ksf)

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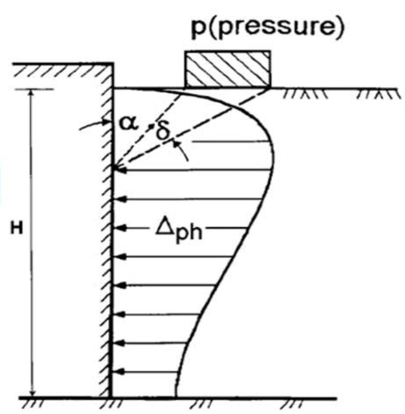
Uniformly Loaded Strip
(Article 3.11.6.2)

$$\Delta_{ph} = \frac{2p}{\pi}\left[\delta - \sin\delta\cos(\delta + 2\alpha)\right]$$



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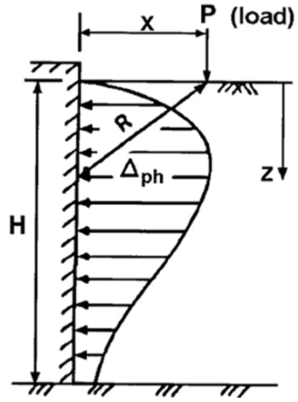
Point load
(Article 3.11.6.2)

$$\Delta_{ph} = \frac{P}{\pi R^2}\left[\frac{3ZX^2}{R^3} - \frac{R(1-2\nu)}{R+Z}\right]$$



Similar provisions for flexible walls
(Article 3.11.6.3)

DD – Downdrag
(Article 3.11.8)

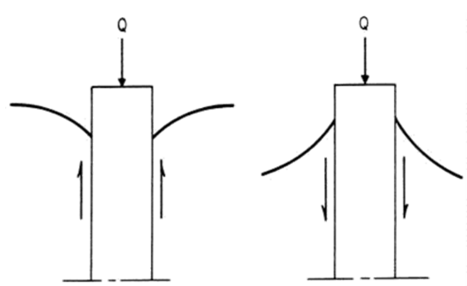
Ground settlement adjacent to pile/shaft

- a, b or l method

  DD = aS_u

  DD = bs'_v

  DD = l(s'_v + 2S_u)



Characterization of Loads

Transient Loads

Live Loads (Article 3.6)

- **LL** – vehicular live load
- **PL** – pedestrian live load
- **IM** – dynamic load allowance
- **CE** – centrifugal load
- **BR** – braking force
- **CT** – truck collision
- **LS** – live-load surcharge (Article 3.11.6.4)

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Characterization of Loads

Transient Loads

Water Load (Article 3.7)

- **WA –** water load

Wind Load (Article 3.8)
- **WS** – wind on structure
- **WL** – wind on live load

Ice Load (Article 3.9)
- **IC** – ice load

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Characterization of Loads

Transient Loads

Earthquake (Article 3.10)

- **EQ –** earthquake – see also Seismic Guide Spec

Superimposed Deformations (Article 3.12)

- **TU** – uniform temperature
- **TG** – temperature gradient
- **SH** – shrinkage
- **CR** – creep
- **SE** – settlement

Characterization of Loads

Transient Loads

Friction (Article 3.13)

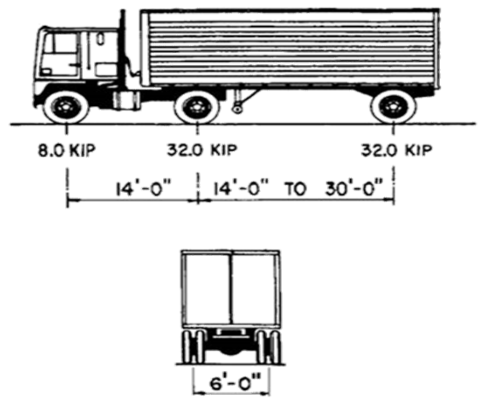
- **FR –** friction

Vessel Collision (Article 3.14)

- **CV** – vessel collision

Transient Loads

- **LL – Vehicular Live Load**
  - HL-93
  - Superposition of vehicle and lane
  - Multiple presence factors



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Transient Loads

- **PL – Pedestrian Loads (Article 3.6.11.6)**
  - 0.075 ksf when sidewalks ≥ 2.0 ft
  - 0.085 ksf when pedestrian or bicycle only bridge
- **IM – Dynamic Load Allowance (Article 3.6.2.1)**
  - Already covered

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Transient Loads

- **BR – Braking Force (Article 3.6.4)**
  - 25% of design truck or tandem axle load
  - 5% of design truck or tandem + lane load
  - number of lanes & traffic direction
- **CE – Centrifugal Force (Article 3.6.3)**
  - Applies to bridges on horizontal curves
  - Design truck or tandem times C
  - $C = 4v^2 / 3gR$
    - V = Velocity
    - g = gravity
    - R = radius

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Transient Loads

- **CT – Vehicular Collision (Article 3.6.5)**
  - 400 kip force in horizontal plane
  - Substructures within 30.0 ft from roadway or 50.0 ft from CL of railway track
- **CV – Vessel Collision (Article 3.14)**
  - Ship collision
  - Barge collision

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Transient Loads

- **IC – Ice Loads (Article 3.9)**

Ice crushing or failure by bending

- if $w/t \leq 6.0$, F = lesser of F_c or F_b
- if $w/t > 6.0$, $F = F_c$

$$F_c = C_a p\ t\ w \qquad F_b = C_n\ p\ t^2$$

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Transient Loads

- **FR – Friction Forces (Article 3.13)**
  - Caused by sliding between members
  - Use extreme friction coefficients between surfaces
- **LS – Live load surcharge (Article 3.11.6.4)**
  - Live load within ½ wall height behind wall
  - $\Delta p = k_s \gamma_s h_{eq}$ k_s taken as k_o or k_a
  - h_{eq} a function of wall height

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Transient Loads

- **WA – Water Loads (Article 3.7) Static pressure, buoyancy, stream pressure**
  - Longitudinal stream pressure:

$$p = \frac{C_D V^2}{1000}$$

  - Lateral stream pressure:

$$p = \frac{C_L V^2}{1000}$$

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Transient Loads

- **WS, WL – Wind Loads (Article 3.8)**

Wind on structure, design load

$$P_D = P_B \left(\frac{V_{DZ}}{V_B} \right)^2 = \left(P_B \frac{V_{DZ}^{\ 2}}{10{,}000} \right)$$

Wind on live load

– 0.10 klf acting on structure
– Applied 6.0 ft above roadway surface

Vertical wind pressure

– Applied only when WL is not present and WS is perpendicular

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Transient Loads

- **TU, TG, CR, SH, SE – Superimposed-Deformation Force Effects (Article 3.12)**

  Internal forces due to
  - Temperature changes
  - Creep/shrinkage
  - Settlement

  Consider for substructure design, especially for longer spans

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Loads & Load Factors at each Limit-state Load Combination

- **Applicable loads at each combination**
- **Load factors**
  - Permanent (maximum & minimum)
  - Transient
- **Load modifiers**
  - Ductility, redundancy, importance

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Load Combinations

- **AASHTO Table 3.4.1-1**
  Load Combinations and Load Factors
- **AASHTO Table 3.4.1-2**
  Load Factors for Permanent Loads
- For each limit state load combination

$$\eta \ \Sigma\gamma_i \ Q_i \leq \phi \ R_n$$

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Load Combinations and Factors

Load Combination Limit State	DC DD DW EH EV ES EL PS CR SH	LL IM CE BR PL LS	WA	WS	WL	FR	TU	TG	SE	Use One of These at a Time				
										EQ	BL	IC	CT	CV
Strength I (unless noted)	γ_p	1.75	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength II	γ_p	1.35	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength III	γ_p	—	1.00	1.40	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength IV	γ_p	—	1.00	—	—	1.00	0.50/1.20	—	—	—	—	—	—	—
Strength V	γ_p	1.35	1.00	0.40	1.0	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Extreme Event I	γ_p	γEQ	1.00	—	—	1.00	—	—	—	1.00	—	—	—	—
Extreme Event II	γ_p	0.50	1.00	—	—	1.00	—	—	—	—	1.00	1.00	1.00	1.00
Service I	1.00	1.00	1.00	0.30	1.0	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Service II	1.00	1.30	1.00	—	—	1.00	1.00/1.20	—	—	—	—	—	—	—
Service III	1.00	0.80	1.00	—	—	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Service IV	1.00	—	1.00	0.70	—	1.00	1.00/1.20	—	1.0	—	—	—	—	—
Fatigue I—LL, IM & CE only	—	~~1.50~~ 1.75	—	—	—	—	—	—	—	—	—	—	—	—
Fatigue II—LL, IM & CE only	—	~~0.75~~ 0.80	—	—	—	—	—	—	—	—	—	—	—	—

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Permanent-Load Load Factors

Table 3.4.1-2 – Load Factors for Permanent Loads, γ_P

TYPE OF LOAD		LOAD FACTOR MAXIMUM	LOAD FACTOR MINIMUM
DC: component & attachments		1.25	0.90
DD: downdrag	piles, α method	1.4	0.25
	piles, λ method	1.05	0.30
	shafts, O'Neill & Reese method	1.25	0.35
DW: wearing surface & utilities		1.50	0.65
EH: horizontal earth pressure			
•active		1.50	0.90
•passive		1.35	0.90
EL: locked-in erection stresses		1.00	1.00
EV: vertical earth pressure			
•overall stability		1.00	N/A
•retaining walls & abutments		1.35	1.00
•rigid buried structures		1.30	0.90
•rigid frames		1.35	0.90
•flexible buried structures other than metal box culverts		1.95	0.90
•flexible metal box culverts		1.50	0.90
ES: earth surcharge		1.50	0.75

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Maximum/minimum Loads Factors for Permanent Loads

- Select to produce maximum/minimum total force effects
- Loads that reduce the force effect being considered should be factored by the minimum load factor

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Analysis

- Approximate and refined analysis methods are allowed.
- Approximate methods, for the most part, consist of the load distribution factors developed by Dr. Roy Imbsen in NCHRP 12-26.
- Refined methods, in practice, are grid models for slab-on-girder bridges.

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FHWA Manual of Refined Analysis

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Why Refined Analysis?

- LRFD requires it
  - Heavy skew
  - Sharp curvature
  - Large variations in stiffness
- Significant savings can be realized
  - Conservatism in distribution factors

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Why Refined Analysis?

- Provides better understanding of behavior
- It's becoming easier
- A better alternative to posting, repair, or replacement

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It Needs to be Done Correctly

- Sometimes harder to find errors
- Complexity can obscure behavior
- Need for guidance and benchmarks
  - Currently scattered
  - Not necessarily bridge focused

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Background

- FHWA determined that a manual was needed to improve consistency of application and make use of refined analysis easier to employ
- Task in cooperative agreement with Lehigh U. – Modjeski and Masters is writing manual as sub

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Background

- Manual development spread over 2 tasks
  - Task 1 Complete
  - Draft manual is available on FHWA website

  www.fhwa.dot.gov/bridge/refined_analysis.pdf
- Task 2 is underway

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Objectives and Approach

- Provide greater consistency in application of FEA to bridge structures
  - Raise the level of basic understanding to encourage wider application of FEA
  - Avoid blunders
  - Understand behavior
  - Introduce economies

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Approach to Manual

- Keep flexible
- Encourage initiative and creativity
- Avoid deep mathematics
- Concentrate on application
- Avoid software specifics to extent possible – try to stay generic

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Division of Topics

- Task 1
  - Focuses on most common bridge types
  - Minimal material-specific topics
  - Linear elastic behavior only
  - No dynamic, only static
- Task 2
  - Material specific topics
  - Nonlinear behavior
  - Dynamic behavior

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Task 1 Chapter List

- Section 1 – Foreword
- Section 2 – Refined Methods of Analysis
- Section 3 – Modeling
- Section 4 – Verification
- Section 5 – Load Application
- Section 6 – Analysis to Design
- Section 7 – Examples

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The Basics

- Introductory chapter
  - Addresses purpose and goal of the manual
  - Provide background on development of FEA
- Definitions provided for 1D, 2D, and 3D
  - Based on how many dimensions are required to identify location of result quantities
  - Dimension can be curved

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The Basics

- Grillage Analysis
  - In-depth details on Plate with Eccentric Beam (PEB)
  - Grillage (grid in AASHTO) is popular with some software, and is a refined analysis when compared to 1D methods
  - Advantages and disadvantages discussed, as well as guidance on implementation

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The Basics

- Spine Beam Modeling
  - Example added to show spine beam modeling of a CIP multi-cell concrete box
  - Could be applied to single or multi-cell steel box

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The Basics

- Use of FEA with Strut and Tie modeling
  - Addresses disturbed regions in concrete bridges
  - Provides guidance on how to use an FEA to develop an accurate S&T model for design
- Use of FEA with Principle Stress Checks
  - Guidance on implementation on latest changes in Section 5 of AASHTO LRFD.

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Some Highlights

- Examples contain comparisons of results from 1D, 2D, and 3D analysis of same bridge
  - 2D and 3D have definite advantages vs 1D
- Steel Examples include:
  - steel girders straight/square,
  - steel girders curved/skewed
- Concrete Examples Too.

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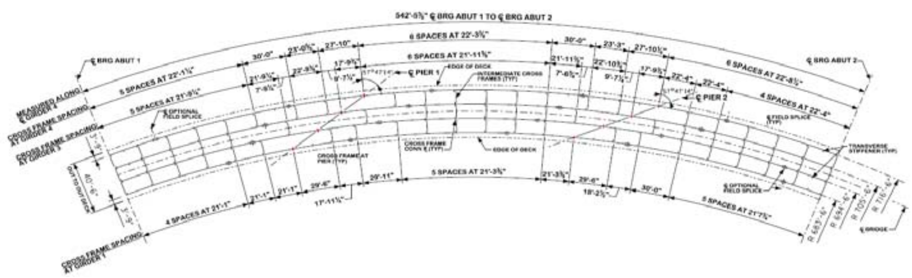
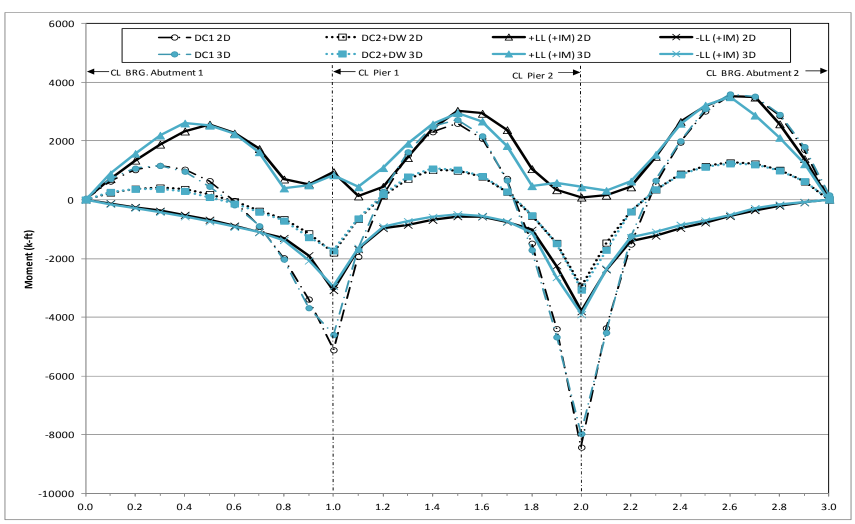
Example 3 – Curved Skewed Bridge



2D vs. 3D Results - Moments



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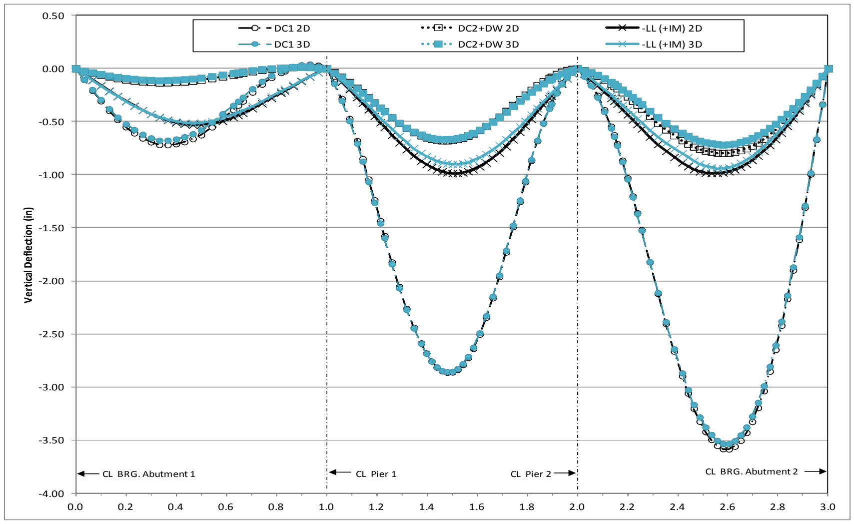
2D vs. 3D Results - Deflections



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Task 2 Chapters (In Progress)

- Concrete Bridges
- Prestressing
- Steel Bridges
- Soil Structure Foundation Interaction
- Steel Connections
- Nonlinear Modeling
- Stability Analyses
- Dynamic Analyses
- Examples

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AASHTO Legal Load Models for Purposes Other Than Design

- Used for Ratings and Postings (signage)
- Routine Commercial Traffic
  - AASHTO Truck and lane load Models
  - State legal loads
- Specialized Hauling Vehicles
  - Multi-Axle Single Unit Trucks
  - Notional Rating load and 4 single unit configurations

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Rating and Posting of Bridges

- Manual for Bridge Evaluation (MBE)
- Ratings are usable capacity for give loads – possibly at two criteria
- Postings are weight limits - signage
- Multiple Methods : LRFR, ASR, LFR
- Loadings vary with method and purpose
- Usually involve some combination of what follows, and State Legal Loads, HS and HL-93 Loadings

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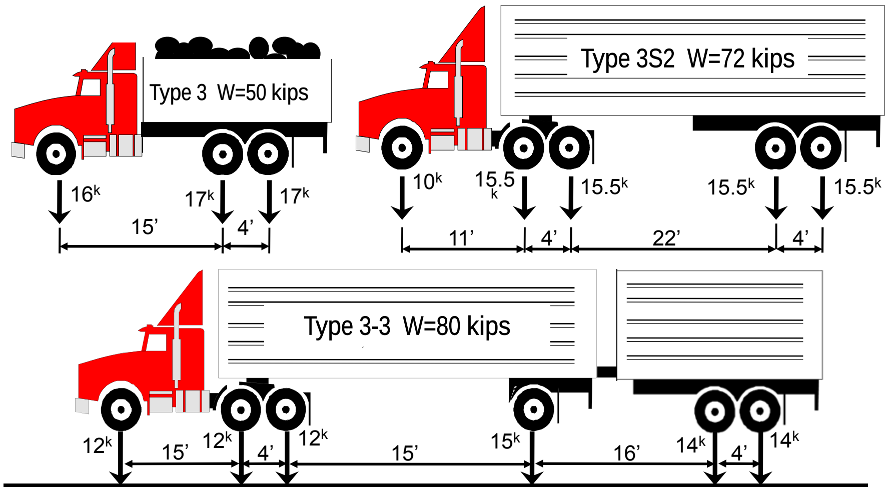
Routine Commercial Traffic
Truck Models AKA Rating Trucks



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Routine Commercial Traffic

Additional Loads For LRFD Ratings

Structure ≤ 200', use each of 3 AASHTO "Legal" trucks and determine controlling vehicle

Type 3, Type 3S2, Type 3-3

Structure > 200', use LRFR legal lane load model

All continuous spans, use LRFR legal lane load model for negative moments & reactions at interior piers

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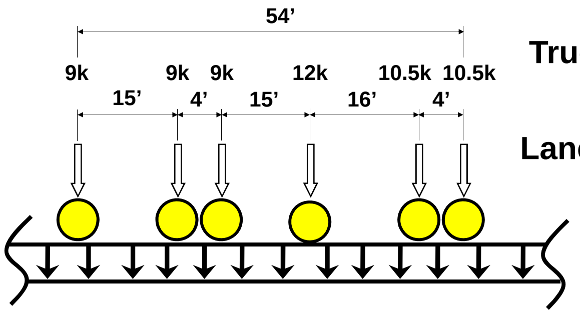
Routine Commercial Traffic Lane Load Model

Additional load model
span length > 200’

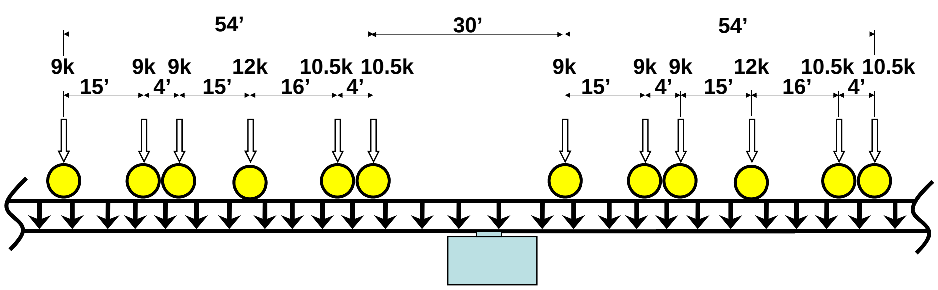


Truck = 75% of Type 3-3 = 60 kips

Lane Load = 0.2 klf

Routine Commercial Traffic Lane Load Model

Additional load model, all span lengths
negative moments & reactions at interior piers



Each Truck = 75% of Type 3-3 = 60 kips
Lane Load = 0.2 klf, Headway Distance = 30’

Specialized Hauling Vehicles (SHV)

Adopted by AASHTO in 2005 to represent new truck models

- Trucks comply with Formula ‘B’ – and meet all Federal weight regulations
- High axle loads concentrated over shorter distance
- Moveable axles – raise/lower as needed for weight

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Federal Weight Limits

- Single Axle Limit – 20,000 lbs
- Tandem Axle Limit – 34,000 lbs
- Gross Vehicle Limit – 80,000 lbs
- Bridge Formula ‘B’

$$W = 500\left\{\frac{LN}{N-1} + 12N + 36\right\}$$

Where N = # of axles
L = distance between first and last axle (ft)
W = weight (lbs)

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Examples of SHVs

SHVs with lift axles

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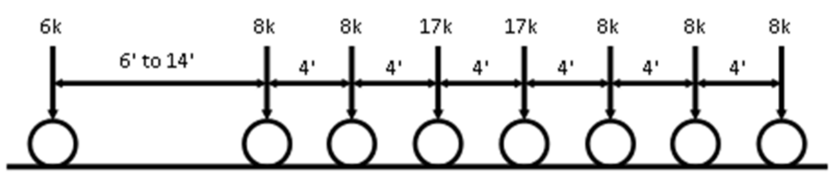
Notional Rating Load (NRL) A Quick Check on SHVs



80 Kips, 30-38 Ft

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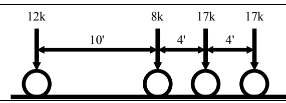
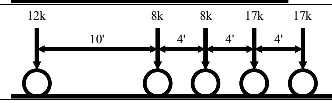
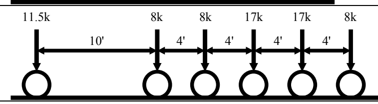
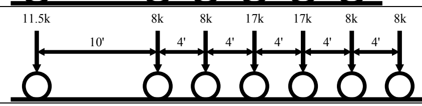
Posting vehicles for FBF-compliant SHVs

Truck Designation	Truck Configuration
SU4	
SU5	
SU6	
SU7	

Rating Process for SHVs

- Be cognizant of SHVs operating in your state
- State specific rules may exist for SHVs
- Single AASHTO Notional Rating Load (NRL) for screening for all SHV configurations
- Four (4) AASHTO SHV configurations for posting

Questions?

8-Session Package Registrants

Course Resources

1. Log on to your AISC account and go to Course Resources. https://www.aisc.org/myaisc/course-resources/
2. Locate your course.
3. Access handouts, videos, quizzes, quiz scores and attendance records.

AISC > MYAISC > COURSE RESOURCES > STEEL BRIDGE DESIGN

Steel Bridge Design

8-SESSION PACKAGE RESOURCES

Event	Date	Handouts	Video	Quiz	Attendance
R1: Introduction To Bridge Engineering	N/A	Handouts	View Passcode: RZNS141	Pass Score: 80	N/A
R2: Introduction and History of AASHTO Bridge Design	N/A	Handouts	Available 9/11/2017 5:00 PM EDT	Available 9/11/2017 5:00 PM EDT	N/A
R3: Steel Material Properties	N/A	Handouts	Available 9/11/2017 5:00 PM EDT	Available 9/11/2017 5:00 PM EDT	N/A
R4: Loads and Analysis	N/A	Handouts	Available 9/11/2017 5:00 PM EDT	Available 9/11/2017 5:00 PM EDT	N/A
L1: Steel Bridge Fabrication	Oct 12 2017 1:30PM EDT	Handouts	Available 10/14/2017 5:00PM EDT	Available 10/14/2017 5:00PM EDT	Pending
L2: Plate Girder Design and Stability	Oct 19 2017 1:30PM EDT	Handouts	Available 10/21/2017 5:00PM EDT	Available 10/21/2017 5:00PM EDT	Pending
L3: Effects of Curvature and Skew	Oct 26 2017 1:30PM EDT	Handouts	Available 10/28/2017 5:00PM EDT	Available 10/28/2017 5:00PM EDT	Pending
L4: Fatigue and Fracture	Nov 2 2017 1:30PM EDT	Handouts	Available 11/04/2017 5:00PM EDT	Available 11/04/2017 5:00PM EDT	Pending
Intro To Steel Bridge Design - Final Exam	Nov 23 2017 8:00AM EST			Available 11/25/2017 5:00PM EST	

There's always a solution in steel!

8-Session Package Registrants

Videos and Quizzes

<u>Videos</u>

- For Sessions R1 – R4, find access to recordings starting September 11. Recording access expires on November 23.
- For Sessions L1 – L4, find access to recordings within two days after the live air date. Recording access expires three weeks after the live session.

<u>Quizzes</u>

- For Sessions R1 – R4, find access to quizzes starting September 11. Quizzes are due on November 23.
- For Sessions L1 – L4, find access to quizzes within two days after the live air date. Quizzes are due three weeks after the live session.
- A final exam will also be given.
- Quiz scores are displayed in the Course Resources table.

There's always a solution in steel!

8-Session Package Registrants

Course Credit

<u>Attendance and PDH Certificates</u>

- For Sessions R1 – R4, you must pass the quiz to receive credit for the session.
- For Sessions L1 – L4, you have two options to receive credit for the session.
  - Option 1: Watch the session live. Credit for live attendance will be displayed in the Course Resources table within two days of the session.
  - Option 2: Watch the recording and pass the quiz.

<u>EEU Certificates – Certificate of Completion</u>

- In addition to PDH certificates earned for each individual session, an EEU (Equivalent Education Unit) certificate of completion will be issued for participants who complete the full course. Participants must pass at least 7 of 8 quizzes and the final exam to earn the EEU.

<u>Distribution of Certificates</u>

- All certificates (PDH and EEU) will be issued after the final session. Only the registrant will receive certificates for the course.

There's always a solution in steel!