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Course Description

Session 2: Introduction and History of AASHTO LRFD Bridge Design Specifications

June 13, 2016

This lecture will introduce the participants to the AASHTO LRFD Bridge Design Specifications (BDS). The session will present a historical background on the evolution of the AASHTO BDS from earlier Allowable Stress Design (ASD) and Load Factor Design (LFD) design methodologies up to the present-day Load and Resistance Factor Design (LRFD) design methodology. The major improvements to the specifications at each step will be highlighted, along with the processes and procedures that are employed to update and maintain the specifications. A broad overview of the LRFD BDS will be provided along with an overview of Section 6 of the BDS on steel structures. The various limit states and the associated behaviors of concern at each limit state for different types of members used in steel bridges will be also discussed. Important design issues related to skewed and curved steel bridges will be briefly highlighted.

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Learning Objectives

- Become familiar with the history of the AASHTO Bridge Design Specification with an emphasis on the major improvements along the way.
- Gain an understanding of the present day LRFD design methodology as well as the processes and procedures employed to update and maintain the specifications.
- Become familiar with Section 6 – Steel Structures of the AASHTO Bridge Design Specification and be introduced to limit states addressed in Section 6.
- Be introduced to skewed and curved bridges and their design challenges pertaining to torsion, uplift, differential deflections and more.

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Introduction to Steel Bridge Design

Session 2: Introduction and History of AASHTO LRFD Bridge Design Specifications

Presented by
Michael A. Grubb, P.E.
M.A. Grubb & Associates, LLC
Wexford, 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
- June 27 - 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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Session Outline

- History of the AASHTO Bridge Design Specifications
- Evolution of Design Methodologies
  - Allowable Stress Design (ASD)
  - Load Factor Design (LFD)
  - Load and Resistance Factor Design (LRFD)
- Overview of Section 6 of AASHTO LRFD
  - Limit States & Behaviors of Concern
  - Overview of Skewed & Curved Bridge Issues

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HISTORY OF THE AASHTO BRIDGE DESIGN SPECIFICATIONS

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History of the AASHTO Specifications

- 1870s – Bridge Specs Began to Appear
  - Developed by individual engineers & railroad companies
  - Early bridges carried rail and canal traffic; some horse-drawn traffic & pedestrians
  - Business model for early bridges was “design-build”
  - Proof of adequacy usually obtained by test loading the bridge

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History of the AASHTO Specifications

- 1874 – Eads Bridge (St. Louis)

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History of the AASHTO Specifications

- 1914 – American Association of State Highway Officials (AASHO) founded
  - Non-governmental organization to coordinate transportation activities amongst state Departments of Transportation
  - Standards setting body for highway design and construction in the U.S.
  - Also now represents air, rail, water and public transportation
  - Name changed to AASHTO in 1973

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History of the AASHTO Specifications

- 1931 – AASHO *Standard Specifications for Highway Bridges and Incidental Structures* (First Edition)
  - ≈ 200 pages (≈ ½″ thick)
- Subsequent Editions (17 total)
  - 1935, 1941, 1944, 1949, 1953, 1957, 1961, 1965, 1969, 1973, 1977, 1983, 1989, 1992, 1996, 2002

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History of the AASHTO Specifications

- 1940s, 1950s & 1960s:
  - Advent of composite construction
    - Modern design procedures traced to 1957 AASHO Specifications – simple spans only
    - Depth-to-span ratio for beams relaxed from 25 to 30
    - Live-load deflection limit introduced in 1941 – L/800
  - Continuous-span construction
    - Became more common in the 1960s

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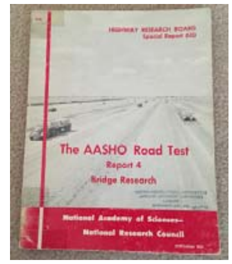
History of the AASHTO Specifications



- Late 1950s & early 1960s:
  - AASHO Road Test
    - Pavement & bridge testing
    - Goals of bridge testing:
      - Determine behavior of short-span highway bridges under repeated application of overstress
      - Determine dynamic effects of moving vehicles on short-span highway bridges
    - 18 simple-span bridges on two test-track loops
    - 8 noncomposite rolled-beam bridges; 2 composite

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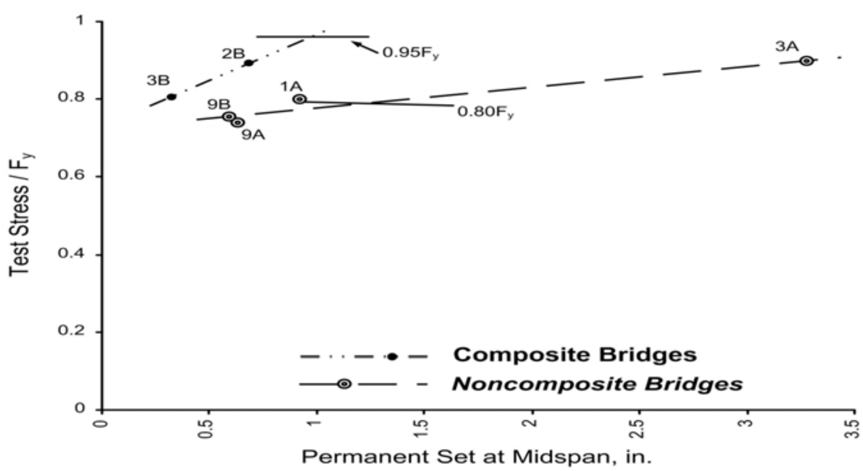
History of the AASHTO Specifications



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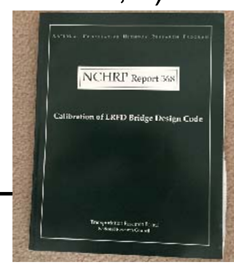
History of the AASHTO Specifications

- National Cooperative Highway Research Program (NCHRP)
  - Administered by TRB and supported by AASHTO in cooperation with the FHWA
  - Problem statements submitted from: 1) AASHTO members; 2) chairs of AASHTO committees, 3) the FHWA; and 4) TRB Committees
  - Oversight by volunteer panels
  - Findings published in reports
  - Results often implemented in specs



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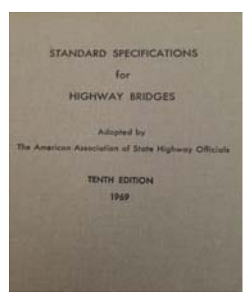
History of the AASHTO Specifications



- 1969 – Steel Box Girder Specs
  - Introduced in Tenth Edition
  - Allowable Stress Design (ASD)
  - Straight boxes only; multi-box sections
  - Torsion not explicitly considered
  - Capacity of bottom flange in compression based on classical plate-buckling equations
  - Special live-load distribution factor developed -> limits placed on the cross-section

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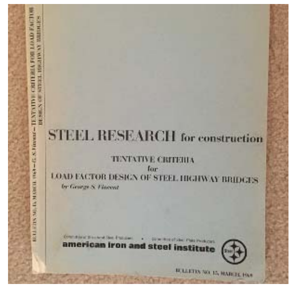
History of the AASHTO Specifications



- 1971 – Load Factor Design
  - Introduced in 1971 Interims
  - Limit-states design approach
  - Alternative to ASD
  - Work sponsored by AISI
  - Proportion for multiples of the design loads to:
    - Allow expected number of passages of ordinary vehicles
    - Allow occasional passages of overloads without damage
    - Allow a few passages of heavy overloads with some damage

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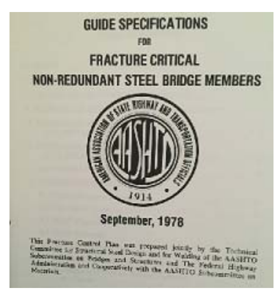
History of the AASHTO Specifications



- 1978 – Fracture Control Plan
  - Adopted after Silver Bridge collapse
  - Originally adopted as a Guide Spec
  - Now in D1.5 Bridge Welding Code
  - Places controls on material properties & initial flaw sizes in FCMs to provide adequate performance
  - Specifies fabrication, inspection & toughness requirements
  - Since plan adopted, no such failures

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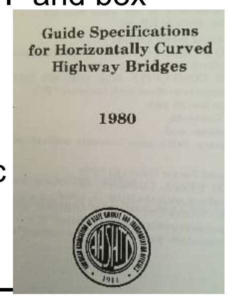
History of the AASHTO Specifications

- 1980 – Guide Specs for Curved Bridges
  - Consortium of University Research Teams (CURT) – late 1960s and early 1970s
  - Analytical studies and lab tests of scaled I- and box girders
  - Tentative Design Specs in 1976 (ASD)
  - AISI Project 190 in 1975 (LFD Specs)
  - ASD and LFD Specs in 1980 Guide Spec
  - Guide spec re-issued in 1993



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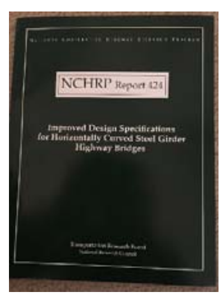
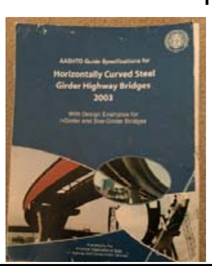
History of the AASHTO Specifications

- NCHRP Project 12-38 (late 1990s)
  - Develop revised Guide Specifications
  - Load Factor Design only
  - Incorporate latest state-of-art knowledge
- 2003 AASHTO Guide Specs





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History of the AASHTO Specifications

- 1986 – NCHRP Project 20-7/31
  - "Development of Comprehensive Bridge Specs and Commentary"
  - Review other specifications for coverage and philosophy of safety
  - Review all AASHTO documents for possible inclusion in the new specification
  - Assess the feasibility of a probability-based limit states design specification
  - Prepare an outline for a revised AASHTO Spec

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History of the AASHTO Specifications

- 1987 – NCHRP Project 12-33
  - Findings of NCHRP 20-07/31 presented at the 1987 AASHTO SCOBS meeting in San Diego, CA
  - Seven options presented for consideration
  - Funding requested to initiate a new NCHRP Project 12-33 ("Development of Comprehensive Specification and Commentary") to develop a new modern bridge design specification
  - Modjeski and Masters, Inc. began work in July 1988

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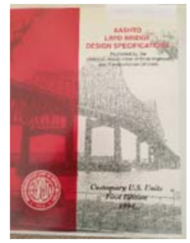
History of the AASHTO Specifications

- NCHRP Project 12-33 Schedule
  - 1990 -> First draft – general coverage
  - 1991 -> Second draft – workable
  - 1992 -> Third draft – getting close
  - 1991 and 1992 -> Two sets of trial designs
  - 1993 -> Fourth draft – adopted
  - 12,000 comments addressed
  - 1st Edition -> Printed and available in 1994
    - Customary U.S. Units & SI Units Versions
  - Co-equal alternative w/ Standard Specs



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History of the AASHTO Specifications

- Major Changes
  - Comprehensive & technically state-of-the-art specification
  - A new philosophy of safety – Load and Resistance Factor Design (reliability determined through statistical calibration)
  - Identification of four limit states
  - Parallel commentary provided (two-column format)
  - Encourage a multi-disciplinary approach to bridge design
  - Emphasis on redundancy, ductility & constructibility

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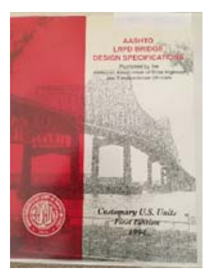
History of the AASHTO Specifications

- Major Changes
  - New design live load (HL-93)
  - New fatigue design live load (1989 Guide Specs)
  - Revised live load distribution factors (NCHRP 12-26)
  - Empirical deck design method (Ontario HBDC)
  - Limit-state design provisions for foundations
  - Expanded coverage on structural analysis, hydraulics, scour, bridge railings and ship collision

History of the AASHTO Specifications

- AASHTO LRFD Specifications
  - First Edition (1994)
  - Second Edition (1998)
  - Third Edition (2004)
  - Fourth Edition (2007)
    - Last SI Units Edition of LRFD Specs
    - 17th Edition (2002) of Standard Specs officially sunsetted
  - Fifth Edition (2010)
  - Sixth Edition (2012)
  - Seventh Edition (2014)



History of the AASHTO Specifications

- 2005 Interims (Third Edition)
  - FHWA CSBRP
  - One-third rule equations

$$f_{bu} + \frac{1}{3} f_{\ell} \leq F_r$$

  - NCHRP Project 12-52
    - Historical unification of the design provisions for straight and horizontally curved steel I- and box girders in the LRFD Specs

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Maintenance of the AASHTO Specifications

- AASHTO Technical Committees
  - T-1: Security
  - T-2: Bearings and Expansion Devices
  - T-3: Seismic Design
  - T-4: Construction
  - T-5: Loads and Load Distribution
  - T-6: Fiber Reinforced Polymer Composites
  - T-7: Guardrail and Bridge Rail
  - T-8: Moveable Bridges
  - T-9: Bridge Preservation
  - T-10: Concrete Design

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Maintenance of the AASHTO Specifications

- AASHTO Technical Committees
  - T-11: Research
  - T-12: Structural Supports for Signs, Luminaires & Traffic Signals
  - T-13: Culverts
  - **T-14: Structural Steel Design**
  - T-15: Substructures and Retaining Walls
  - T-16: Timber Structures
  - T-17: Welding
  - T-18: Bridge Management, Evaluation & Rehabilitation
  - T-19: Software and Technology
  - T-20: Tunnels

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Maintenance of the AASHTO Specifications

– Tech. committees meet or conference twice per year
– Ballot Items Proposed
– Placed on Portal for review
– Presented at Annual Meeting
– Approval by 2/3 of members
– Annual Interims published


AASHTO BRIDGE COMMITTEE AGENDA ITEM:
TECHNICAL COMMITTEE:
REVISION
ADDITION
NEW DOCUMENT
DESIGN SPEC
MANUAL FOR BRIDGE EVALUATION
CONSTRUCTION SPEC
SEISMIC GUIDE SPEC
OTHER
MOVABLE SPEC
COASTAL GUIDE SPEC
DATE PREPARED:
DATE REVISED:
AGENDA ITEM:
OTHER AFFECTED ARTICLES:
BACKGROUND:
ANTICIPATED EFFECT ON BRIDGES:
REFERENCES:

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Other Bridge Specifications

- AASHTO LRFD Bridge Construction Specifications
- ASTM Specifications (e.g. ASTM A709 for bridge steels)
- AASHTO Material Specifications (e.g. AASHTO M270 for bridge steels)
- AASHTO/AWS D1.5M/D1.5 Bridge Welding Code
- AASHTO Manual for Bridge Evaluation
- AASHTO LRFD Movable Highway Bridge Design Spec
- AASHTO Guide Spec for LRFD Seismic Bridge Design
- AASHTO/NSBA Steel Bridge Collaboration Docs
- State Design Specifications

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EVOLUTION OF SPECIFICATION DESIGN METHODOLOGIES

Allowable Stress Design (ASD)

Load Factor Design (LFD)

Load and Resistance Factor Design (LRFD)

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Evolution of Design Methodologies

- Allowable Stress Design (ASD)

$$\sum DL + \sum LL \leq R_n / FS$$

- Advantage:
  - Simple design technique used for decades
- Limitations:
  - Factor of safety (FS) based on judgment & experience
  - No consistent measure of risk

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Evolution of Design Methodologies

- Allowable Stress Design (ASD)
  - For flexure: $f_{DL} + f_{LL} \leq 0.55F_y$
  - Rearranging: $1.82f_{DL} + 1.82f_{LL} \leq F_y$

- Does not reflect that dead loads are known with more certainty
- Greater consistency needed in determining the maximum live-load carrying capacities

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Evolution of Design Methodologies

- Load Factor Design (LFD)

$$\gamma\left(\sum \beta_{DL} DL + \sum \beta_{LL} LL\right) \le \phi R_n$$

- Advantages:
  - Accounts for variable predictability of various load types, uncertainty in the load analysis, and variability in material strength
  - Greater consistency in maximum live-load capacities
- Limitation:
  - No quantitative measure of risk

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Evolution of Design Methodologies

- Load Factor Design (LFD)

$$\gamma\left(\sum \beta_{DL} DL + \sum \beta_{LL} LL\right) \le \phi R_n$$

- ϕ allows for uncertainty in the strength of a section, etc.
  - For flexure, shear, and tension: $\phi = 1.0$
  - For compression and connections: $\phi < 1.0$
- β_{DL} allows for possible increase in the dead load
  - $\beta_{DL} = 1.0$
- β_{LL} allows for possible overloads
  - $\beta_{LL} = 5/3$ (= 2.2 for loads less than H20)
- γ allows for uncertainty in the load analysis and other overall effects

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Evolution of Design Methodologies

- Load Factor Design (LFD)
  - For flexure & shear: $\frac{\gamma}{\phi}\left(\sum \beta_{DL} DL + \sum \beta_{LL} LL\right) \le R_n$
  - Minimum margin of safety in ASD is associated with short spans
  - γ/ϕ selected to give the same section by ASD & LFD for a short non-composite simple-span bridge
  - Occurs at a 40-ft span for γ/ϕ = 1.25; ratio later increased to 1.3

$$1.3\left[1.0(DL) + 5/3(LL)\right] \le R_n$$

$$1.3(DL) + 2.17(LL) \le R_n \quad \text{Group I}$$

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Evolution of Design Methodologies

- Load Factor Design (LFD)
  - Service Load: $1.0(DL) + 1.0(LL)$
    - Limit fatigue damage
    - Limit elastic live-load deflections
  - Overload: $1.0(DL) + 5/3(LL) \le 0.95F_y \text{ or } 0.80F_y$
    - Limit permanent deformations caused by local yielding
    - Limit permanent deformations caused by slip in bolted connections
  - Maximum Design Load: $1.3(DL) + 2.17(LL) \le \phi R_n$
    - Ensure an adequate level of safety or strength

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Evolution of Design Methodologies

- Load and Resistance Factor Design (LRFD)

$$\eta\left(\sum \gamma_{DL} DL + \sum \gamma_{LL} LL\right) \leq \phi R_n$$

- Advantages:
  - Load and resistance factors determined from calibration based on theories of probability and reliability
  - Calibration process targets a "reliability index"
  - Limit states formalized and made of equal importance
  - Introduction of a load modifier, η, to address ductility, redundancy & operational importance

$$\eta = \eta_D \eta_R \eta_I \geq 0.95$$

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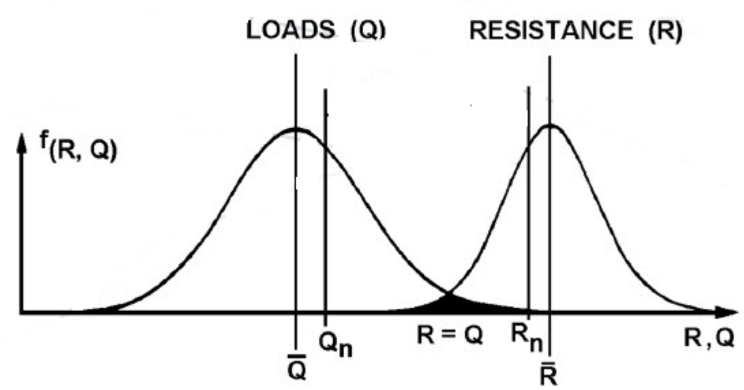
Evolution of Design Methodologies

- Load and Resistance Factor Design (LRFD)



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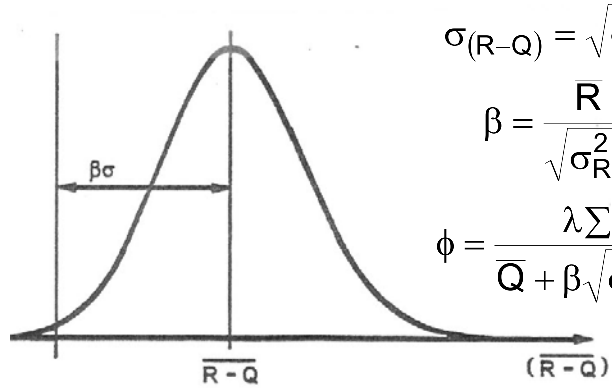
Evolution of Design Methodologies

- Load and Resistance Factor Design (LRFD)



$$\sigma_{(R-Q)} = \sqrt{\sigma_R^2 + \sigma_Q^2}$$

$$\beta = \frac{\overline{R} - \overline{Q}}{\sqrt{\sigma_R^2 + \sigma_Q^2}}$$

$$\phi = \frac{\lambda \sum \gamma_i x_i}{\overline{Q} + \beta\sqrt{\sigma_R^2 + \sigma_Q^2}}$$

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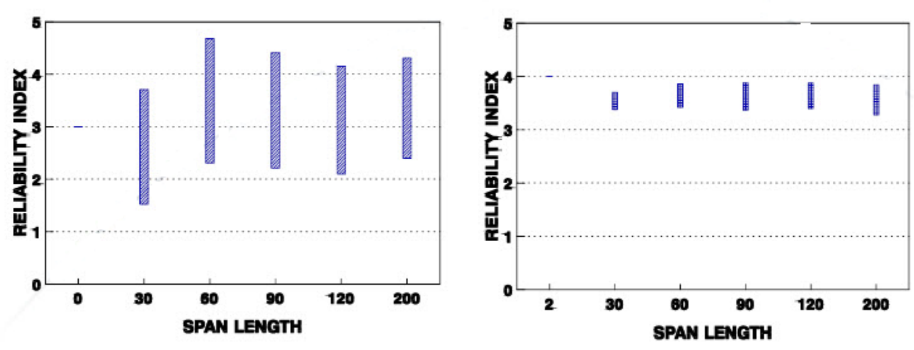
Evolution of Design Methodologies

- Load and Resistance Factor Design (LRFD)

Standard Specifications | LRFD Specifications



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Evolution of Design Methodologies

- Load and Resistance Factor Design (LRFD)
  - Service I: $1.0(DC + DW) + 1.0(LL)$
    - Limit elastic live-load deflections
  - Fatigue I and II: $(1.5 \text{ or } 0.75)(\text{Single fatigue truck})$
    - Limit fatigue damage
  - Service II: $1.0(DC + DW) + 1.3(LL) \leq 0.95F_y \text{ or } 0.80F_y$
    - Limit permanent deformations caused by local yielding
    - Limit permanent deformations caused by slip in bolted connections
  - Strength I: $\eta[1.25(DC) + 1.5(DW) + 1.75(LL)] \leq \phi R_n$
    - Ensure an adequate level of safety or strength

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Evolution of Design Methodologies

- Load and Resistance Factor Design (LRFD)

- For flexure $\phi_f = 1.00$
- For shear $\phi_v = 1.00$
- For axial compression, steel only $\phi_c = 0.95$
- For axial compression and combined axial compression and flexure in composite CFSTs $\phi_c = 0.90$
- For axial compression, composite columns $\phi_c = 0.90$
- For tension, fracture in net section $\phi_u = 0.80$
- For tension, yielding in gross section $\phi_y = 0.95$
- For bearing on pins in reamed, drilled or bored holes and on milled surfaces $\phi_b = 1.00$
- For bolts bearing on material $\phi_{bb} = 0.80$
- For shear connectors $\phi_{sc} = 0.85$
- For A 325 and A 490 bolts in tension $\phi_t = 0.80$
- For A 307 bolts in tension $\phi_t = 0.80$
- For F 1554 bolts in tension $\phi_t = 0.80$
- For A 307 bolts in shear $\phi_s = 0.75$
- For F 1554 bolts in shear $\phi_s = 0.75$
- For A 325 and A 490 bolts in shear $\phi_s = 0.80$
- For block shear $\phi_{bs} = 0.80$
- For shear, rupture in connection element $\phi_{vu} = 0.80$
- For truss gusset plate compression $\phi_{cg} = 0.75$
- For truss gusset plate chord splices $\phi_{cs} = 0.65$
- For truss gusset plate shear yielding $\phi_{vy} = 0.80$
- For web crippling $\phi_w = 0.80$
- For weld metal in complete penetration welds:
  - shear on effective area $\phi_{e1} = 0.85$
  - tension or compression normal to effective area same as base metal
  - tension or compression parallel to axis of the weldsame as base metal
- For weld metal in partial penetration welds:
  - shear parallel to axis of weld $\phi_{e2} = 0.80$
  - tension or compression parallel to axis of weldsame as base metal
  - compression normal to the effective areasame as base metal
  - tension normal to the effective area $\phi_{e1} = 0.80$
- For weld metal in fillet welds:
  - tension or compression parallel to axis of the weldsame as base metal
  - shear in throat of weld metal $\phi_{e2} = 0.80$

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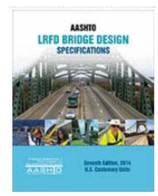
AISC vs. AASHTO Design Specifications

– AISC Design Specification
- Supports ASD and LRFD design methodologies
- Emphasis on noncomposite rolled-beam design
- Less emphasis on moving loads and fatigue

– AASHTO Design Specification
- LRFD design methodology only
- Emphasis on composite plate-girder design
- Singly-symmetric and hybrid sections
- Greater emphasis on moving loads and fatigue



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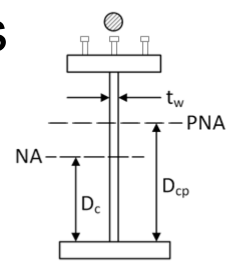
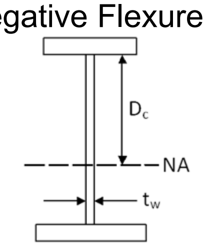
AISC vs. AASHTO Design Specifications

Compact Web Sections	$\frac{2D_{cp}}{t_w} \leq \lambda_{pw(D_c)}$
Noncompact Web Sections	$\frac{2D_c}{t_w} \leq \lambda_{rw}$
Slender Web Sections	$\frac{2D_c}{t_w} > \lambda_{rw}$



Negative Flexure



Positive Flexure

AISC vs. AASHTO Design Specifications

$$\lambda_{pw(D_{cp})} = \frac{\sqrt{\frac{E}{F_{yc}}}}{\left(0.54\frac{M_p}{R_h M_y} - 0.09\right)^2} \leq \lambda_{rw}\left(\frac{D_{cp}}{D_c}\right)$$

F_{yc} (ksi)	$\lambda_{pw(D_{cp})}$	
	$M_p/M_y = 1.12$	$M_p/M_y = 1.30$
50	91	64

$$\lambda_{rw} = 5.7\sqrt{\frac{E}{F_{yc}}}$$

F_{yc} (ksi)	λ_{rw}
50	137

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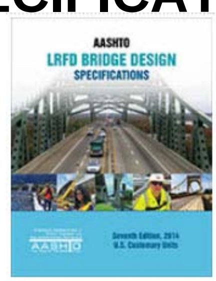
OVERVIEW OF SECTION 6 OF THE AASHTO LRFD SPECIFICATION



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AASHTO LRFD Specifications

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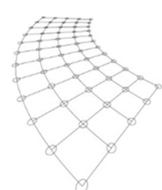
Section 4

AASHTO LRFD Specifications

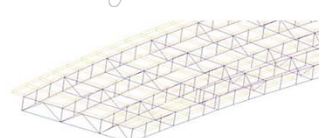
- Approximate methods of analysis

$$g = 0.075 + \left(\frac{S}{9.5}\right)^{0.6}\left(\frac{S}{L}\right)^{0.2}\left(\frac{K_g}{12.0Lt_s^3}\right)^{0.1}$$

- 2D refined methods of analysis



- 3D refined methods of analysis



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Overview of Section 6
AASHTO LRFD Specifications

- 6.1 – Scope
- 6.2 – Definitions
- 6.3 – Notation
- 6.4 – Materials
- **6.5 – Limit States**
- 6.6 – Fatigue and Fracture Considerations
- 6.7 – General Dimension and Detail Requirements
- 6.8 – Tension Members
- 6.9 – Compression Members
- 6.10 – I-Section Flexural Members
- 6.11 – Box-Section Flexural Members
- 6.12 – Miscellaneous Flexural Members
- 6.13 – Connections and Splices
- 6.14 – Provisions for Structure Types
- 6.15 – Piles
- 6.16 – Provisions for Seismic Design

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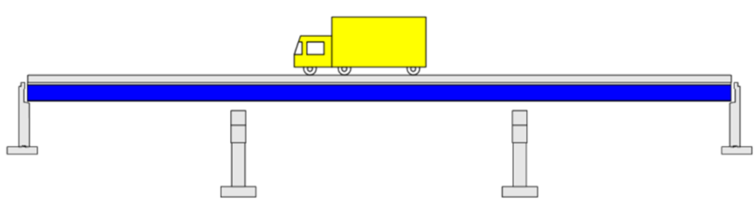
Overview of Section 6
AASHTO LRFD Specifications

- Service Limit State (Articles 1.3.2.2 & 6.5.2)

  Restrictions on stress, deformation, and crack width under regular service conditions

  - Article 6.10.4.1 – Control of elastic deformations (LL & DL deflections)



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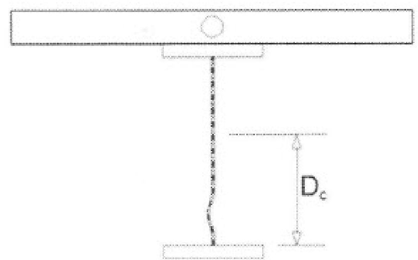
Overview of Section 6
AASHTO LRFD Specifications

- Service Limit State (Articles 1.3.2.2 & 6.5.2)
  - Article 6.10.4.2 – Control of permanent deformations (flange stresses, web bend buckling)



  - Article 6.10.1.7 – Control of deck cracking

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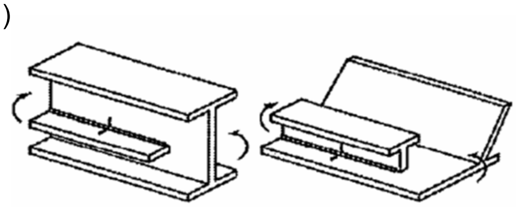
Overview of Section 6
AASHTO LRFD Specifications

- Fatigue & Fracture Limit State (Articles 1.3.2.3 & 6.5.3)

  Fatigue Limit State - Restrictions on stress range as a result of a single design truck occurring at a number of expected stress range cycles:

  - Article 6.6.1.2 – Load-induced fatigue (fatigue effects due to the in-plane stresses for which components and details are explicitly designed)



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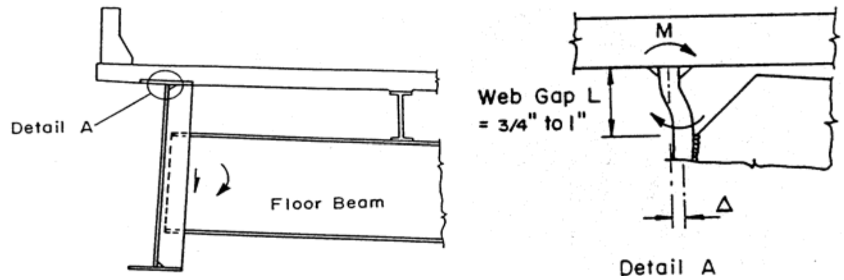
Overview of Section 6
AASHTO LRFD Specifications

- Fatigue & Fracture Limit State (Articles 1.3.2.3 & 6.5.3)
  - Article 6.6.1.3 – Distortion-induced fatigue (fatigue effects due to secondary stresses not normally quantified in the typical analysis and design of a bridge)



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Overview of Section 6
AASHTO LRFD Specifications

- Fatigue & Fracture Limit State (Articles 1.3.2.3 & 6.5.3)

Fracture Limit State – A set of material toughness requirements of the AASHTO Materials Specifications

- Article 6.6.2 – Fracture toughness
  - Charpy V-Notch Test

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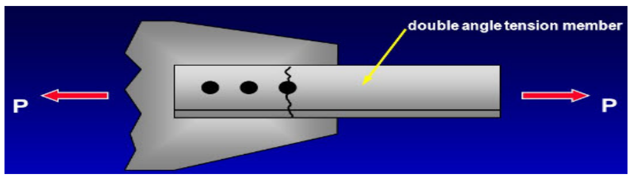
Overview of Section 6
AASHTO LRFD Specifications

- Strength Limit State (Articles 1.3.2.4 & 6.5.4)

  Ensures that strength and stability, both local and global, are provided to resist the specified statistically significant load combinations that a bridge is expected to experience in its design life

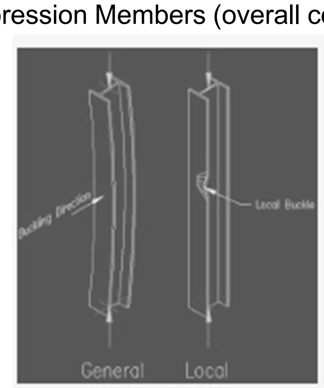
  - Article 6.8 – Tension Members (yielding on the gross section, fracture on the net section)



Overview of Section 6
AASHTO LRFD Specifications

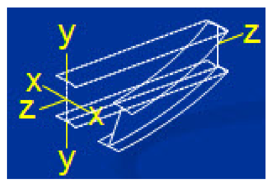
– Strength Limit State (Articles 1.3.2.4 & 6.5.4)

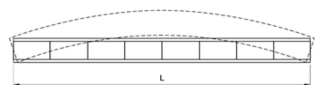
  - Article 6.9 – Compression Members (overall column buckling, local buckling)

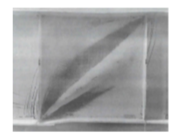


Overview of Section 6
AASHTO LRFD Specifications

– Strength Limit State (Articles 1.3.2.4 & 6.5.4)
  - Articles 6.10, 6.11 & 6.12 – Flexural Members
    - Nominal Yielding
    - Flange Local Buckling
    - Lateral-torsional buckling







    - Shear

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Overview of Section 6
AASHTO LRFD Specifications

- Extreme Event Limit State (Articles 1.3.2.5 & 6.5.5)

  Ensures the structural survival of a bridge during a major earthquake or flood, or when collided by a vessel, vehicle, or ice flow, possibly under scoured conditions

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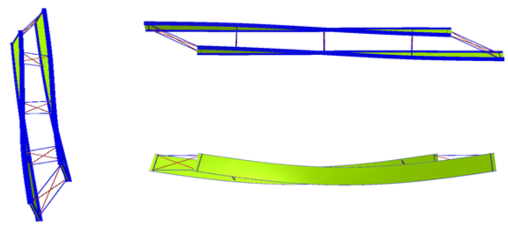
Overview of Section 6
AASHTO LRFD Specifications

- Skewed Bridges – Issues of Concern
  - Differential deflections between the girders
  - Torsion (flange lateral bending; fit-up)
  - Larger than normal cross-frame forces
  - Unique thermal movements
  - Uplift



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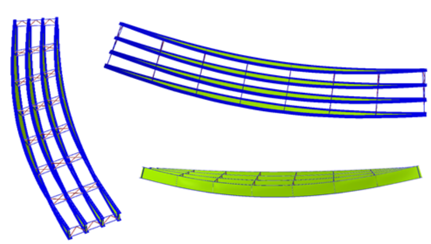
Overview of Section 6
AASHTO LRFD Specifications

- Curved Bridges – Issues of Concern
  - Torsion (flange lateral bending; fit-up)
  - Increased fabrication, shipping & erection costs
  - Increased design and construction complexity
  - Bracing members carry design loads
  - Uplift



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Summary

Session 2

- History of the AASHTO Bridge Design Specifications
- Evolution of Design Methodologies
  - Allowable Stress Design (ASD)
  - Load Factor Design (LFD)
  - Load and Resistance Factor Design (LRFD)
- Overview of Section 6 of AASHTO LRFD
  - Limit States & Behaviors of Concern
  - Overview of Skewed & Curved Bridge Issues

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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

Videos

- 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.

Quizzes

- 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

Attendance and PDH Certificates

- 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.

EEU Certificates – Certificate of Completion

- 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.

Distribution of Certificates

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

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