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Course Description

Session 1: Introduction to Bridge Engineering

June 6, 2016

This session will be a general introduction to bridge engineering with the goal to prepare students for the 8-part course. The session will include a review of basic bridge nomenclature and the various steel bridge superstructure types, bearings, and supporting substructure types. In addition, a brief tutorial on how to read bridge plans will be provided. This will be followed by a detailed look into the various types of framing plans typically used for steel I-girder bridges and a cursory discussion of analysis methods. The session will identify the two major bridge design specifications, AASHTO LRFD Bridge Design Specifications and the AREMA Manual for Railway Engineering.

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Learning Objectives

- Become familiar with basic bridge nomenclature including aspects of superstructure, substructure and foundations.
- Gain an understanding of the various types of bridges and the characteristics of each.
- Gain an understanding of the information included in steel bridge construction documents and an in-depth look at various types of framing plans.
- Be introduced to the two major bridge design specifications; AASHTO LRFD Bridge Design Specifications and the AREMA Manual for Railway Engineering.

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Introduction to Steel Bridge Design

Session 1: Introduction to Bridge Engineering

Presented by

Anna Teague, PE
HDR
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structural STEEL

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Introduction to Steel Bridge Design

Session 1: Introduction to Bridge Engineering

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NSBA Night School: Session Overviews

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 1

- **Introduction to Bridge Engineering**
  - Bridge Nomenclature
  - Types of Bridges
  - Girder Bridge Superstructures
  - Substructures
  - Bridge Plan Set Organization and Content
  - I-Girder Bridge Framing Plans
  - Analysis Methods
  - Design Codes

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Bridge Nomenclature

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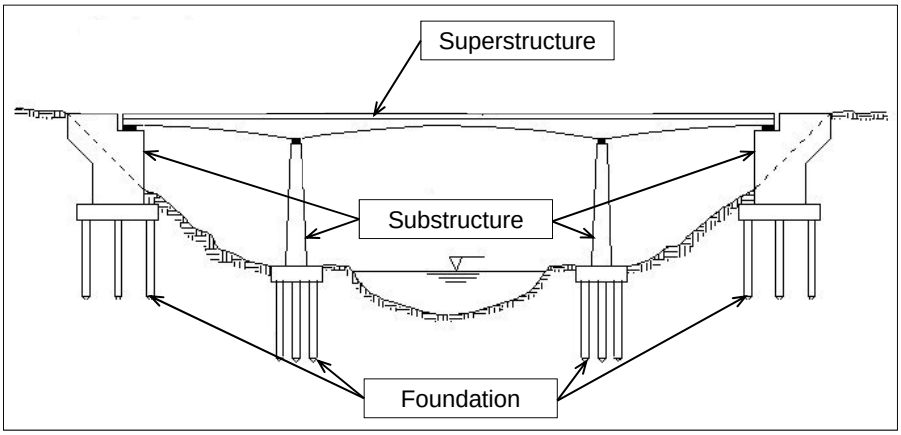
Main Elements of a Bridge



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Presentation Poll 1

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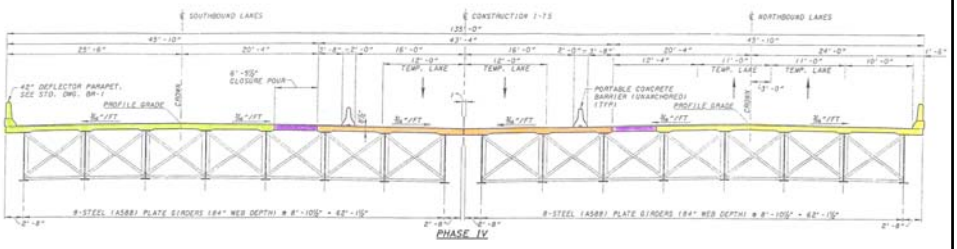
Superstructure

- **Everything Above the Substructure**



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Superstructure

- **Everything Above the Substructure**
  - Barriers, Medians, Sidewalks
  - Wearing Surfaces
  - Deck
  - Deck Forms
  - Girders
  - Cross Frames, Diaphragms, Lateral Bracing
  - Bearings

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Superstructure

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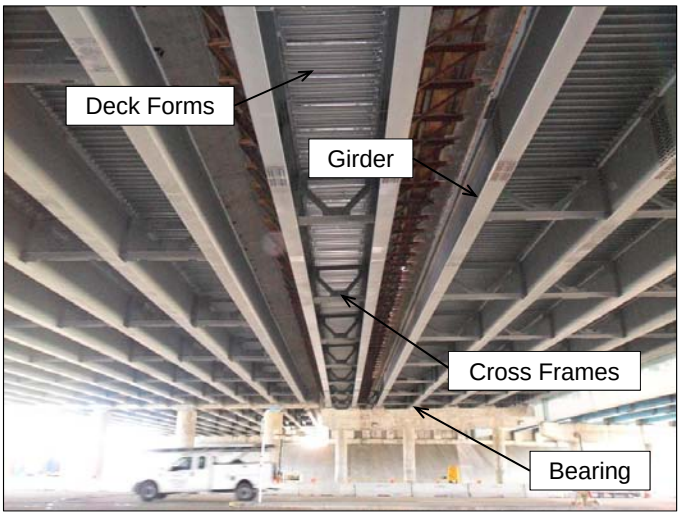
Superstructure



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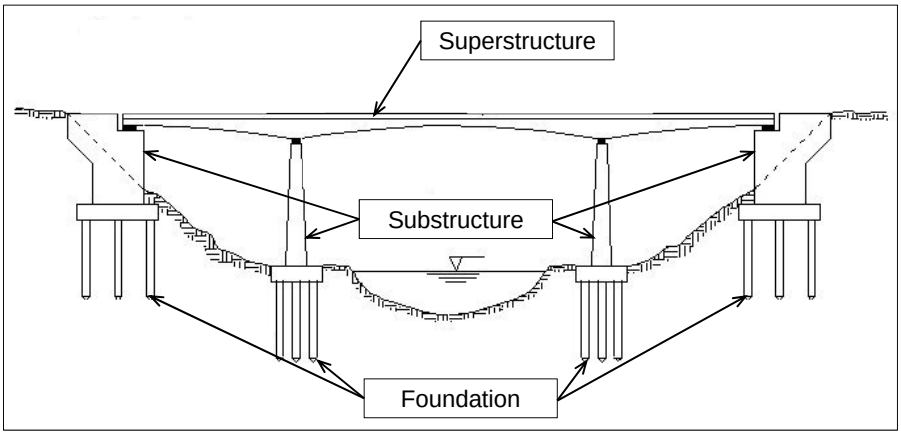
Main Elements of a Bridge



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Substructure

- **Everything Below the Superstructure and Above the Ground**
  - Abutments/End Bents
  - Piers/Bents
  - Pier/Bent Caps
  - Columns

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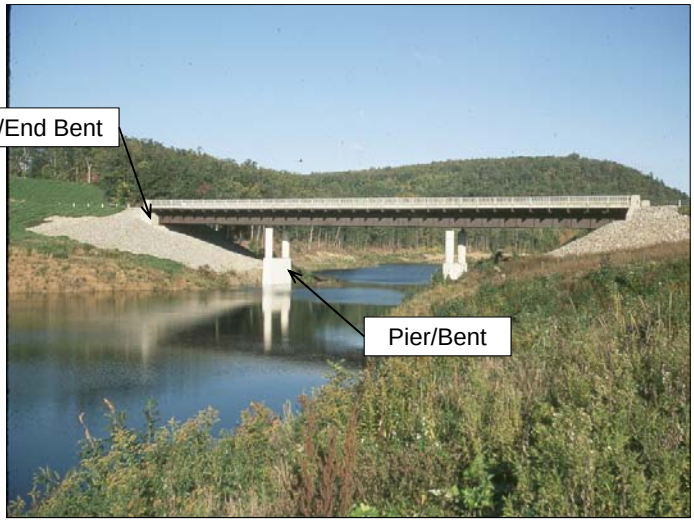
Substructure



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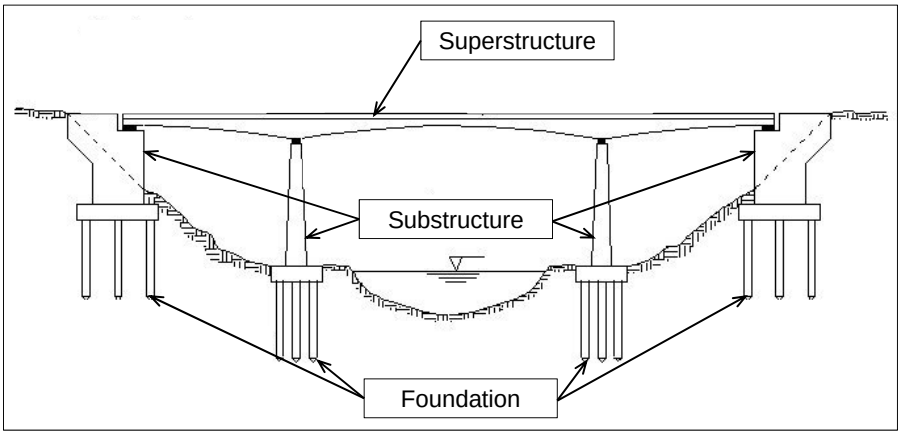
Substructure

23

Main Elements of a Bridge



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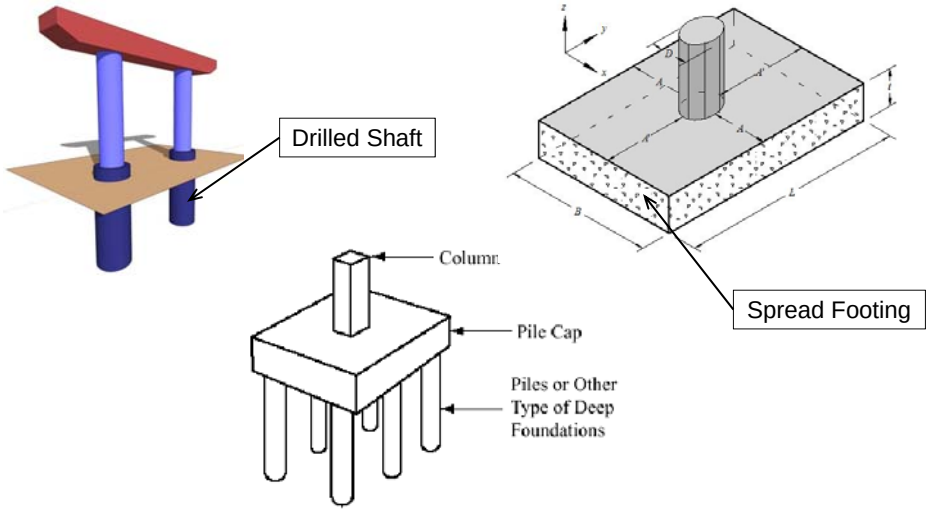
Foundations

- **Everything Below the Ground**
  - Footings
    - Pile Caps
    - Spread Footings
  - Drilled Shafts
  - Piles

25

Foundations



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Other Bridge Nomenclature

- Joints
- Approach Slab
- Slope Protection
- Wingwalls

27

Types of Bridges

28

Deck Arch

- Generally true arch
- Entire arch located below the deck
- Generally used in deep valleys with steep walls
- May use half-through arch to keep bearings above high water elevations

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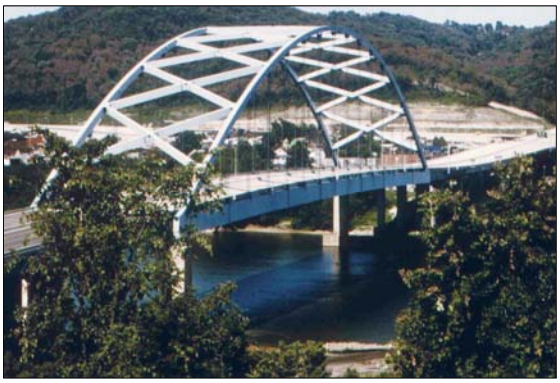
Through Arch

- Generally tied arch
- Often used when underclearance is limited
- Effective where deep foundations are required
- Above-deck portion of half-through arch can be a tied arch



30

Partial Through Arch

- Can be either true or tied arch

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Presentation Poll 2

32

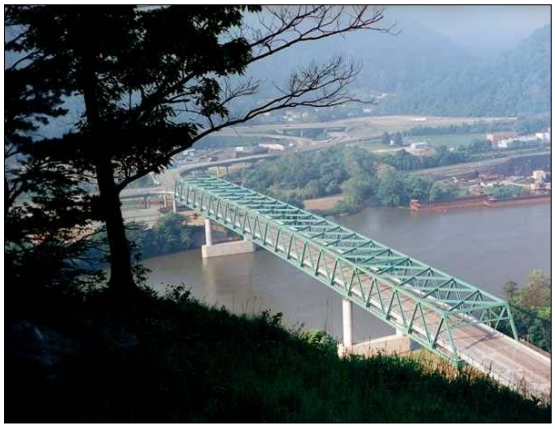
Deck Truss

- Entire truss is below the bridge deck
- Floorbeams frame into top chord or rest on top
- Truss spacing closer than for through truss
  - Reduces length/cost of lateral bracing / sway bracing systems
- Easier to widen in the future

33

Through Truss

- Deck runs between trusses close to bottom chords
- Desirable when vertical clearance is limited
- Sidewalk can be inside or outside trusses



34

Partial Through Truss

- Similar constraints to through trusses
- Truss type needs to have vertical members
- All sway bracing stays below the bridge deck

35

Cable Stayed Bridges

- Tall towers
- Stay cables carry deck loads back to towers
- Stay cables attached to edge girders

36

Suspension Bridges

- Main cables outside the edges of deck and draped over towers in saddles
- Vertical cables support deck at relatively short intervals
- Very light superstructure
- Appropriate for spans >3000’

37

Through Girder Bridges

- Main support girders located outside the deck
- Useful where vertical clearance is limited and heavy loads are anticipated
- Common superstructure type for Railroad Bridges

38

Deck Girder Bridges

- Common superstructure type for highway bridges
  - Girder/Beam Bridges
  - Floorbeam/Substringer Bridges

39

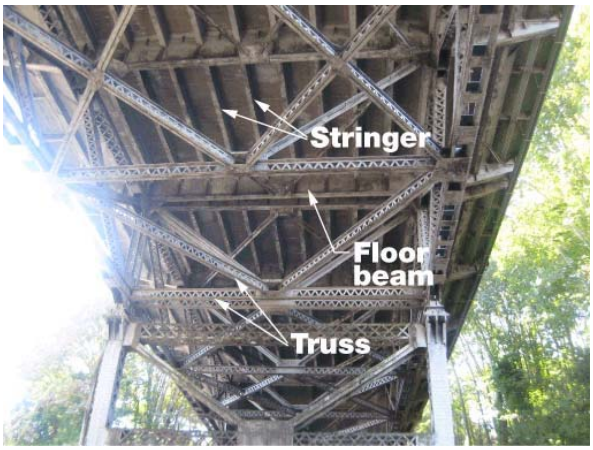
Deck Girder Bridges: Girder/Beam Bridges

- Versatile shapes and configurations

40

Deck Girder Bridges: Floorbeam/Substringer Bridges

- Stiff systems
- Capable of carrying heavy loads
- Often used in Railroad bridges



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Introduction to Steel Bridge Design

Session 1: Introduction to Bridge Engineering

Joanne Shaner, PE
HDR – Cleveland, OH

structural STEEL

Girder Bridge Superstructures

43

Barriers

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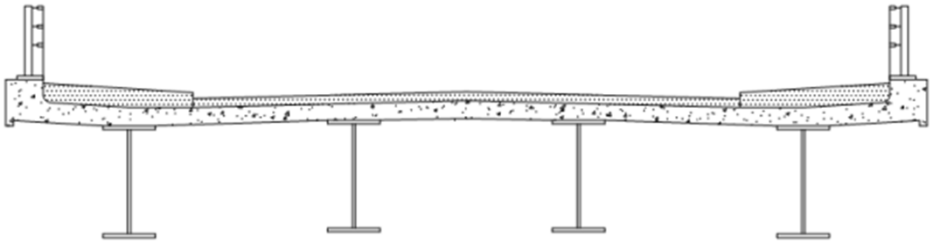
Decks

- Provide lateral stiffness to the superstructure



45

Future Wearing Surfaces

- Provides a smooth riding surface on older/damaged decks

46

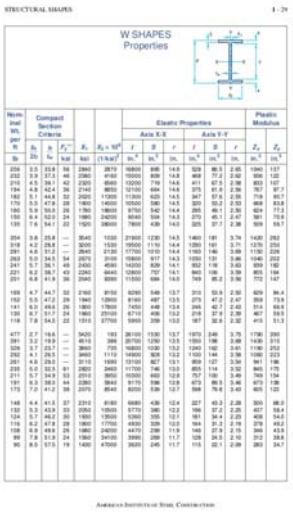
Deck Forms

- Provides formwork for cast in place deck
- Can be stay in place or removable

47

I-Girders: Rolled Beams

- Efficient for shorter spans
- Limited sizes and shapes



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I-Girders: Plate Girders

- Deep girders can span very long distances
- Vast range of sizes and shapes

49

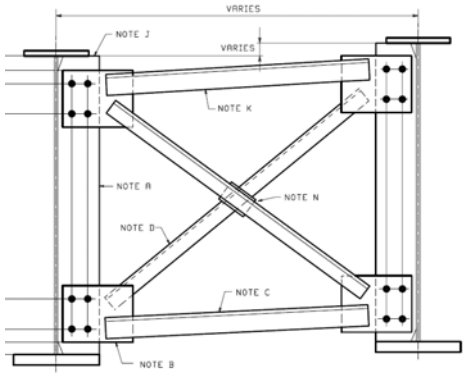
Box Girders

- Box section efficiently resists torsion effects
- Vast range of sizes and shapes

50

Cross Frames

- Used on steel girder bridges to provide torsional stiffness during construction and in the final condition



51

Diaphragms

- Similar to cross frames: provide torsional stiffness during construction and in the final condition
- Typically used on shallow beams

52

Lateral Bracing

- Used to provide lateral stiffness and limit lateral deflections

53

Bearings

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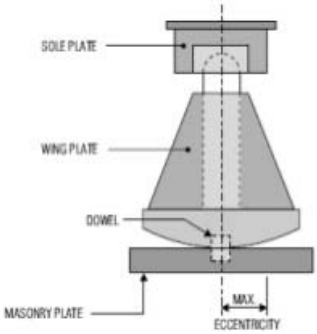
Bearings: Rocker Bearings



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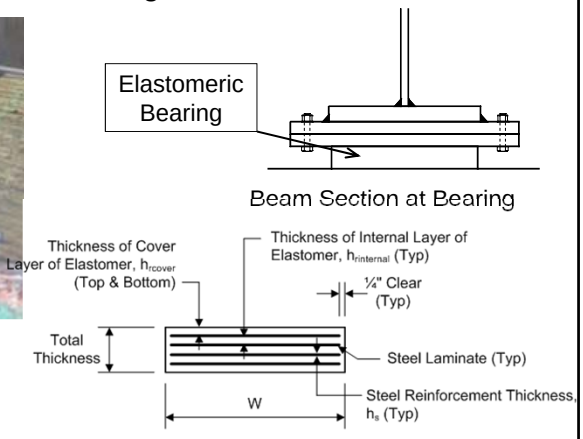
Bearings: Elastomeric Bearings

- Common and economical bearing

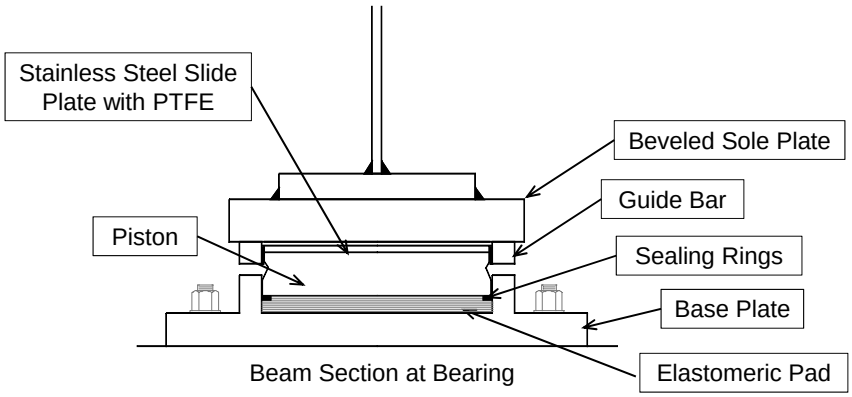


Steel Reinforced Elastomeric Bearing

56

Bearings: Pot Bearings

- Allows for high loads, large movement, and moderate rotations



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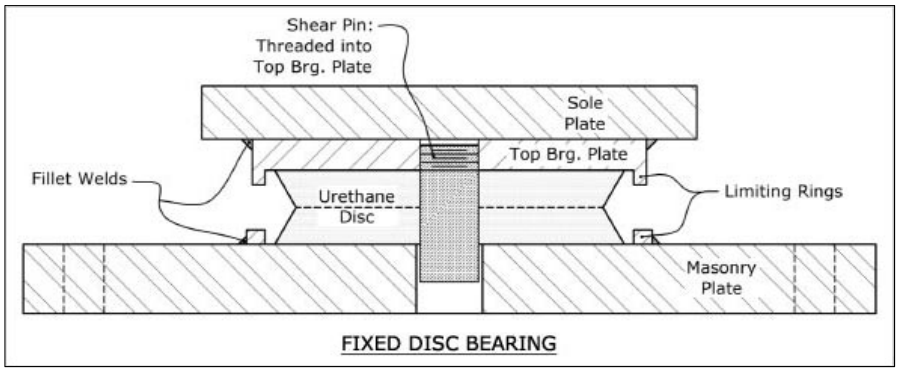
Bearings: Disc Bearings

- Allows for high loads, large movement, and moderate rotations



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Bearings: Disc and Pot Bearings

Disc Bearing **Pot Bearing**

59

Bearings: Disc Bearings

Guided Bearing Non- Guided Bearing

60

Bearings: Roller Bearings

- Accommodates heavy loads, large movement, and minimal rotations

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Presentation Poll 3

62

Substructures

63

Abutments

- Where the roadway ends and the bridge begins

64

Abutments

Independent Backwall

Integral

65

Multicolumn Piers

- Pier cap supported by columns

66

Single Column Piers

- Aesthetically pleasing

67

Integral Piers

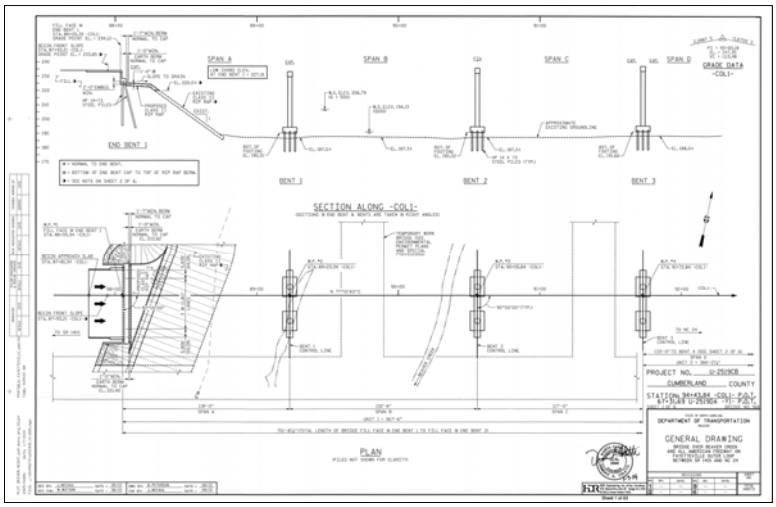
- Useful when vertical clearance constraints exist

68

Bridge Plan Set Organization and Content

69

Plan and Elevation



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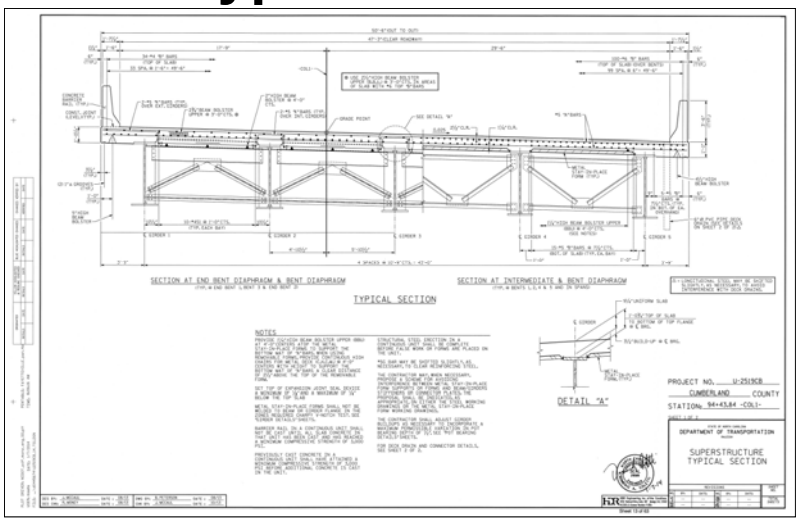
Typical Section



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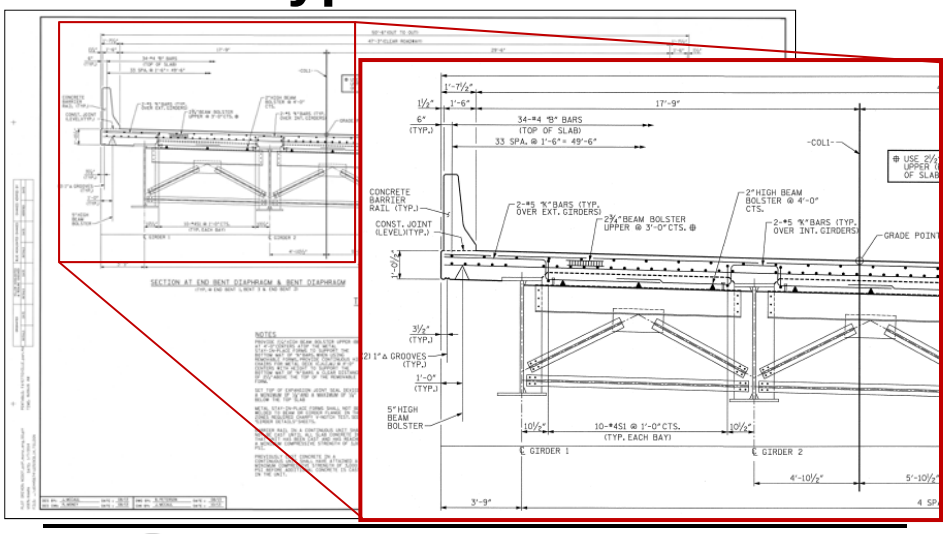
Typical Section



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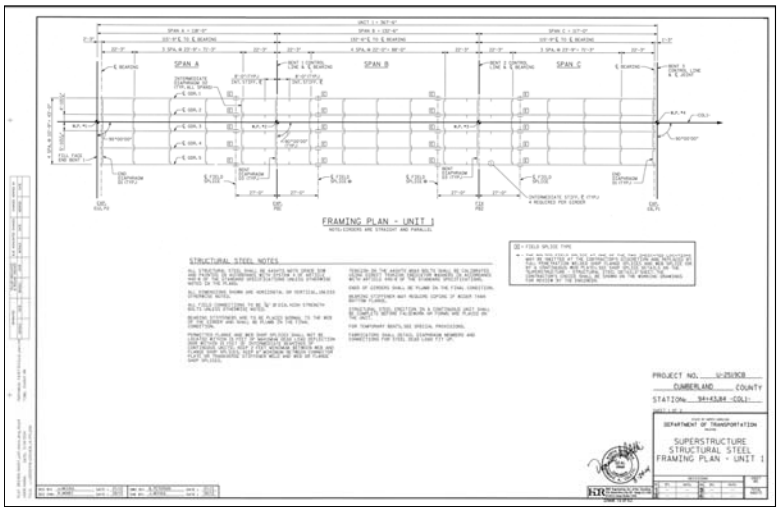
Framing Plan



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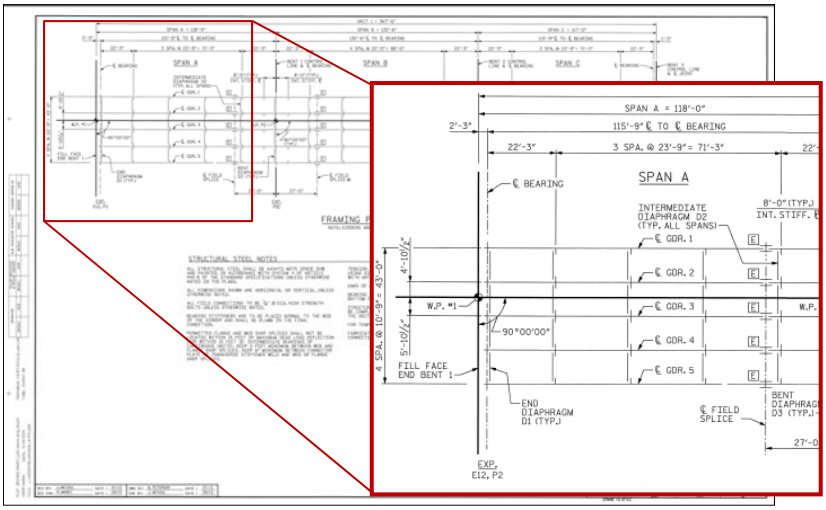
Framing Plan



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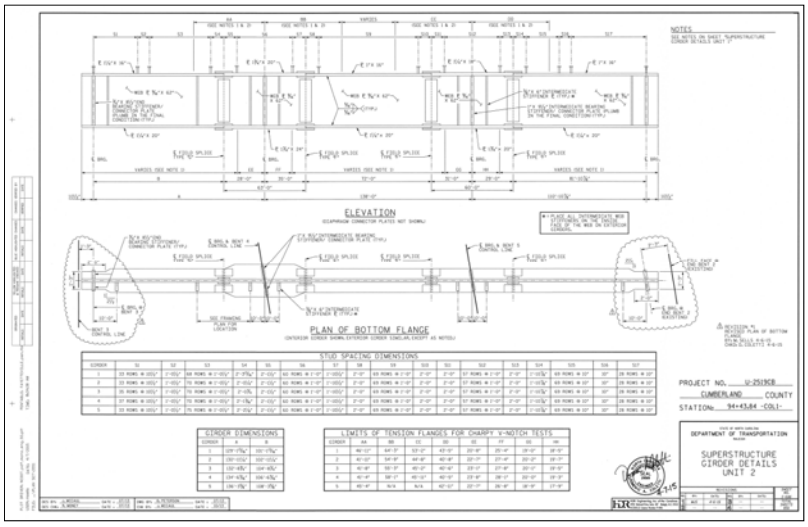
Girder Elevation



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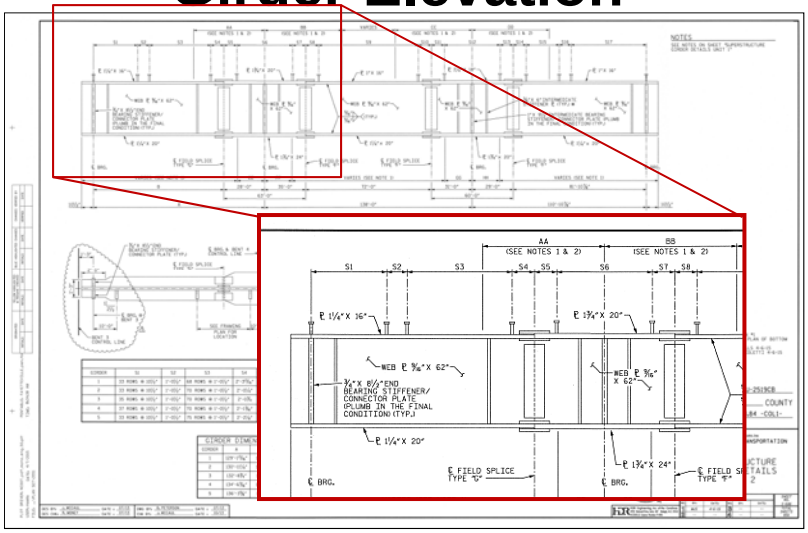
Girder Elevation



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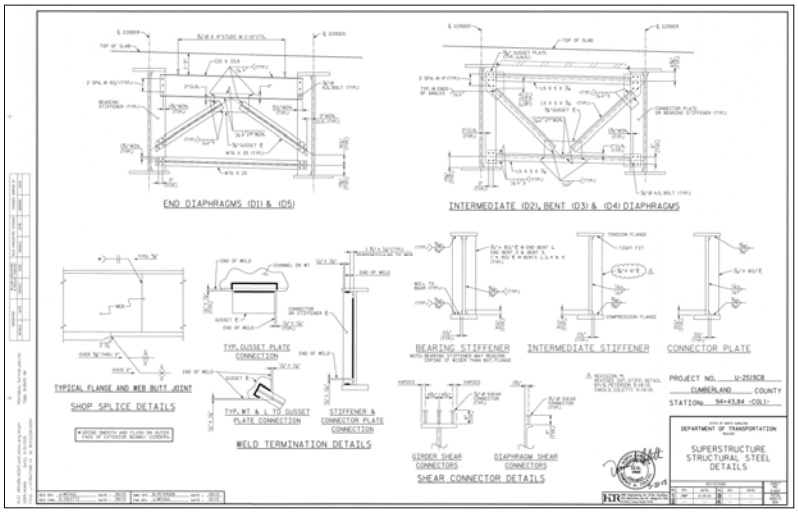
Cross-Frame Details



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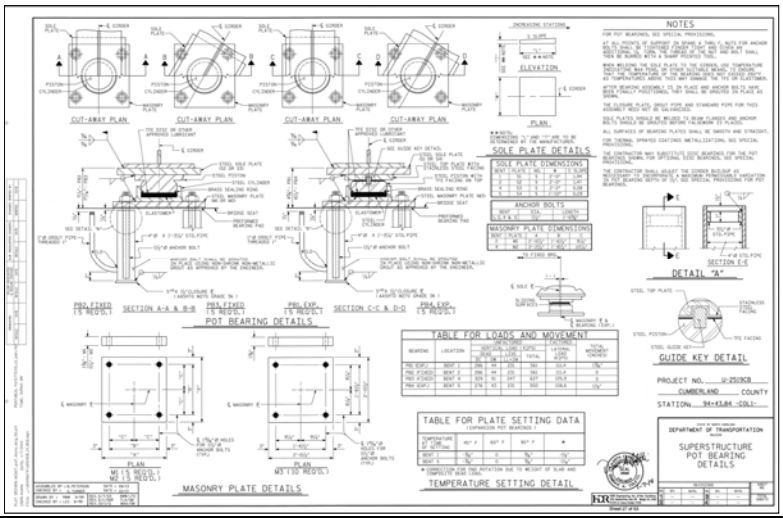
Bearing Details



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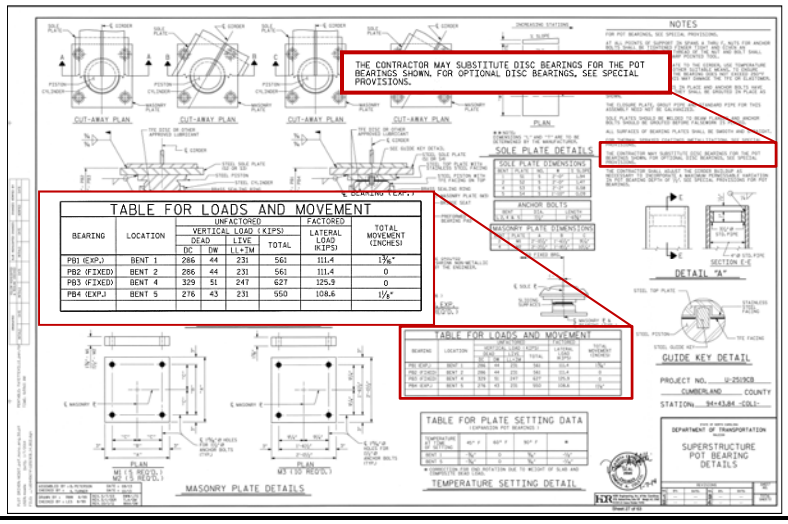
Bearing Details



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Presentation Poll 4

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Introduction to Steel Bridge Design

Session 1: Introduction to Bridge Engineering

Domenic Coletti, PE
HDR – Raleigh, NC

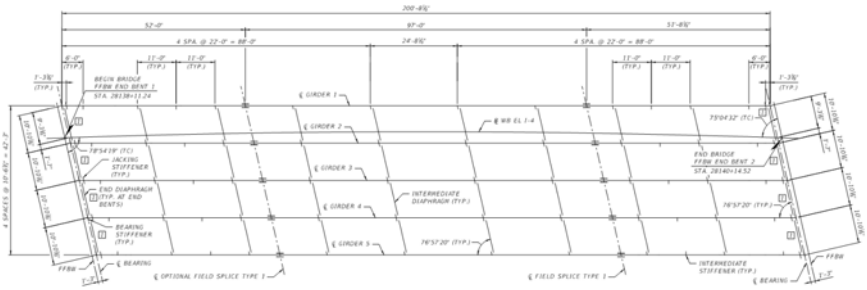
structural STEEL

I-Girder Bridge Framing Plans

- Framing Plans show identification, geometry and arrangement of:
  - Girders
  - Cross-frames
  - Supports (Abutments, Piers, Bearings)
  - Field Splices
  - Stiffeners

I-Girder Bridge Framing Plans

- Straight girders



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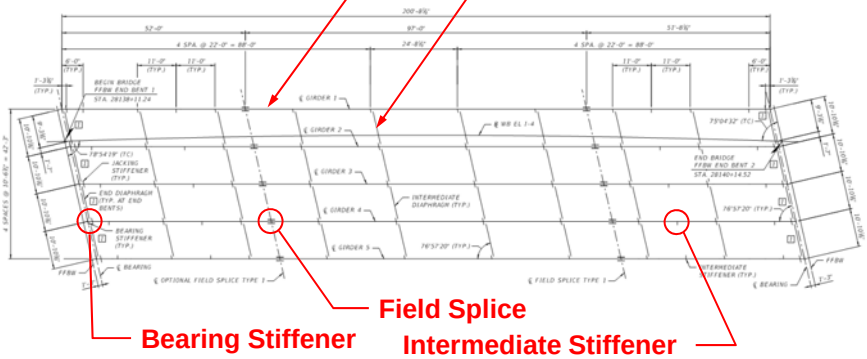
I-Girder Bridge Framing Plans

- Straight girders



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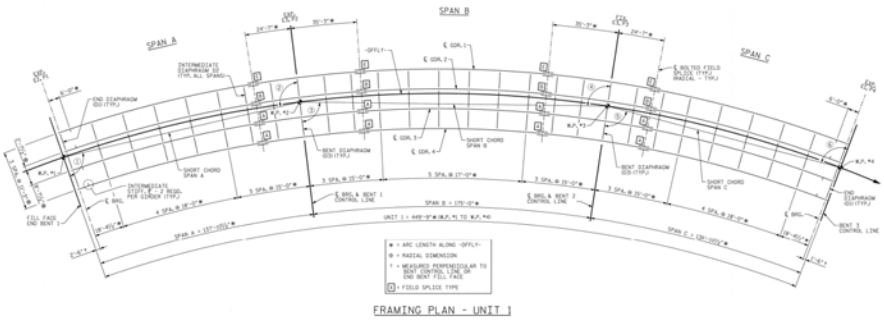
I-Girder Bridge Framing Plans

- Straight girders

85

I-Girder Bridge Framing Plans

- Curved girders



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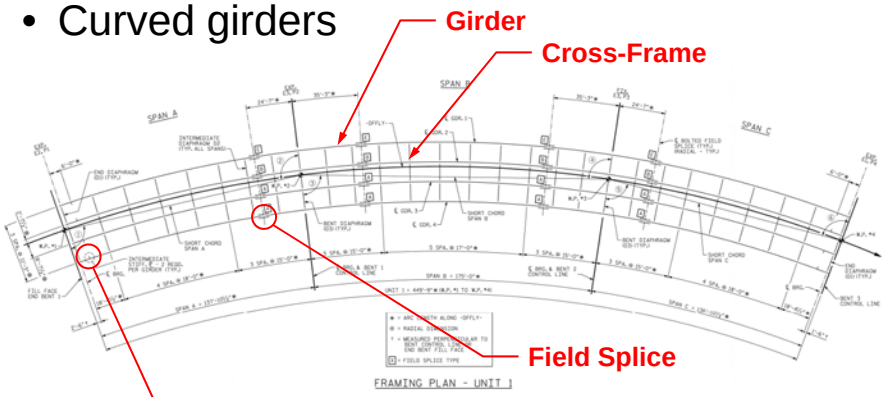
I-Girder Bridge Framing Plans

- Curved girders



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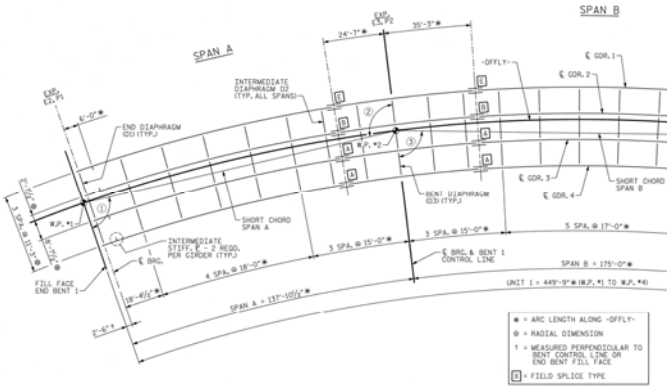
I-Girder Bridge Framing Plans

- Curved girders

88

I-Girder Bridge Framing Plans

- Radial / normal supports



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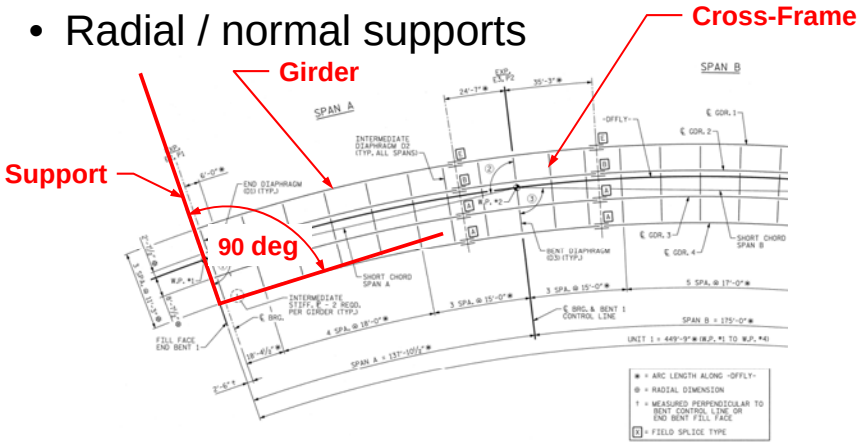
I-Girder Bridge Framing Plans

- Radial / normal supports



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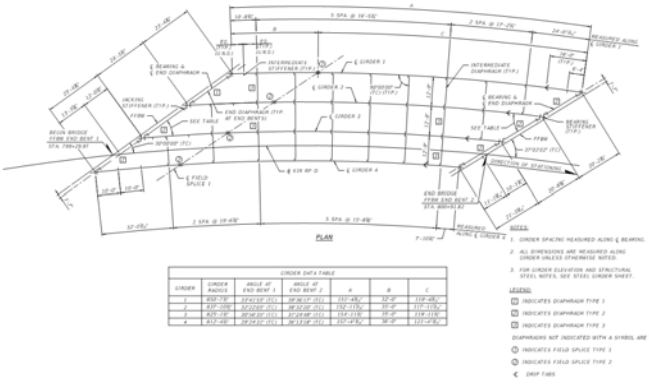
I-Girder Bridge Framing Plans

- Radial / normal supports

91

I-Girder Bridge Framing Plans

- Skewed supports



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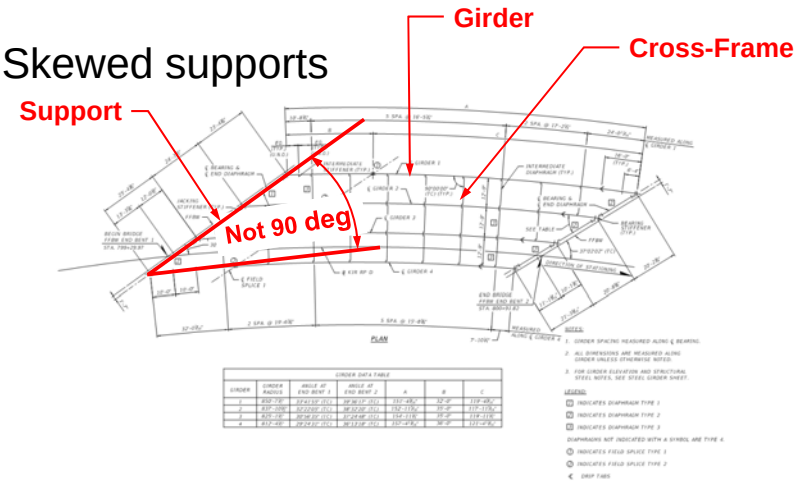
I-Girder Bridge Framing Plans

- Skewed supports



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I-Girder Bridge Framing Plans

- Skewed supports

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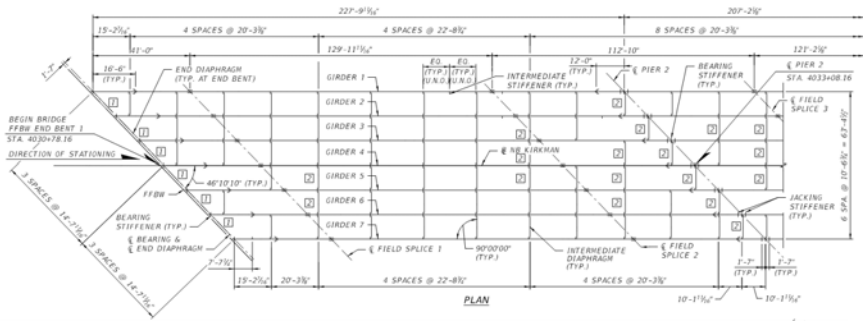
I-Girder Bridge Framing Plans

- Parallel girders



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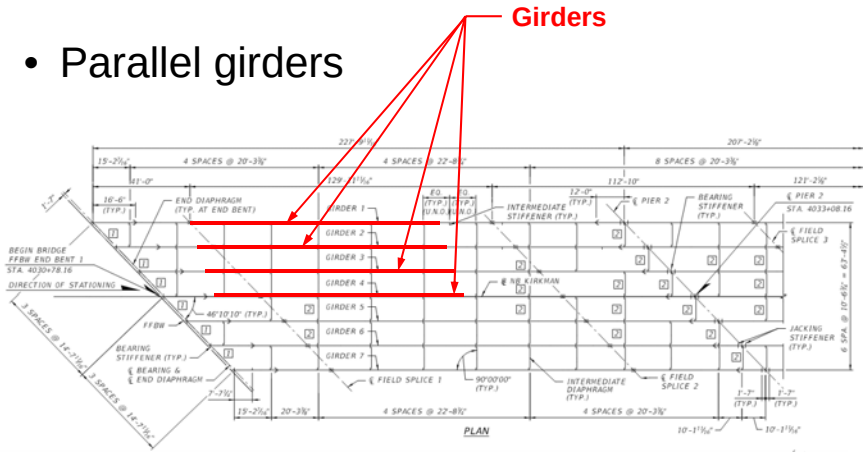
I-Girder Bridge Framing Plans

- Parallel girders



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I-Girder Bridge Framing Plans

- Parallel girders

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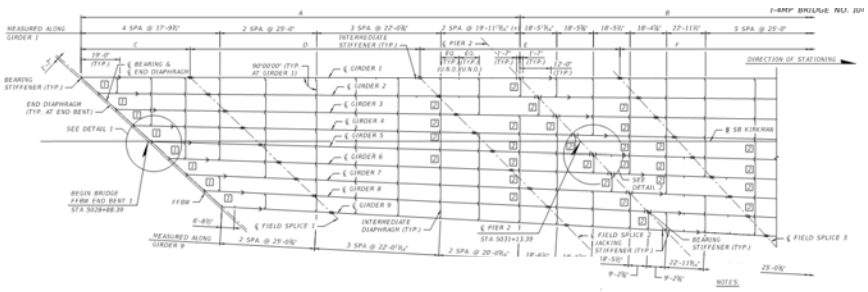
I-Girder Bridge Framing Plans

- Variable spacing girders



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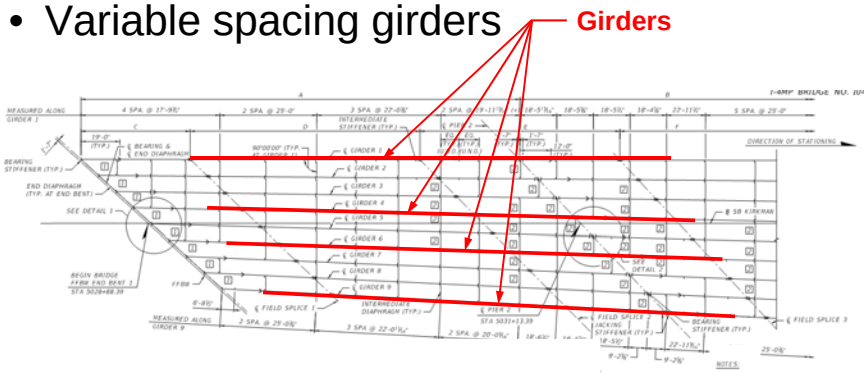
I-Girder Bridge Framing Plans

- Variable spacing girders



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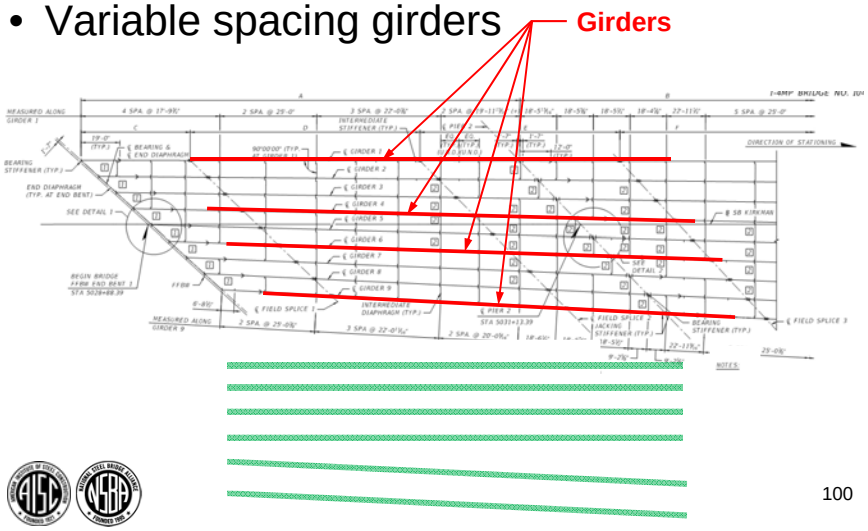
I-Girder Bridge Framing Plans

- Variable spacing girders



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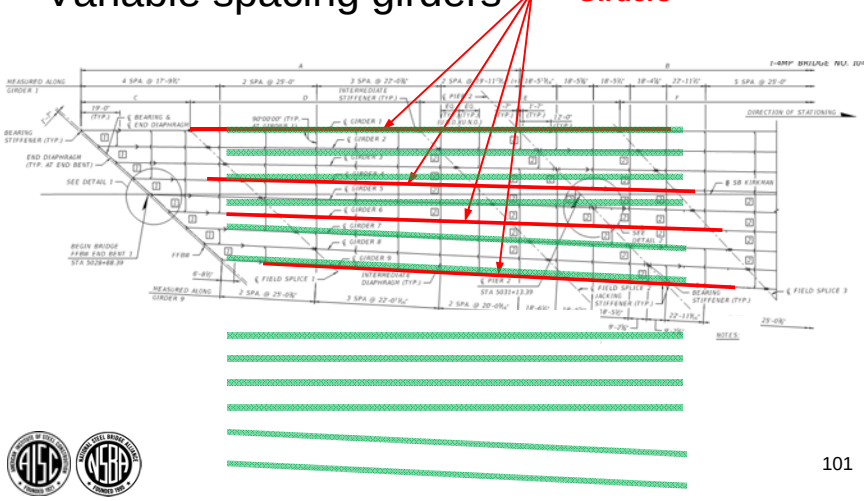
I-Girder Bridge Framing Plans

- Variable spacing girders



101

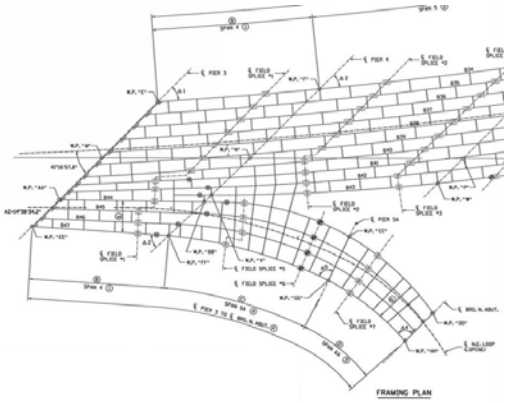
I-Girder Bridge Framing Plans

- Variable spacing girders

102

I-Girder Bridge Framing Plans

- Bifurcated girders



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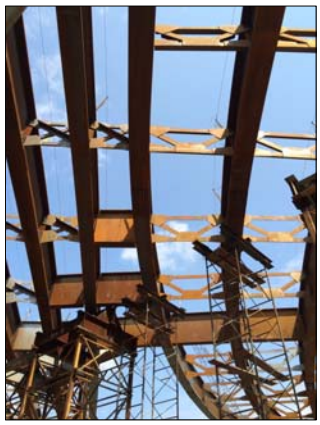
I-Girder Bridge Framing Plans

- Bifurcated girders

104

I-Girder Bridge Framing Plans

- Bifurcated girders



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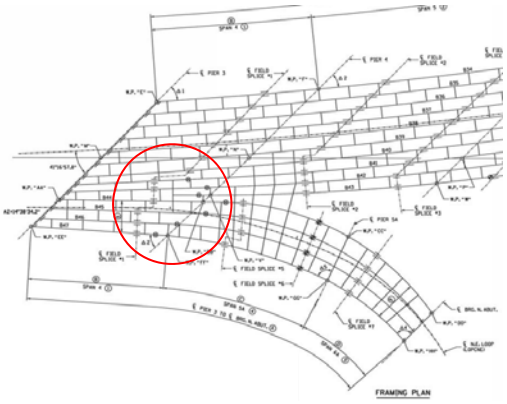
I-Girder Bridge Framing Plans

- Bifurcated girders



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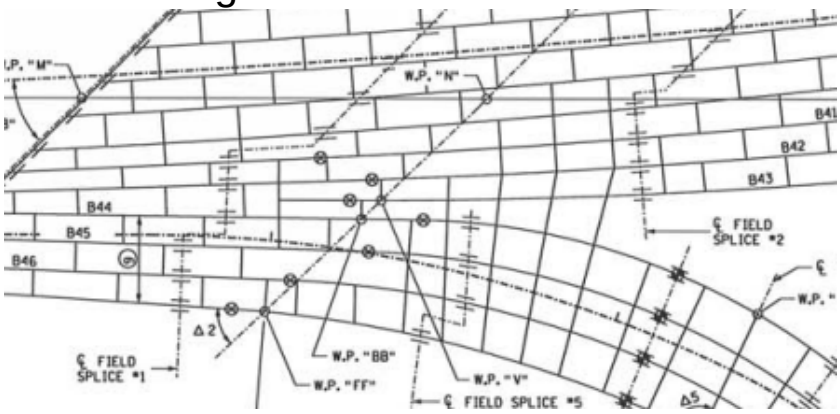
I-Girder Bridge Framing Plans

- Bifurcated girders



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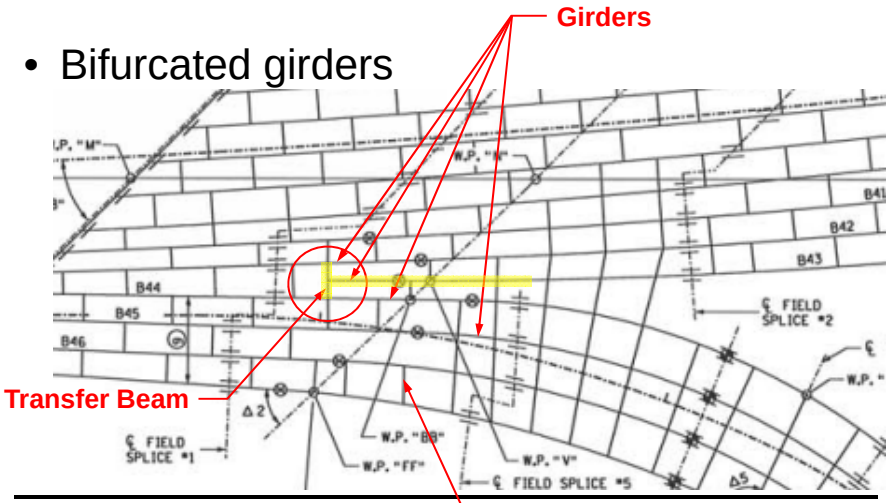
I-Girder Bridge Framing Plans

- Bifurcated girders



108

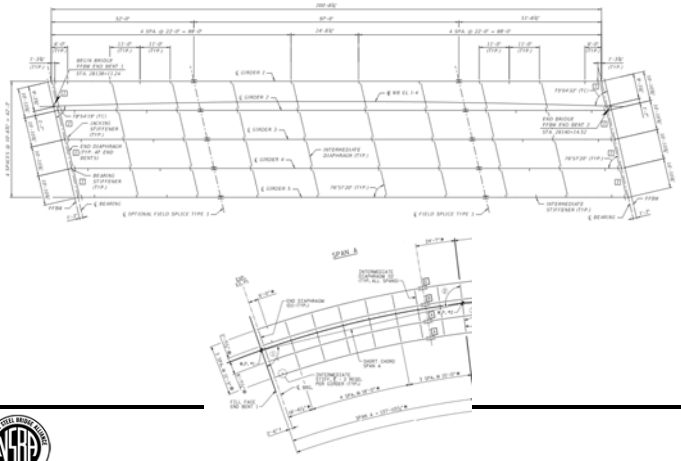
I-Girder Bridge Framing Plans

- Bifurcated girders

109

I-Girder Bridge Framing Plans

- Contiguous cross-frames



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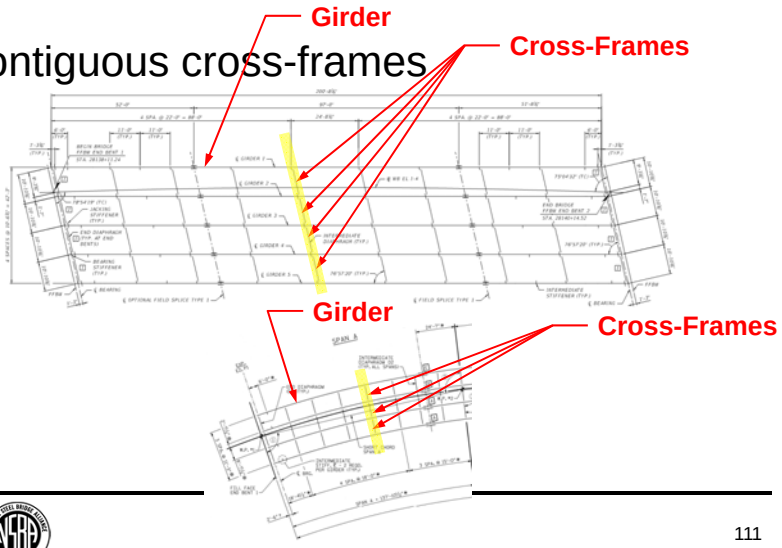
I-Girder Bridge Framing Plans

- Contiguous cross-frames



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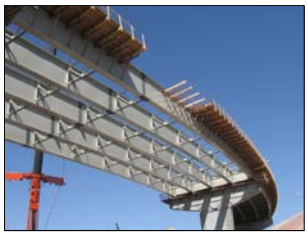
I-Girder Bridge Framing Plans

- Contiguous cross-frames



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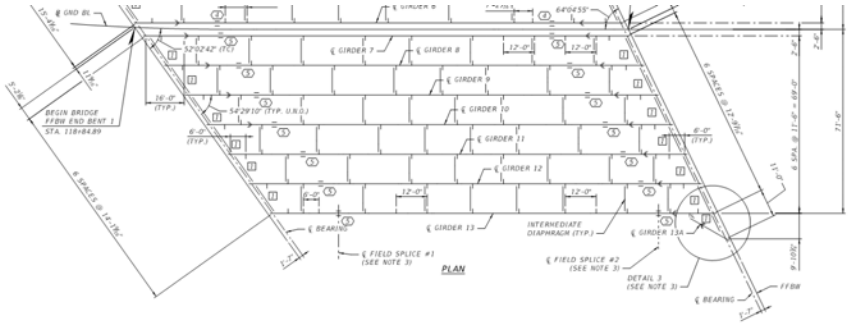
I-Girder Bridge Framing Plans

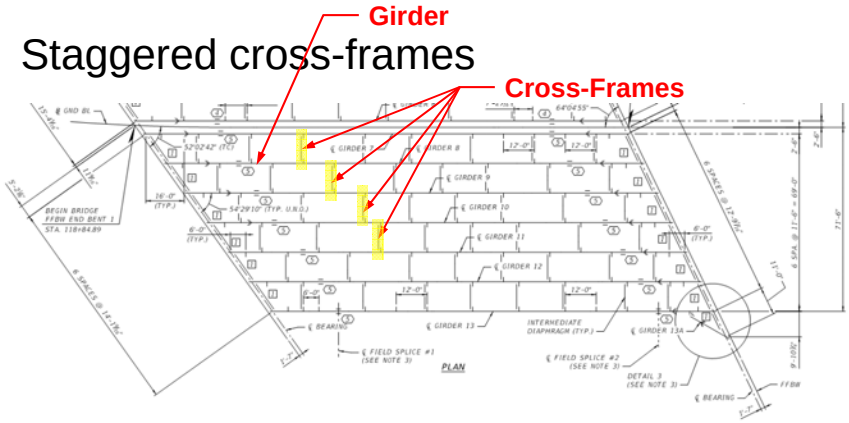
- Staggered cross-frames



113

I-Girder Bridge Framing Plans

- Staggered cross-frames



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I-Girder Bridge Framing Plans

- Staggered cross-frames

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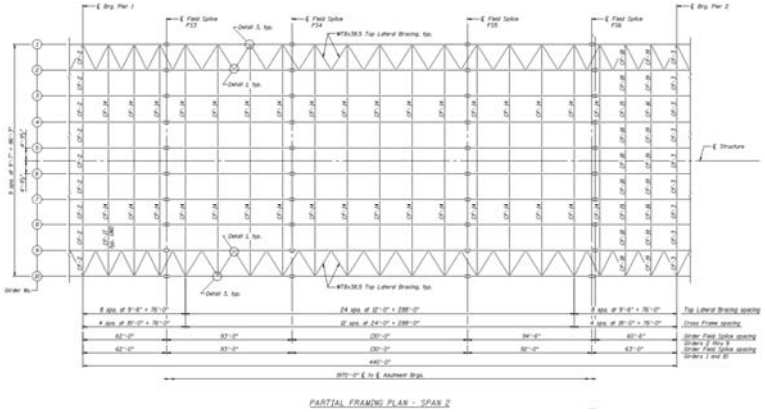
I-Girder Bridge Framing Plans

- Lateral bracing



PARTIAL FRAMING PLAN - SPAN 2

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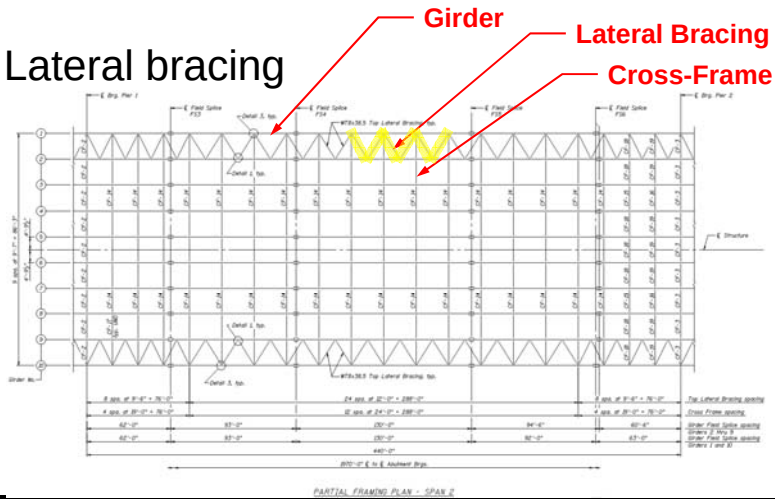
I-Girder Bridge Framing Plans

- Lateral bracing



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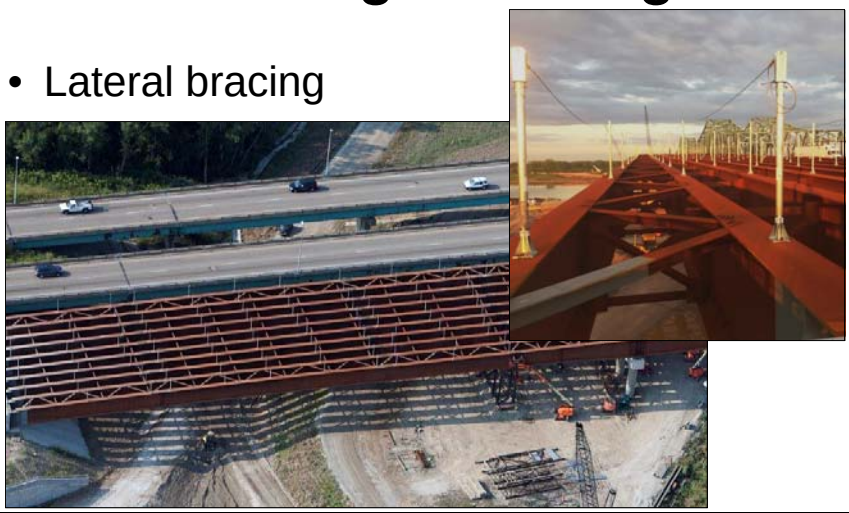
I-Girder Bridge Framing Plans

- Lateral bracing



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Presentation Poll 5

Analysis Methods

- Line girder analysis (“1D”)
- Refined analysis (“2D” and “3D”)

Analysis Methods

- Line Girder Analysis
  - Considers girder only
  - No recognition of system behavior
  - Appropriate for final design of simple bridges
  - Appropriate for preliminary design and validation of complex bridges, with caveats

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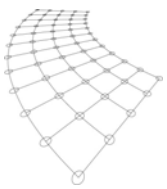
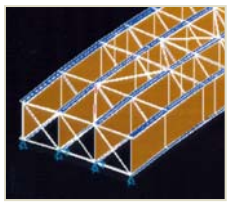
Analysis Methods

- Refined analysis methods
  - 2D Grid Analysis
  - 2D Plate & Eccentric Beam Analysis
  - 3D FEM Analysis





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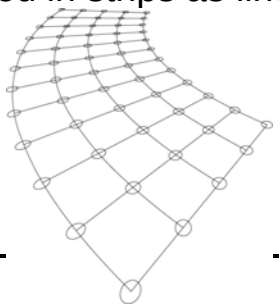
Analysis Methods

- 2D Grid Analysis
  - Girders modeled as line elements
  - Diaphragms modeled as line elements
  - Deck modeled in strips as line elements



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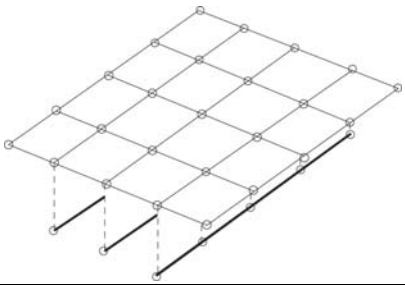
Analysis Methods

- 2D Plate & Eccentric Beam Analysis
  - Variant of 2D grid analysis
  - Deck modeled with plate or shell elements



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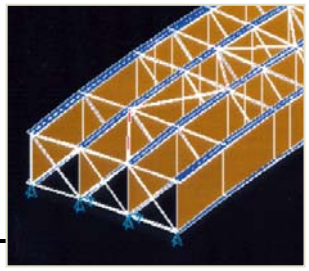
Analysis Methods

- 3D FEM Analysis
  - Flanges: beam or plate elements
  - Webs: plate elements
  - Diaphragms, bracing: truss or plate elements
  - Deck: solid or plate elements



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Analysis Methods

- Which should you use?
  - "It depends…"
  - Analysis method should be appropriate for the complexity of the bridge

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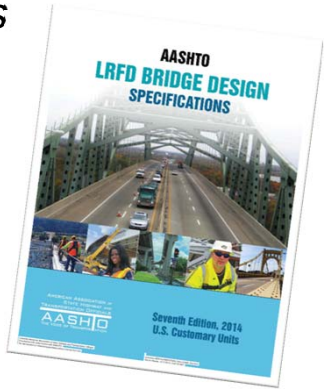
Design Codes

- AASHTO *LRFD Bridge Design Specifications*



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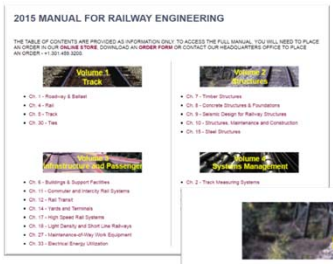
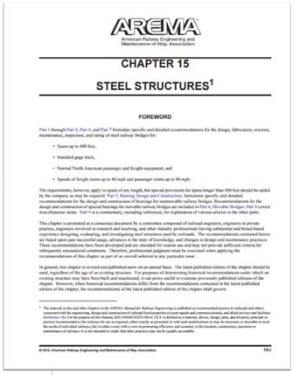
Design Codes

- AREMA Manual for Railway Engineering



- Ch. 7 - Timber Structures
- Ch. 8 - Concrete Structures & Foundations
- Ch. 9 - Seismic Design for Railway Structures
- Ch. 10 - Structures, Maintenance and Construction
- Ch. 15 - Steel Structures



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Session 1 Recap

- **Introduction to Bridge Engineering**
  - Bridge Nomenclature
  - Types of Bridges
  - Girder Bridge Superstructures
  - Substructures
  - Bridge Plan Set Organization and Content
  - I-Girder Bridge Framing Plans
  - Analysis Methods
  - Design Codes

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Questions?

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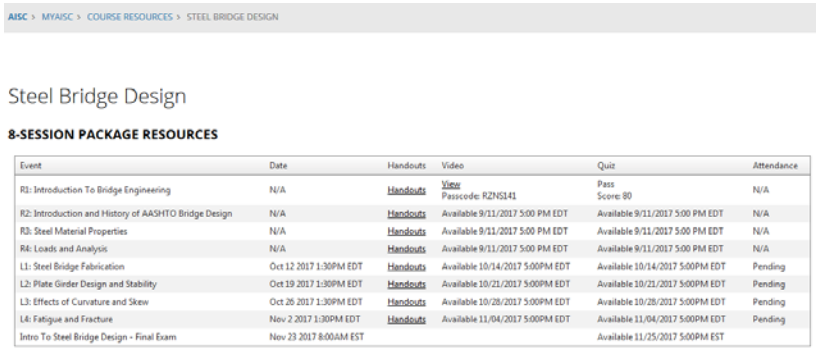
8-Session Package Registrants

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.



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.

There's always a solution in steel!