2024 TSQC Meeting
Triple I-Girder Steel Straddle Bent Cap Design

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LJA

NSTMs and Redundancy

- Fracture Critical designation is obsolete and replaced by NSTM (Non-Redundant Steel Tension Member)

Per the 2022 FHWA National Bridge Inspection Standards (NBIS) a NSTM is defined as:
A *primary steel member fully or partially in tension, and without load path redundancy, system redundancy or internal redundancy, whose failure may cause a portion of or the entire bridge to collapse.*

- How to achieve Redundancy:

1. Load Path Redundancy (LPRM)
   ≥ 3 primary load carrying members
2. System Redundancy (SRM)
   Fracture at one location of a primary member will not cause partial or complete bridge collapse
3. Internal Redundancy (IRM)
   Fracture on the cross section of a primary member will not propagate through the entire member, it is discoverable and will not cause partial or complete bridge collapse

Box Girder Steel Straddle Bent Caps

- Advantages :
    - Longer spans
    - Minimum closure to roadway during construction
    - Easy to transport and erect
    - Reduced load on substructure and foundations
    - High torsional constant

- Disadvantages:
    - Higher cost to fabricate
    - Fabrication in confined space
    - These have been classified as Fracture Critical Members requiring:
        - Hands on inspection every 2 years
        - Higher material (CVN) and fabrication (FCP) requirements

LP 1604 / IH 10 Interchange

- LP 1604 North Expansion Project
  - 23-mile-long corridor
  - Split into 6 Segments
  - Complete reconstruction of the Interchange in Segment 2
  - Segment 2 had a 12-month design schedule

- TxDOT requested that we minimize traffic impacts
  - High traffic volume
  - Major institutions near the interchange (UTSA & Six Flags Fiesta Texas)
  - Minimization of frontage roads closures was a focus

- Accelerated Bridge Construction (ABC) Study
  - Comprehensive study for all bridge types and elements

Segment 2

Owner

Prime Consultant

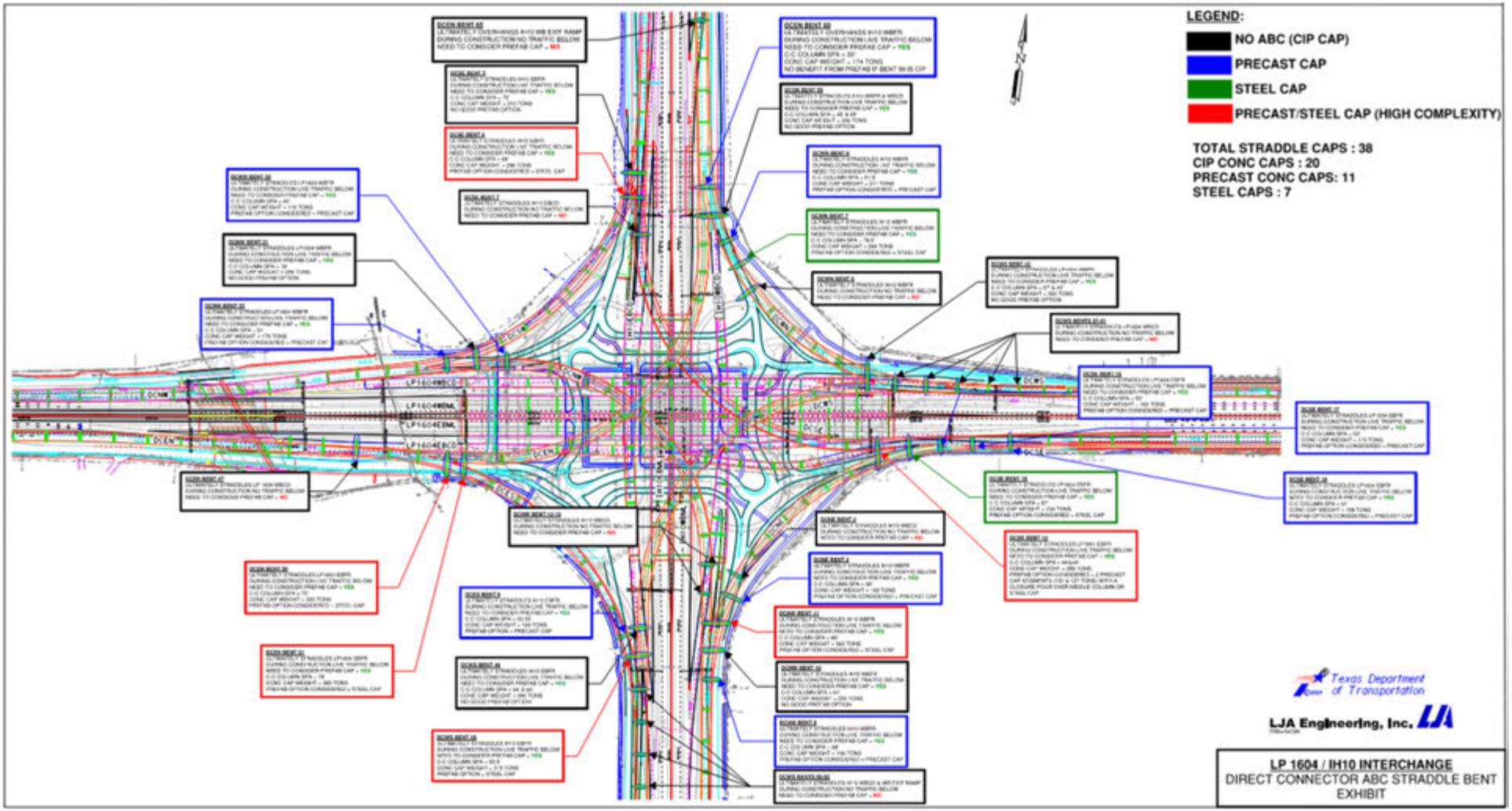
LJA Engineering, Inc.

Contractor

Williams Brothers

Fabricator

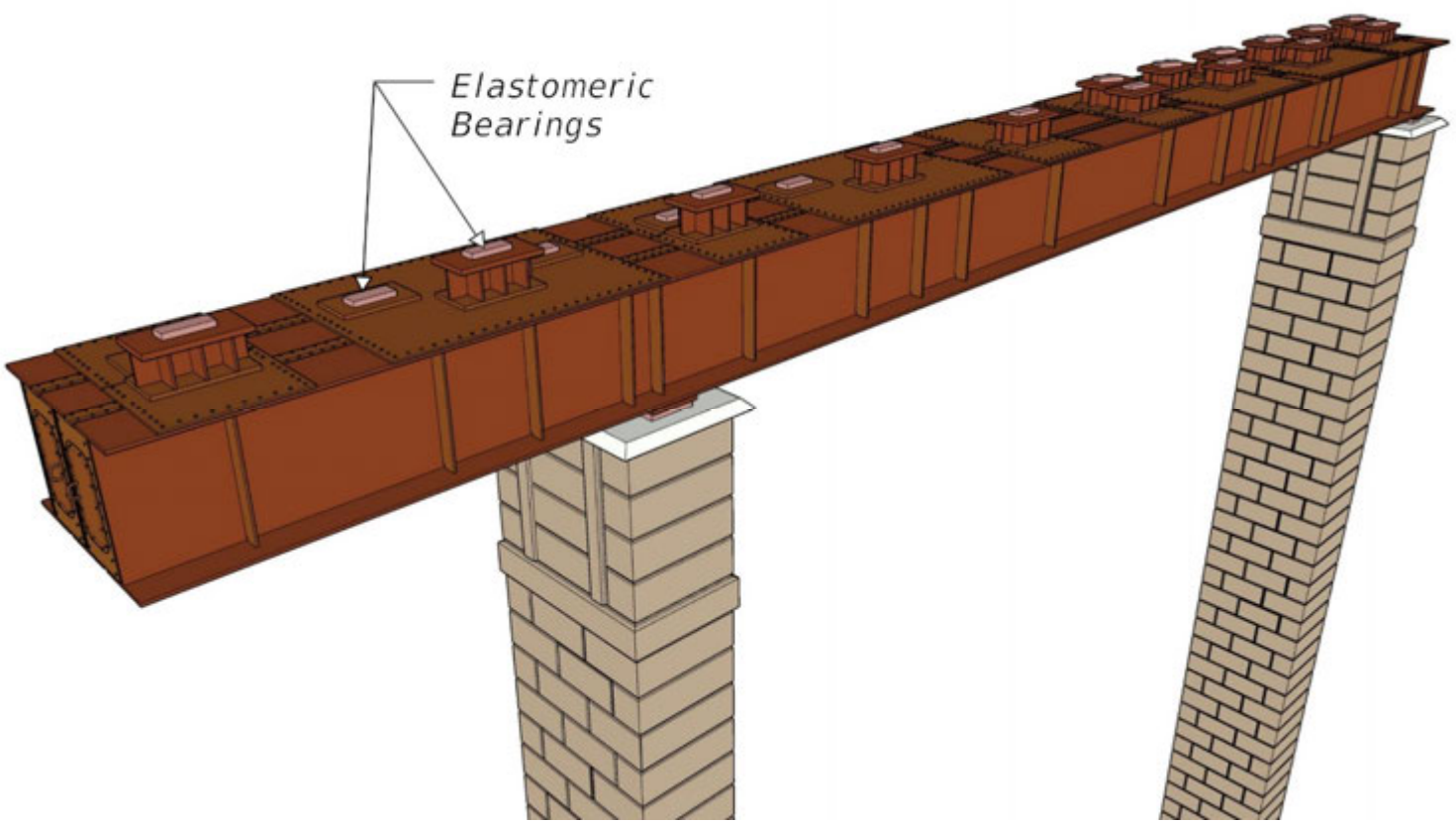
W&W/AFCO Steel


LEGEND:
NO ABC (CIP CAP)
PRECAST CAP
STEEL CAP
PRECAST/STEEL CAP (HIGH COMPLEXITY)
TOTAL STRADDLE CAPS : 38
CIP CONC CAPS : 20
PRECAST CONC CAPS: 11
STEEL CAPS : 7
Texas Department of Transportation
LJA Engineering, Inc.
LP 1604 / IH10 INTERCHANGE
DIRECT CONNECTOR ABC STRADDLE BENT EXHIBIT

LP 1604 / IH 10 Interchange

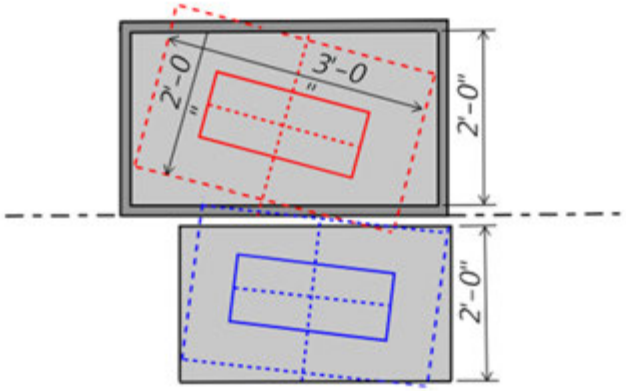
- Investigated the applicability of the three-girder steel straddle bent cap developed for the I-91 interchange in Hartford, CT
- Differences between LP1604/IH10 and I-91 interchange steel staddle bent caps:
  - Simple prestressed concrete girders framing in the cap (LP1604) vs a continuous trapezoidal steel box girders (I-91)
  - Caps overhang one of the two columns (LP1604) vs columns set at the two ends of the cap (I-91)
  - 113’ max overall length of cap with 85’ max c-c column spacing (LP1604) vs 70.5’ overall length of cap with 64.5’ c-c column spacing (I-91)
  - Different size superstructure girders framing on either side of the cap (LP1604)

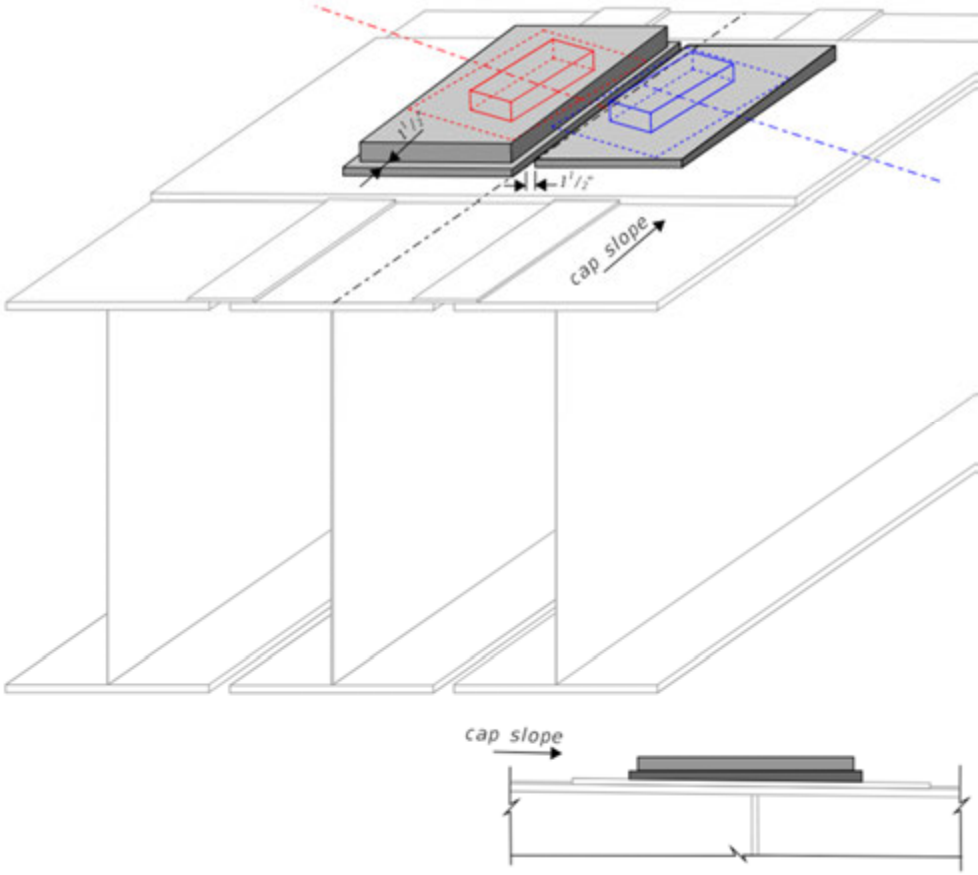
Three-Girder Steel Straddle Bent Caps – General



Three-Girder Steel Straddle Bent Caps – Detailing

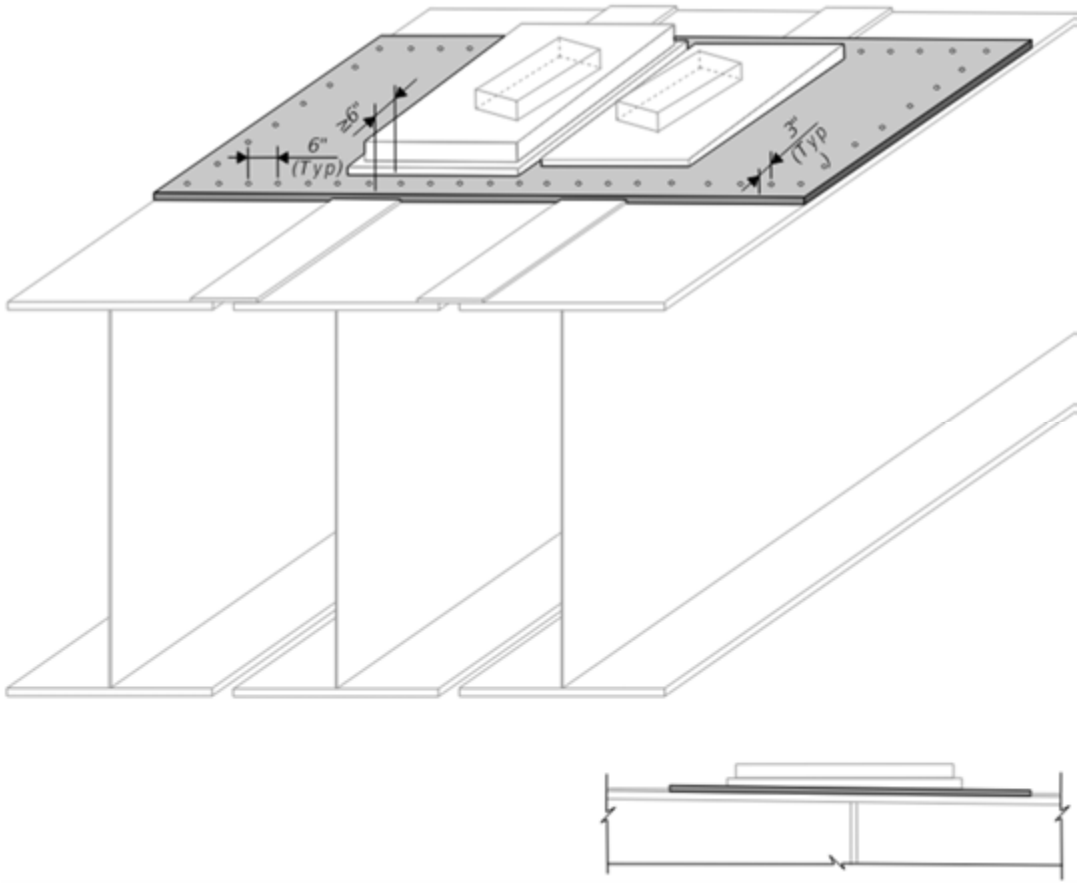
- Masonry Plates
  - Variable thickness plate when T ≤ 4”
  - Stacked plates when T > 4”. Top plate had a constant thickness
  - Width was set to inscribe outmost corners of a “fictitious” 3’x2’ bearing seat





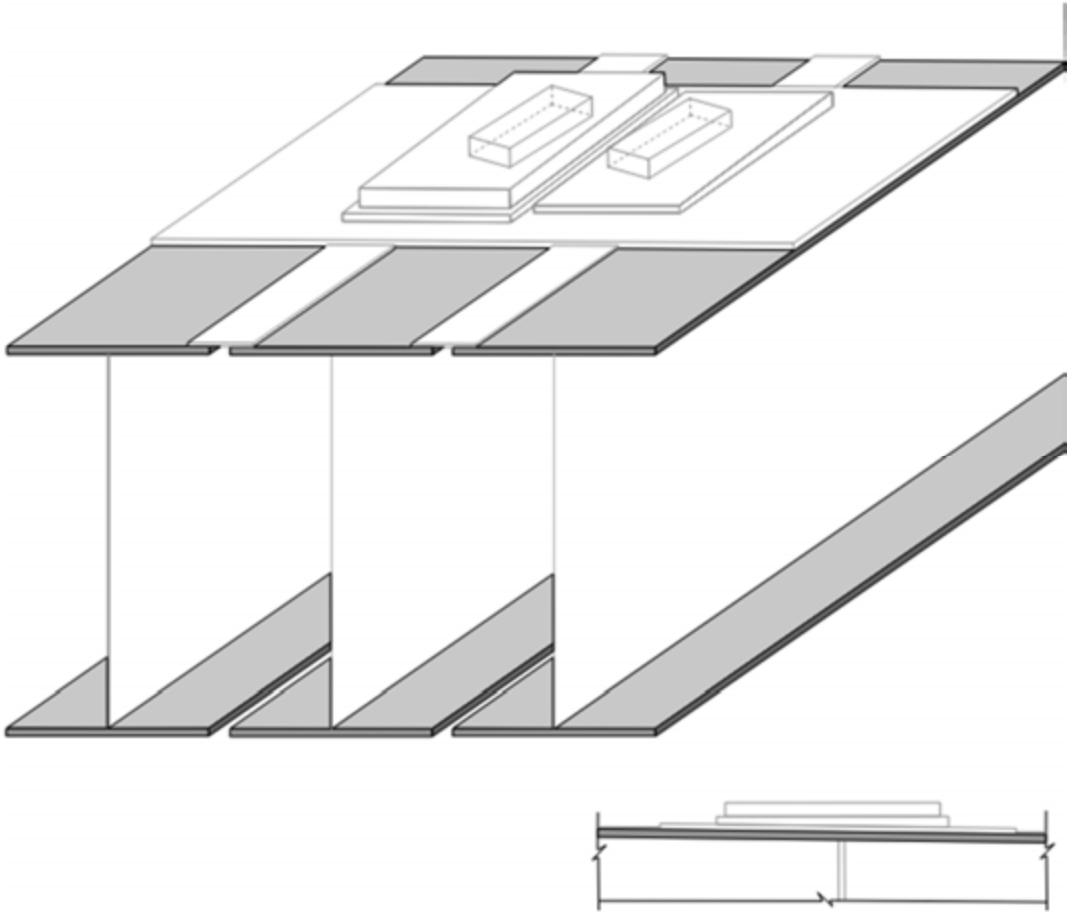
Three-Girder Steel Straddle Bent Caps – Detailing

- Bearing Plates
  - 1” thick (no bevel)
  - Uniform width (across the cap)
  - Group length of plates as much as possible
  - 7/8” Dia H.S. Bolts



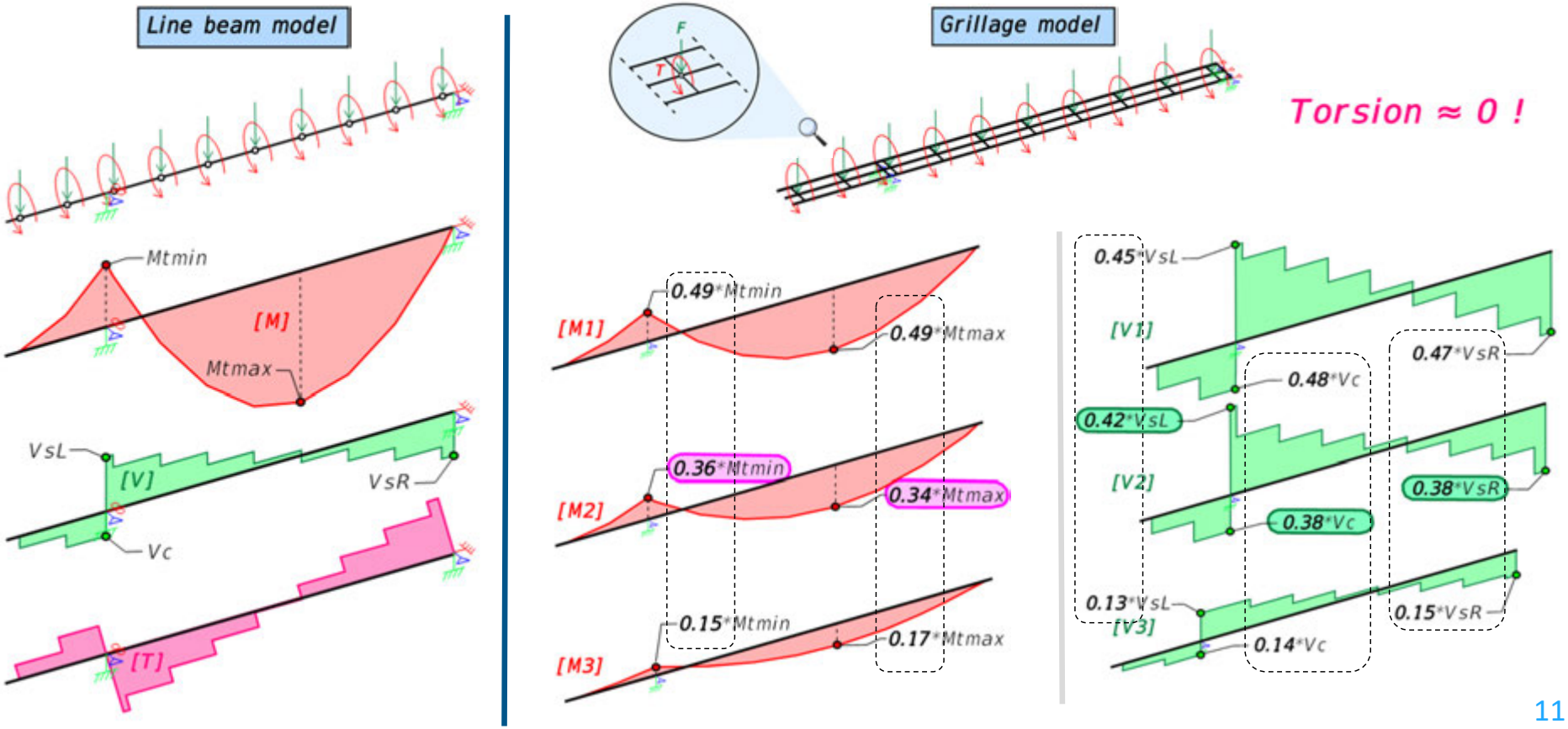
Three-Girder Steel Straddle Bent Caps – Detailing

- I-Girders
  - Flange & Webs are identical for all three girders
  - Inspection Access
    - Flange W = 2’-9” min
    - Web D = 5’-0” min
  - Flange T = 1 ½” min
  - Web T = ½” min



Three-Girder Steel Straddle Bent Caps – Design

- Structural System



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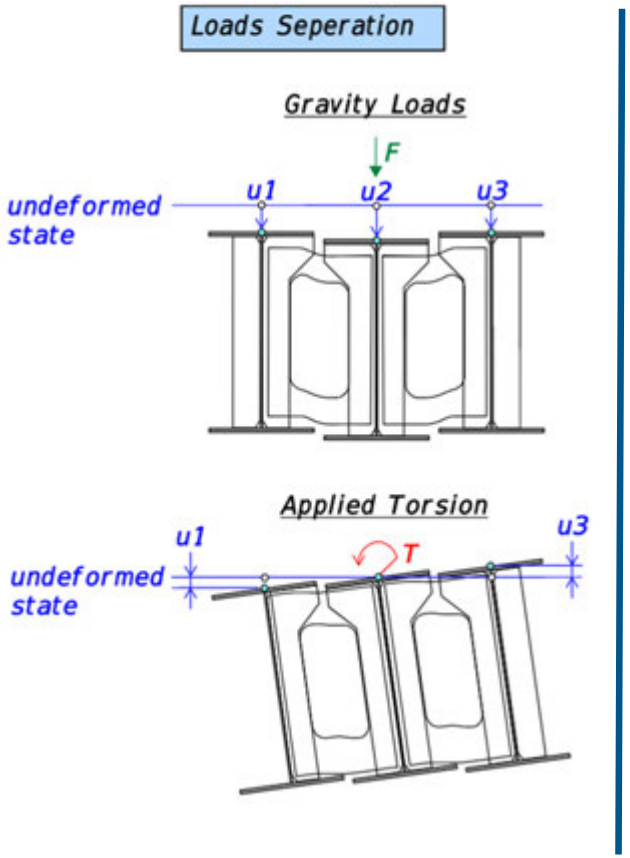
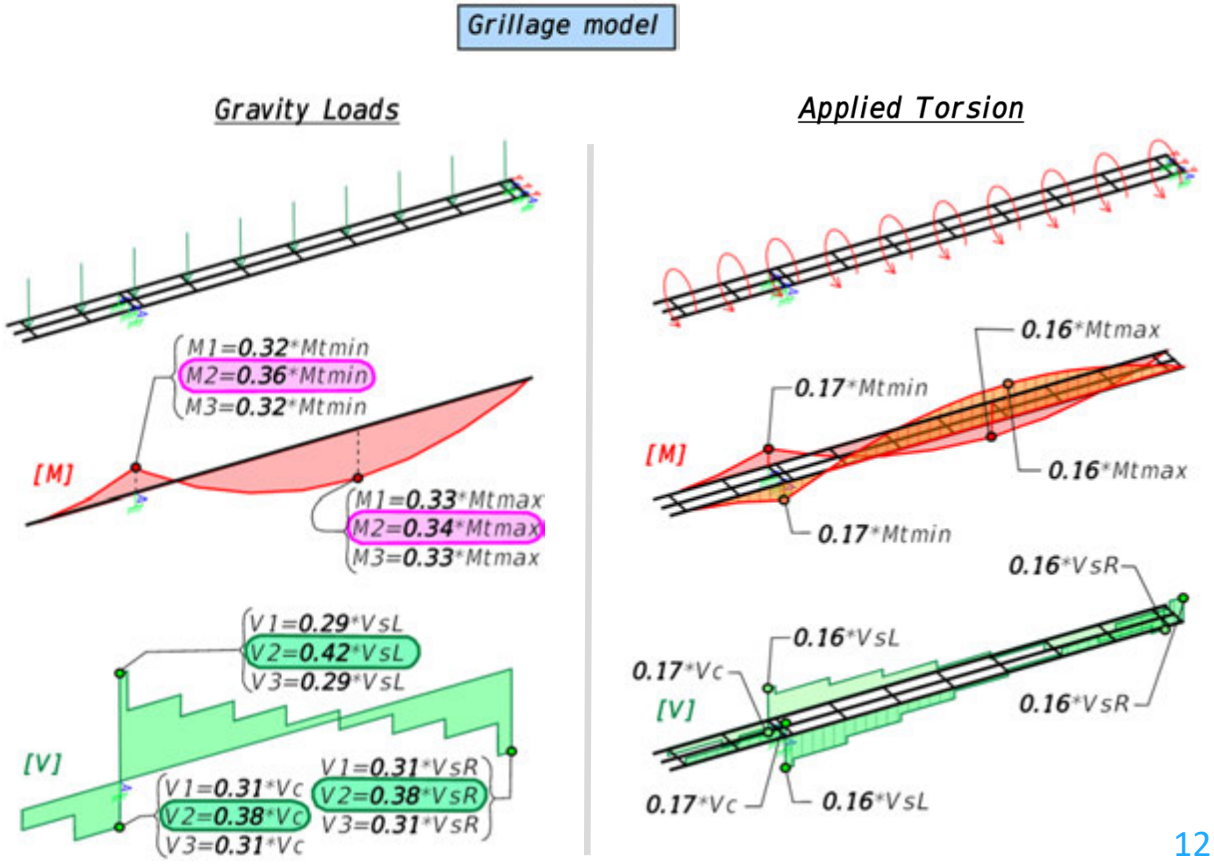
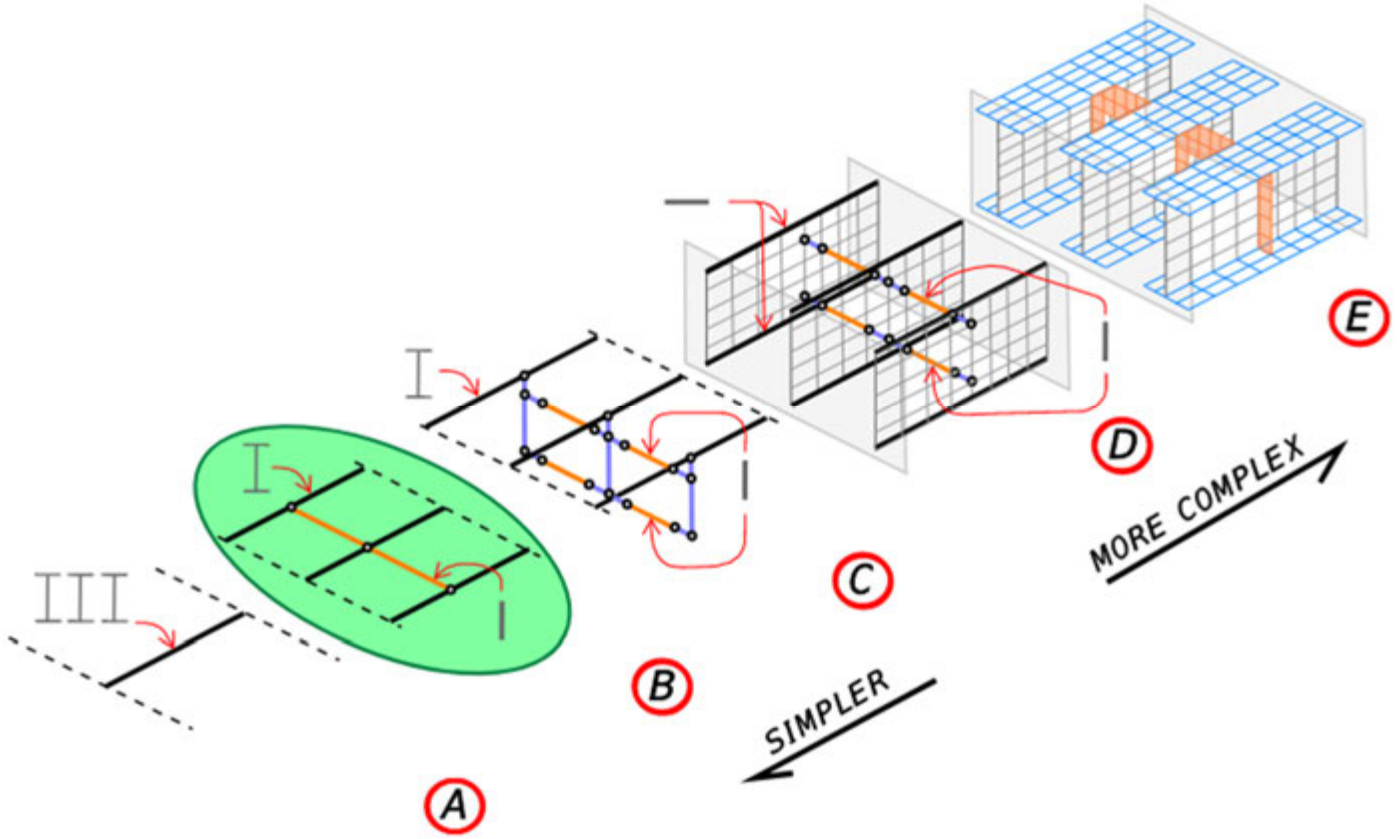




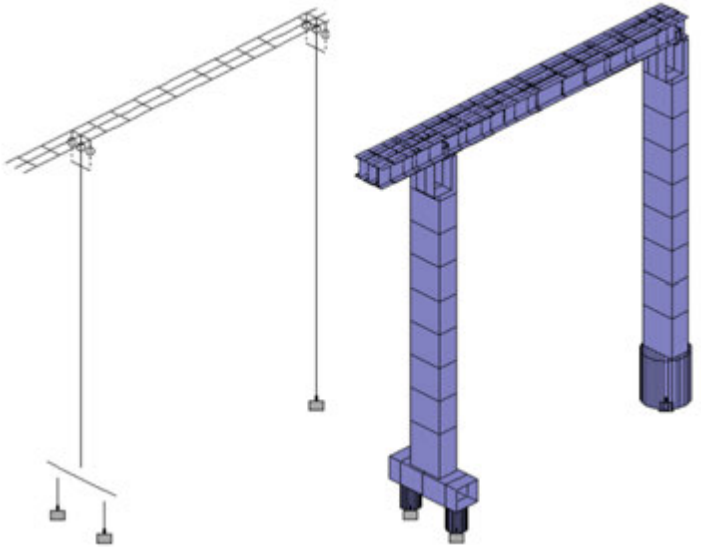
Three-Girder Steel Straddle Bent Caps – Design

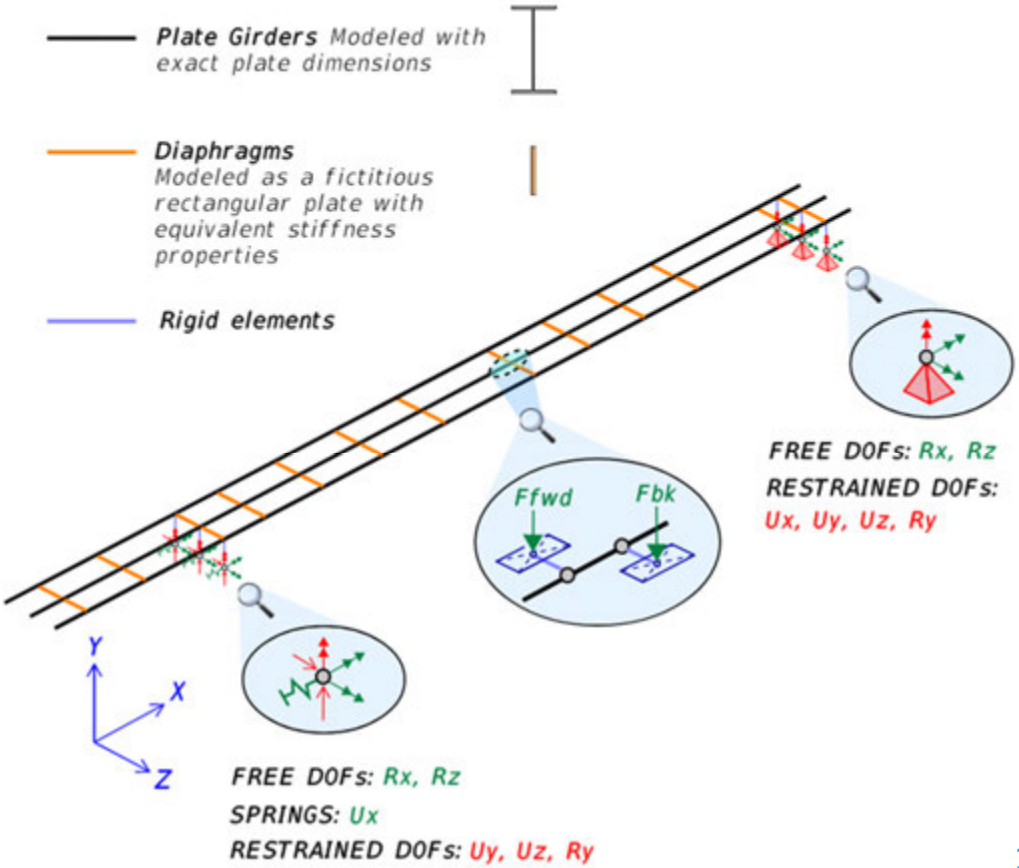
- Modeling: Possible modeling approaches



Three-Girder Steel Straddle Bent Caps – Design

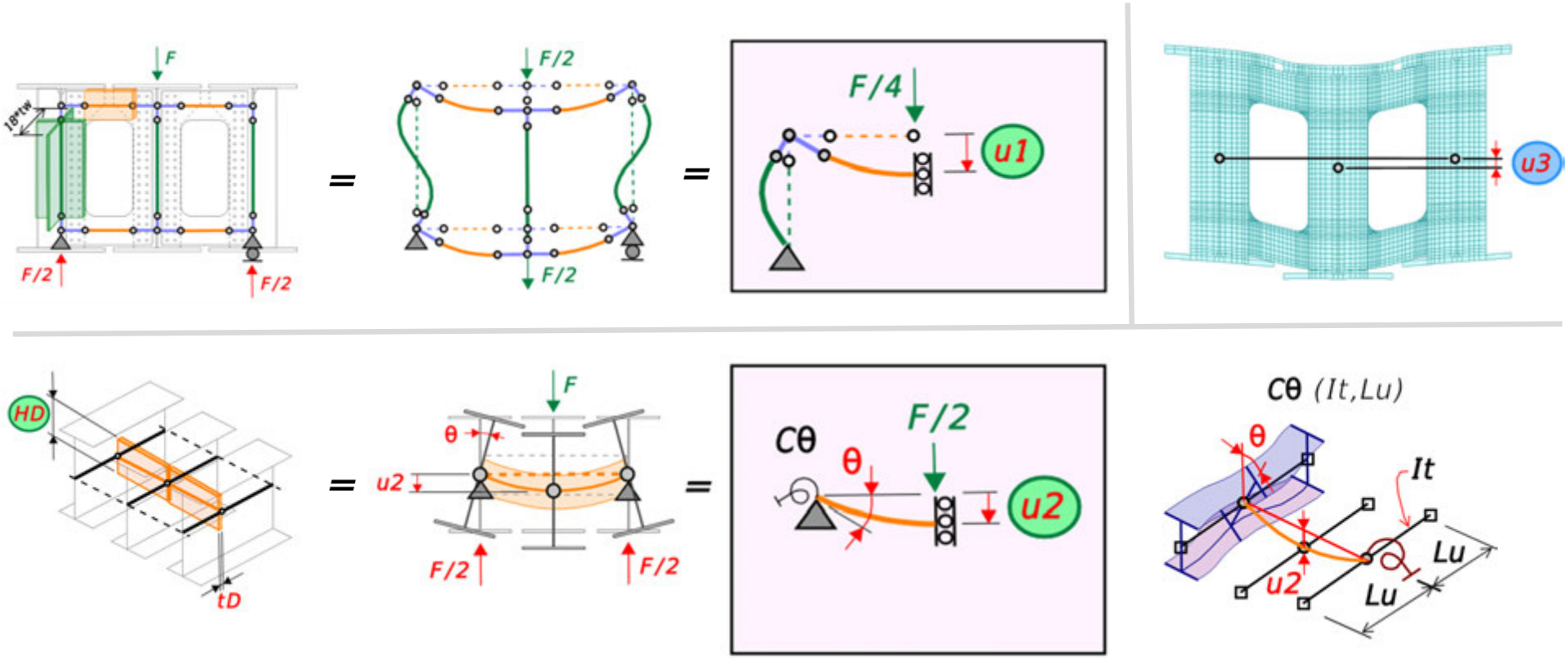
- Modeling: Selected modeling approach





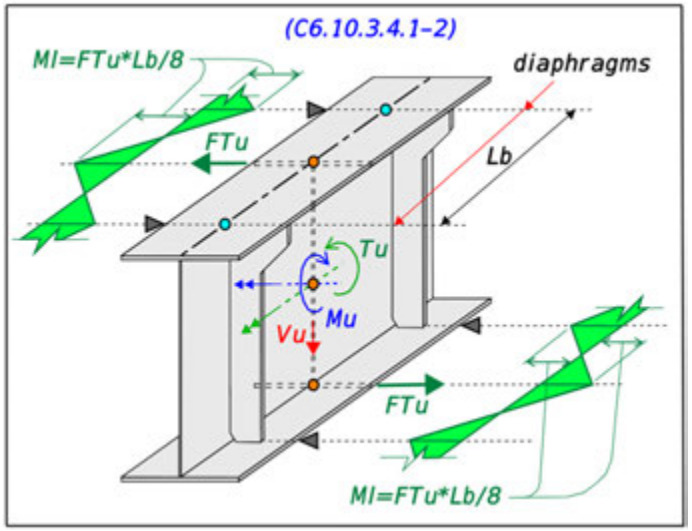
Three-Girder Steel Straddle Bent Caps – Design

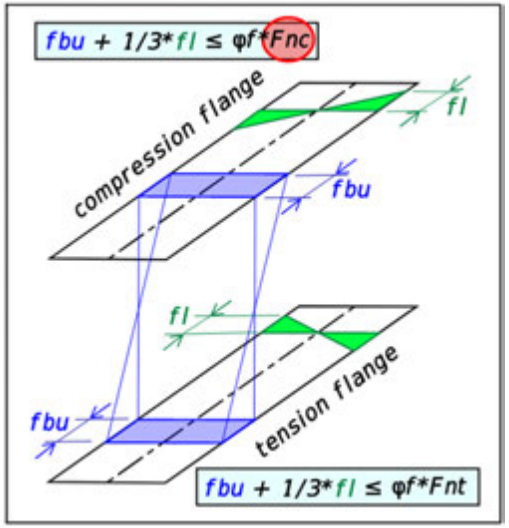
- Modeling: Diaphragm simulation

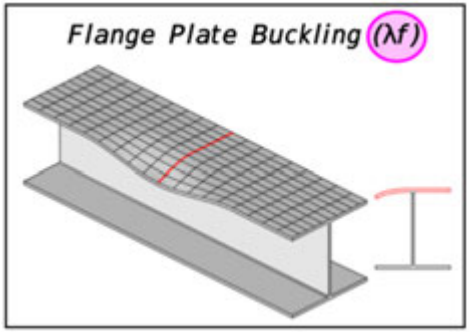


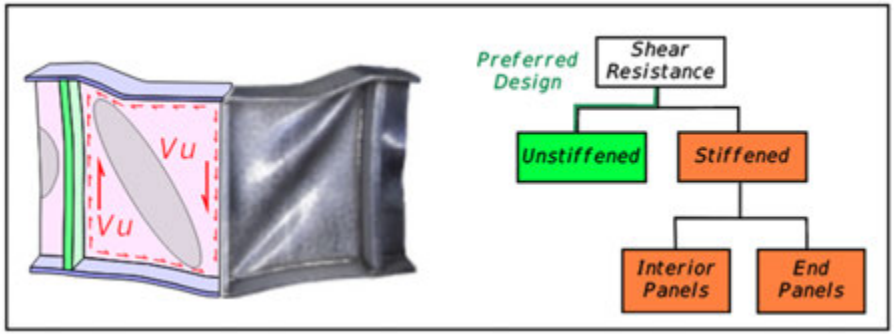
Three-Girder Steel Straddle Bent Caps – Design

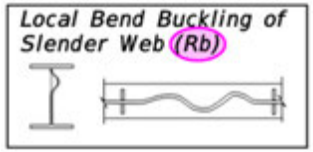
- Design Checks: I-Girders



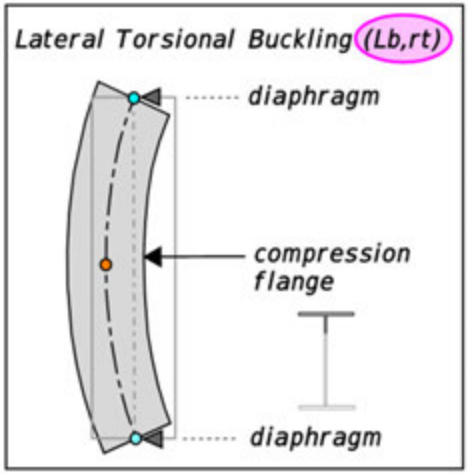






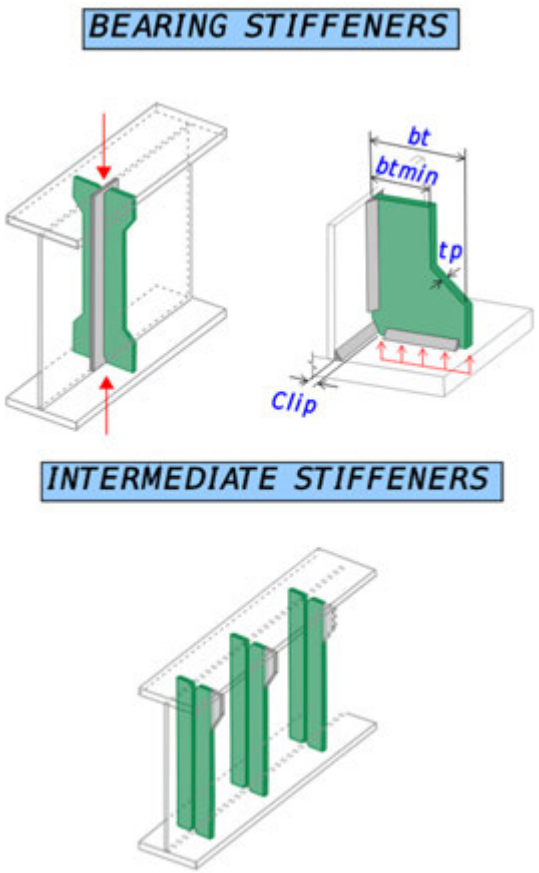


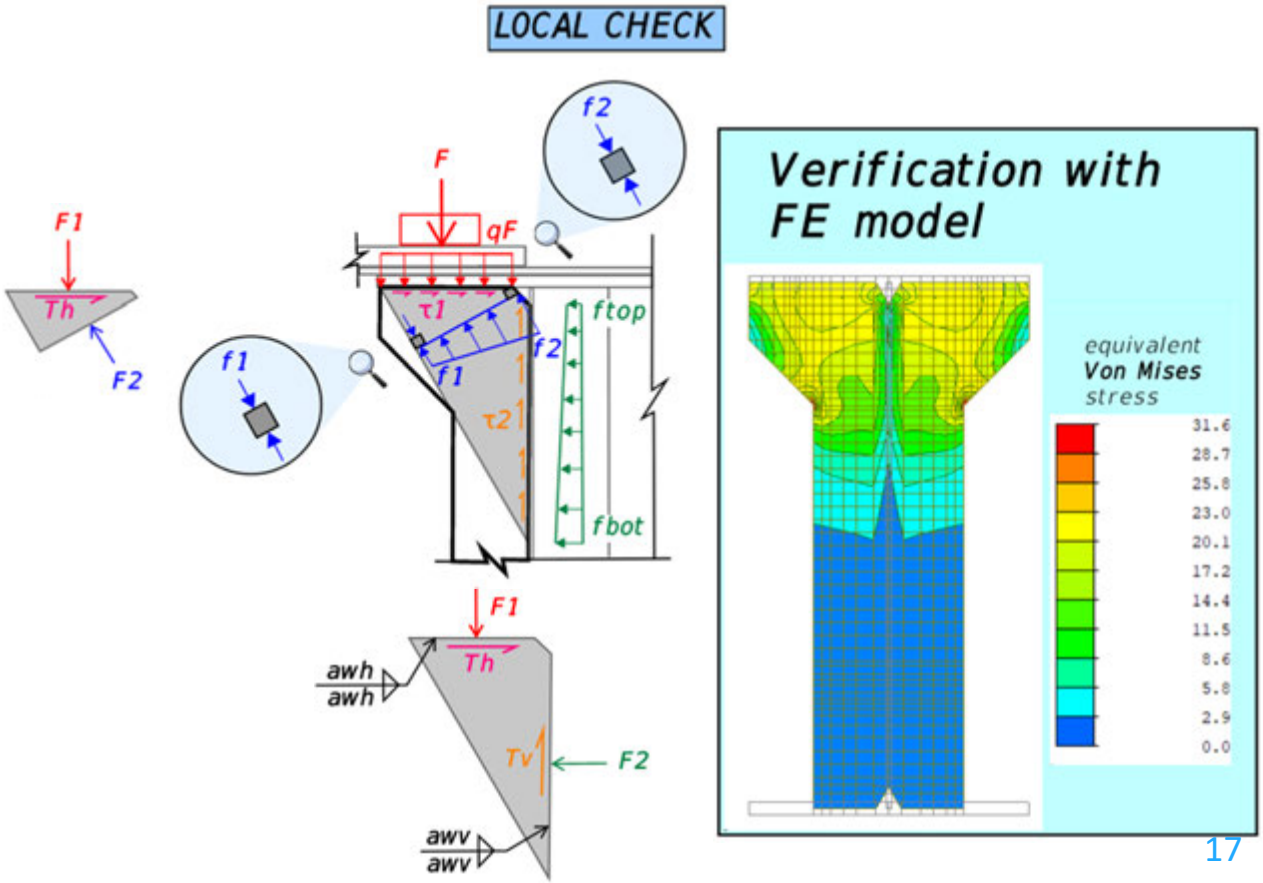
- Cross section Proportion Limits
- Fatigue
- Weld Check



Three-Girder Steel Straddle Bent Caps – Design

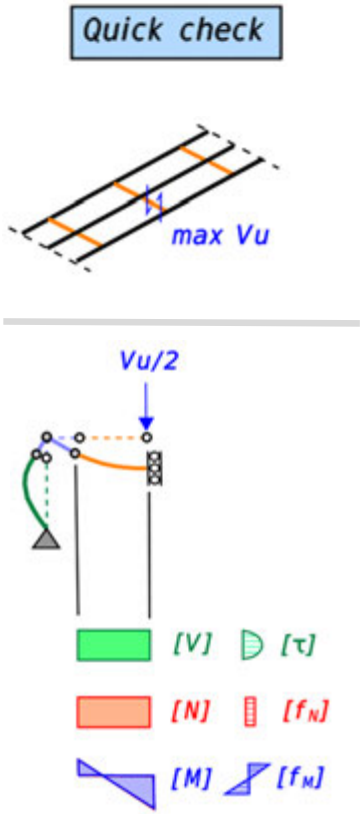
- Design Checks: Stiffeners

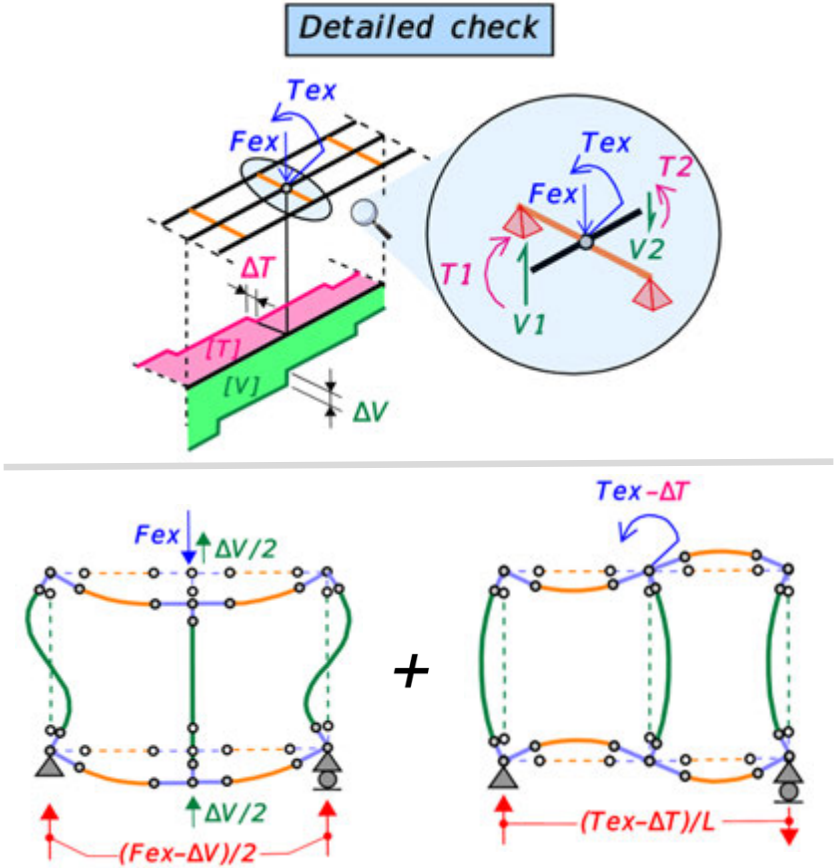


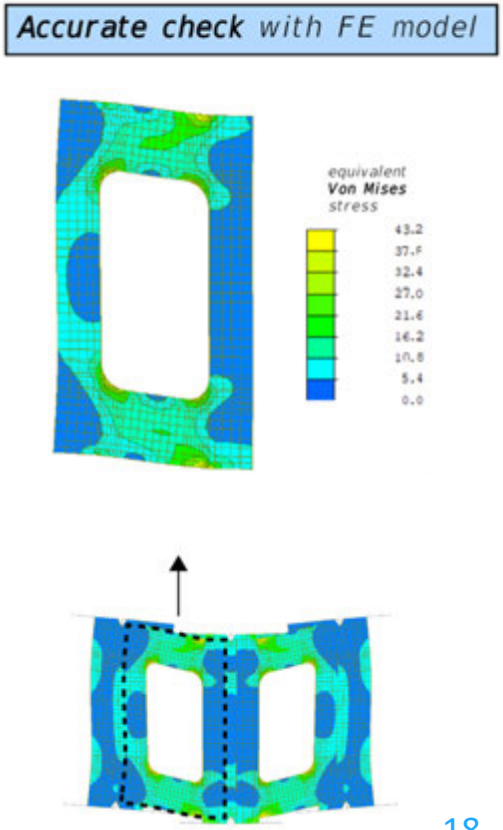


Three-Girder Steel Straddle Bent Caps – Design

- Design Checks: Diaphragms



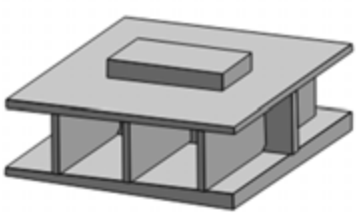




Three-Girder Steel Straddle Bent Caps – Design

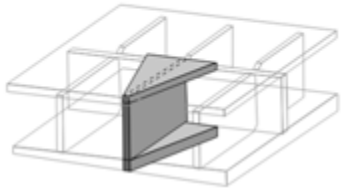
- Design Checks: Miscellaneous

PEDESTAL CHECK

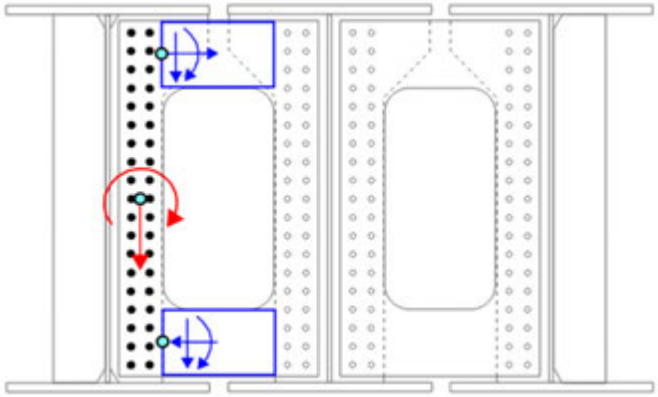


TOP PLATE BENDING CHECK

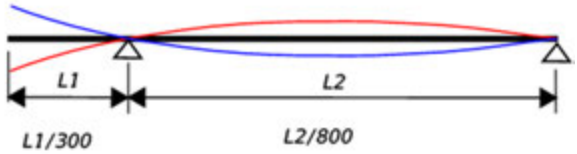
BENDING & SHEAR AT EACH DIRECTION



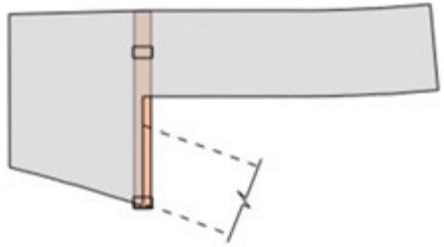
DIAPHRAGM CONNECTION CHECK



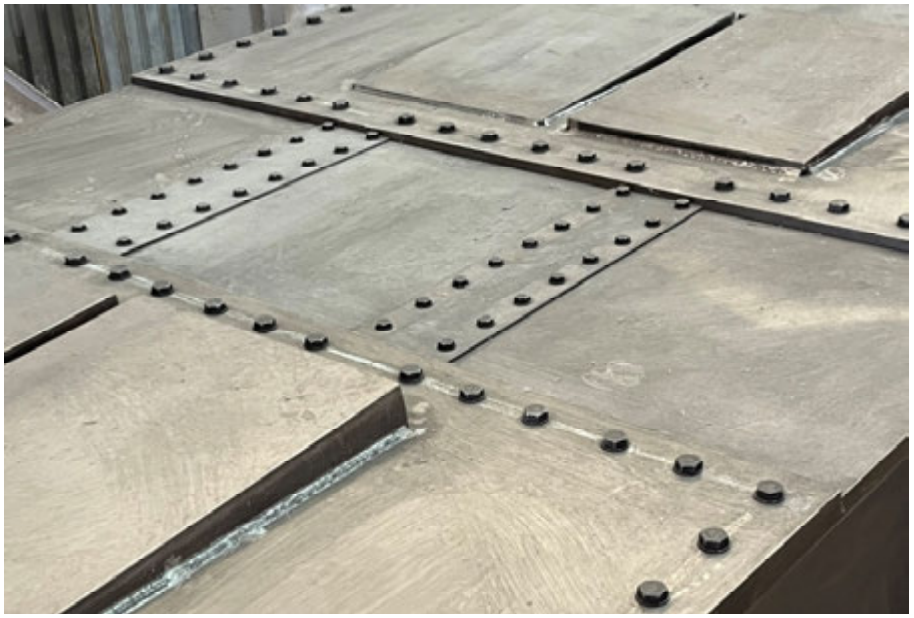
LIVE LOAD DISPLACEMENT CHECK



ELASTOMERIC BEARING CHECKS



Pictures



Pictures

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Questions?

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