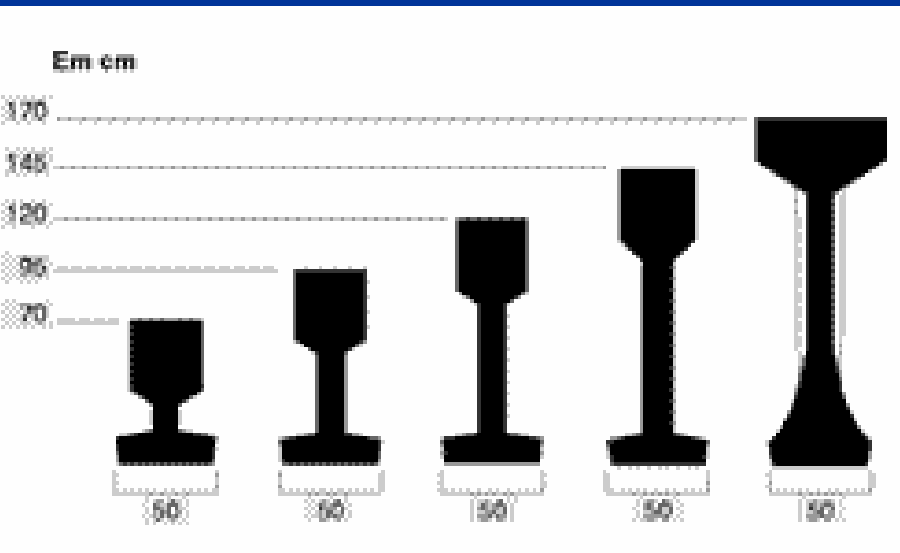
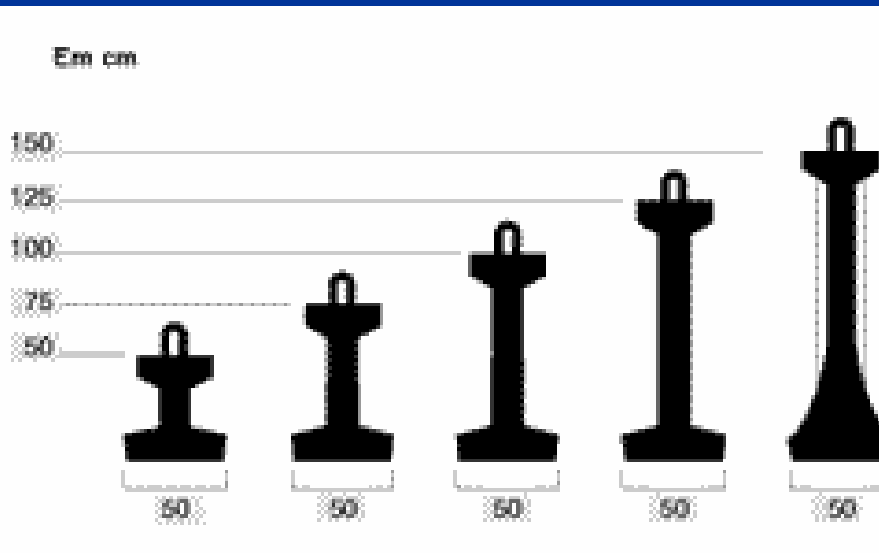
Past, Present and Future of Precast Prestressed Concrete Bridges in the U.S.

First Brazilian Meeting
on
Integration of Research-Design-Production
in
the Field of Precast Concrete

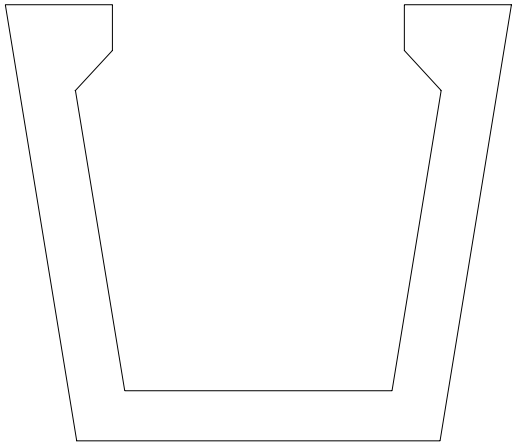
Maher K. Tadros, P.E., Ph.D.
Charles Vranek Professor of Civil Engineering
University of Nebraska Lincoln

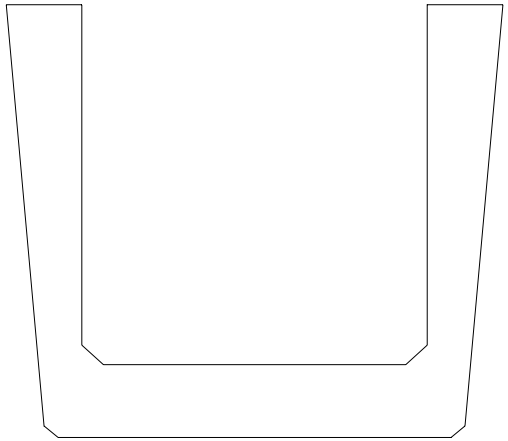
Types of Bridge Girders in Brazil





I Girders

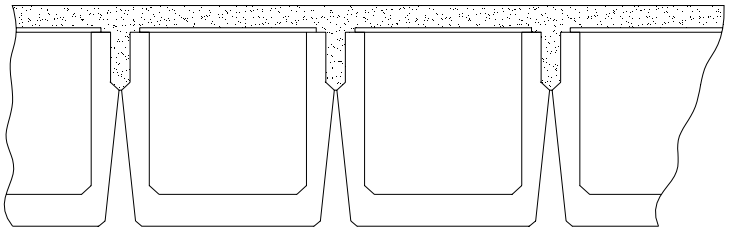


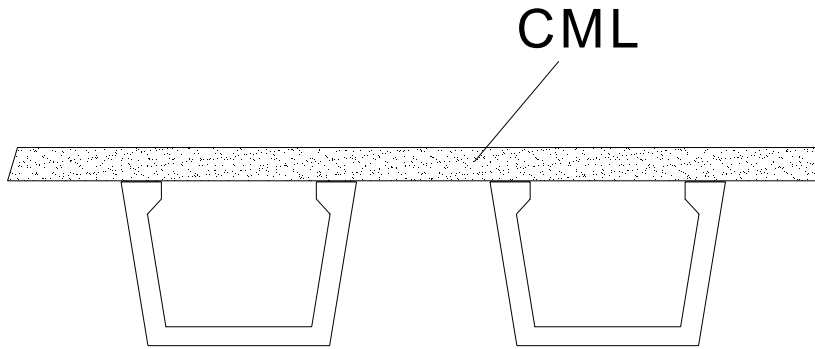


seção trapezoidal

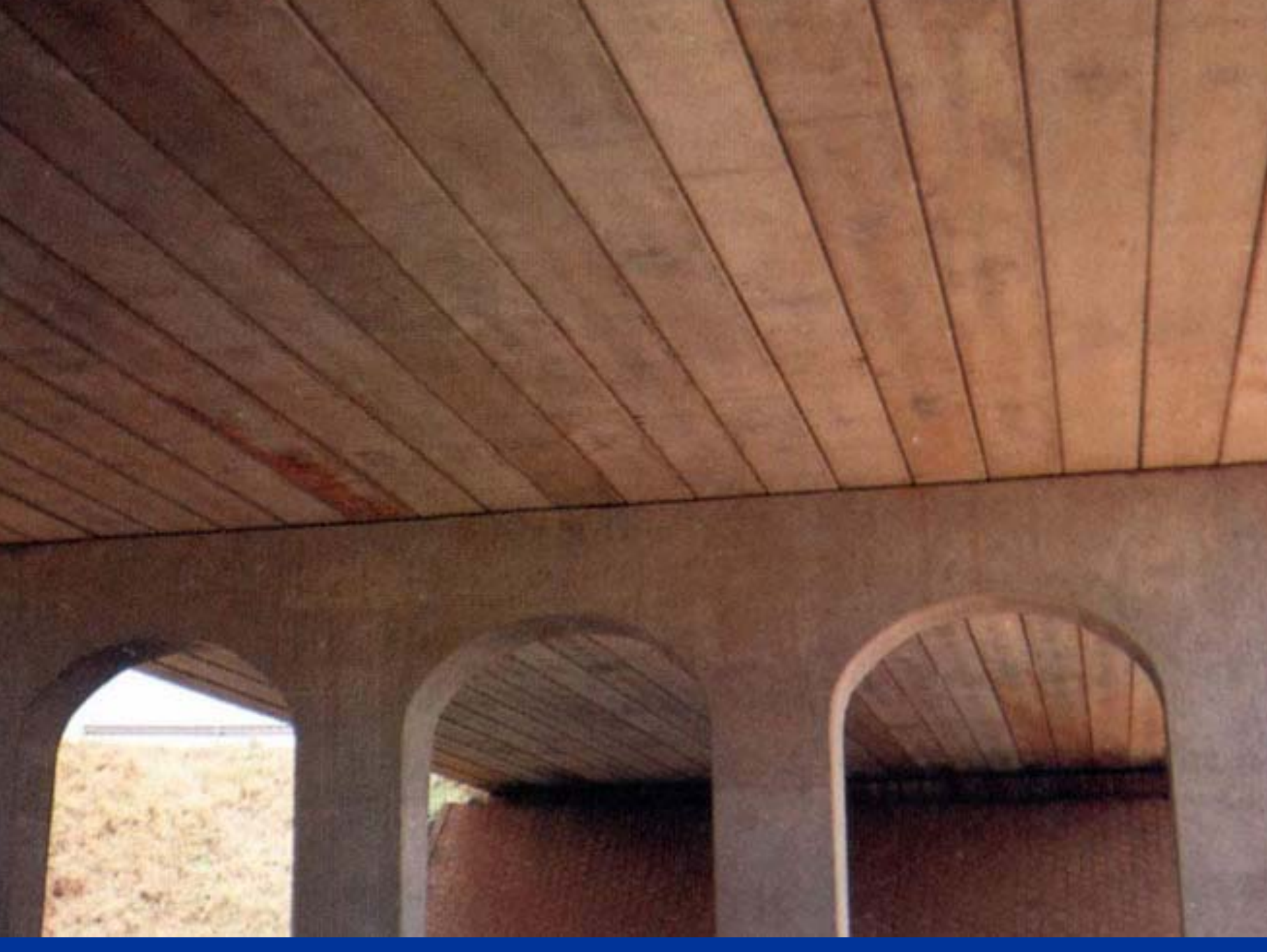
Box Girder

a) tipos de elementos





b) arranjo dos elementos



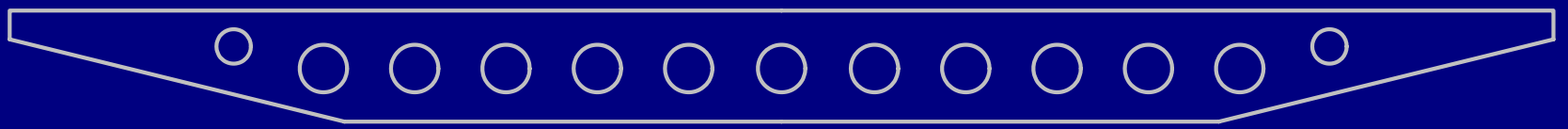
Types of Precast Concrete Bridges Built in the US

- Double Tee and Multi-stem (20 m)
- Inverted Tee (30 m)
- AASHTO Box (36 m)
- AASHTO I-Beam (45 m)
- New I-Beam shapes (65 m)
- Spliced New I-Beams (96 m)

Introduced in Nebraska 1996 for Shallow Bridges with spans to 30 meters, span/depth = 30-33

Also used in Kansas, Iowa, North Carolina, Florida, and Australia

Standardized Precast Segmental Overpass, Post-Tensioned Voided and Ribbed Slabs



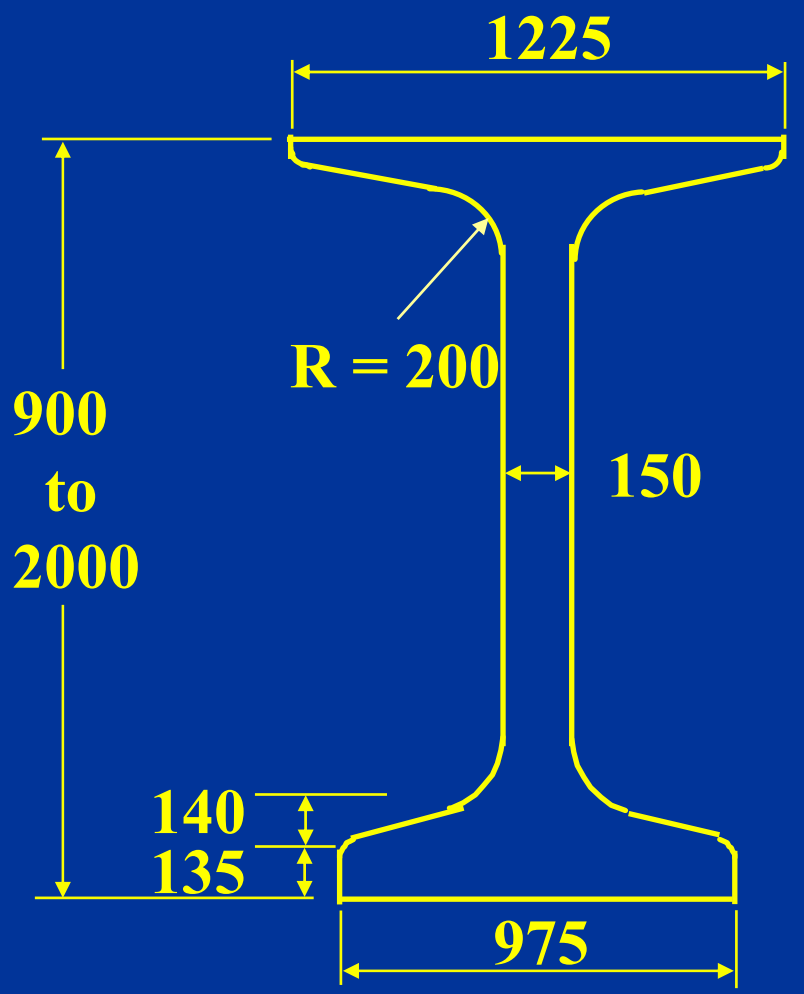
- 3-Span Continuous
- Typical Span 24 – 37 m
- Typical Span/Depth Ratio 30

Overpasses with Reduced Vertical Clearance

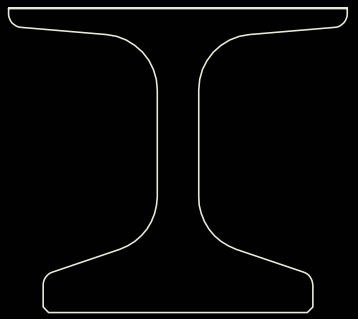
Channel Bridge, **Upstate, New York, USA**

Utilizes the parapet as a structural element, thereby minimizing the structural depth.

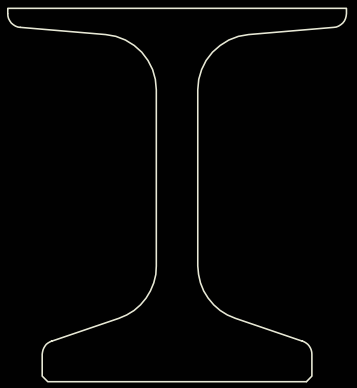
NU (Nebraska University)
I- GIRDER



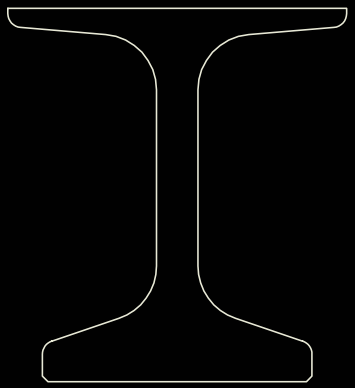
NU GIRDER



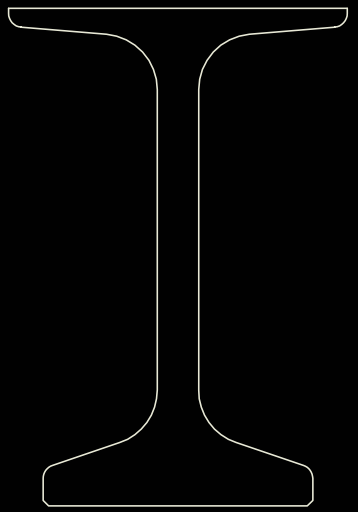
NU 1100



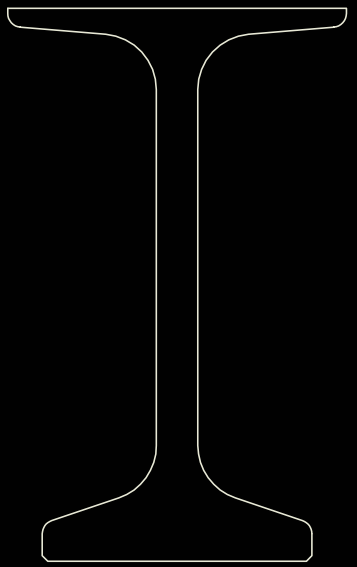
NU 1350



NU 1600

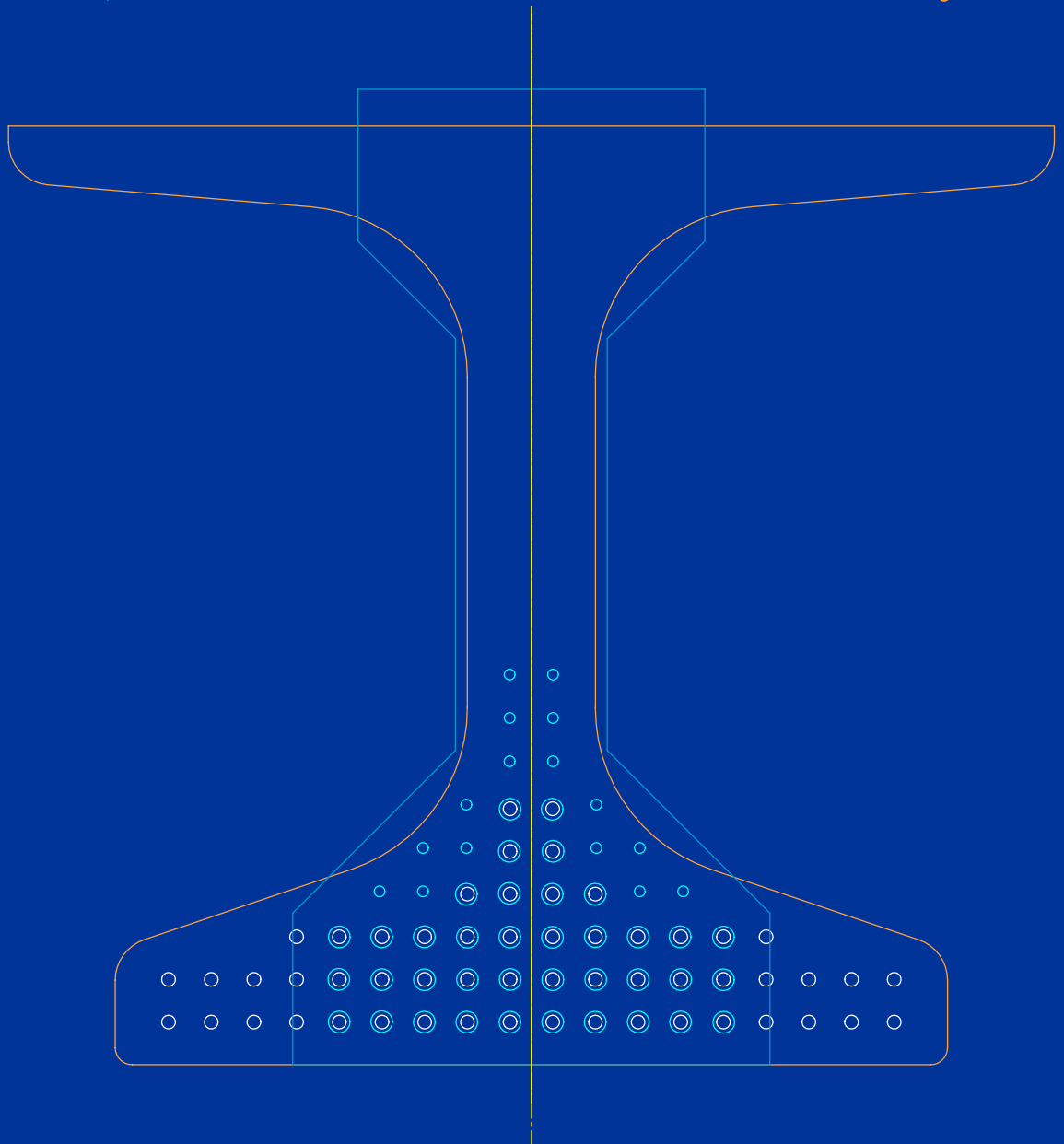


NU 1800



NU 2000

tandard American Association of State Highway and Transportati
Officials (AASHTO) Beams and Nebraska University I-Beams



Features:

- Adaptable to high strength concrete
- Hard metric dimensions
- Stable during shipping and erection
- Aesthetically appealing
- Accepts Welded Wire Reinforcement
- Accepts internal post-tensioning

Welded Wire Reinforcement

- Economy
- Reinforcement spacing is accurate
- Higher Strength

Lifting Device

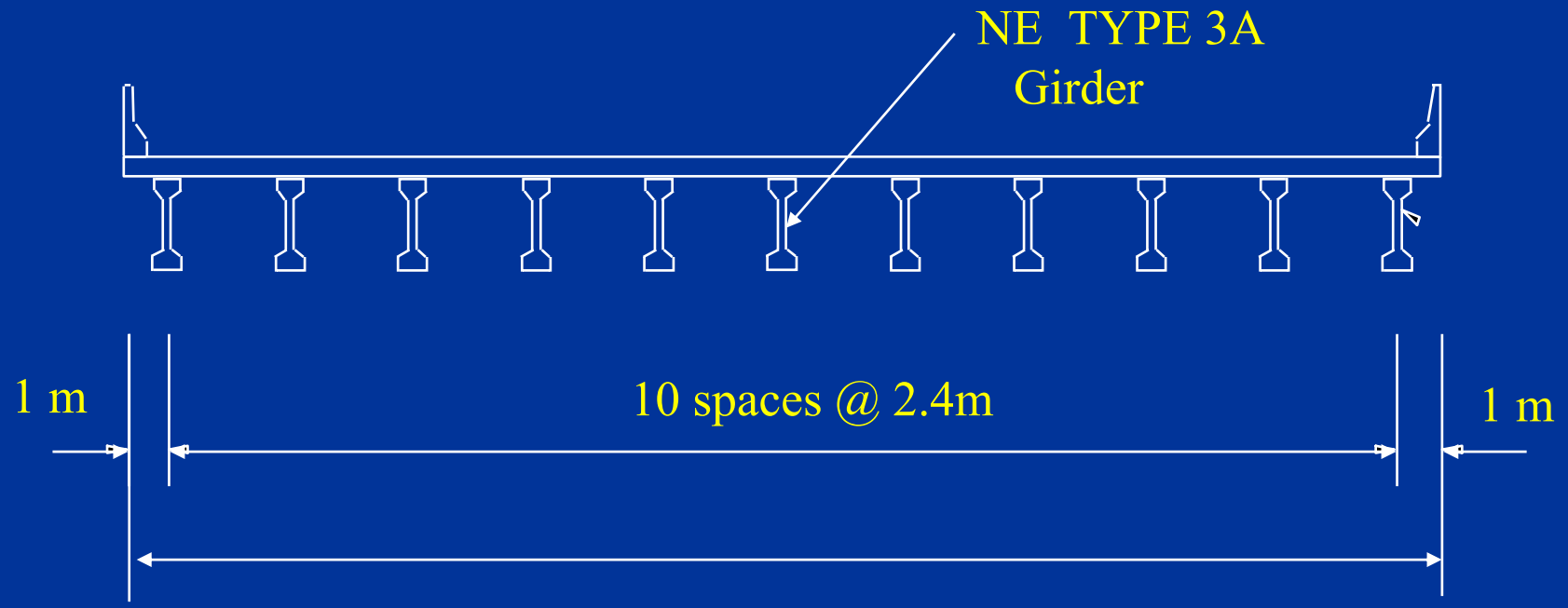
Applications Outside Nebraska

- New England Bulb Tee (6 states)
- Michigan I-Girder
- Washington Super Girder
- Utah
- Minnesota
- Wisconsin
- Iowa
- Mexico
- Panama
- India

Washington state 2.1 m deep, 47.2 m long for
construction over the Yakima River


12-18
VIN
U502952
HEAVY HAULING
O-308566

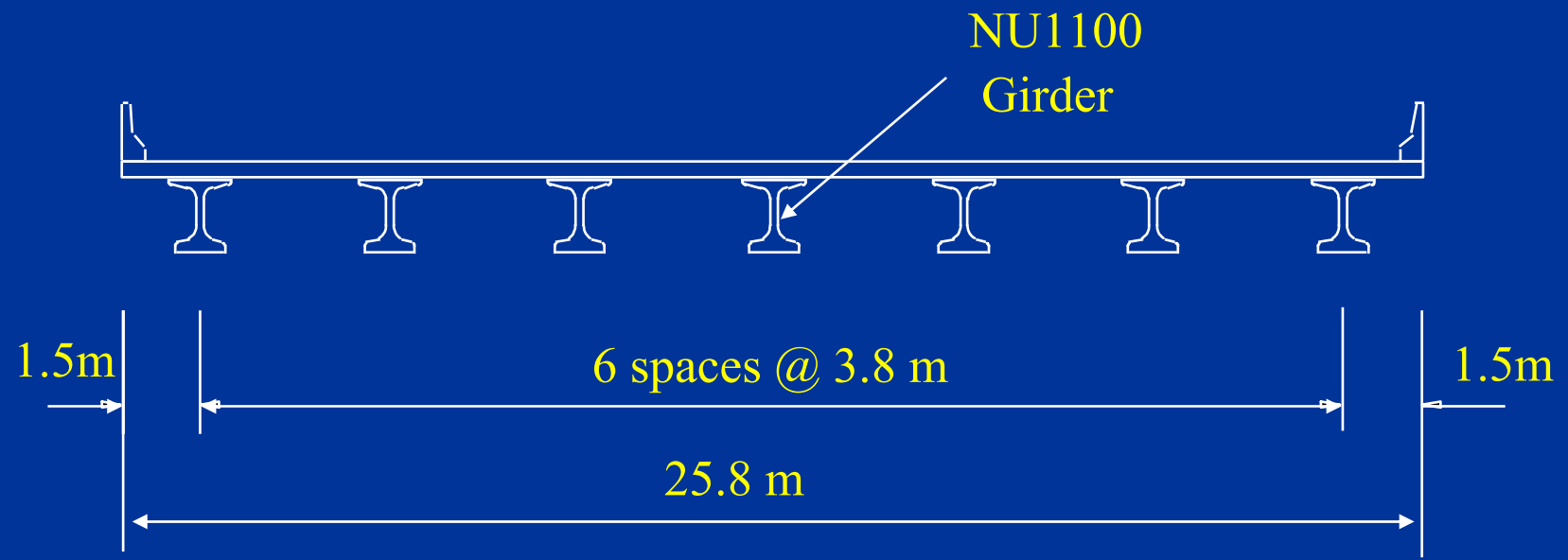
Standard Design: Eleven AASHTO Girder Lines, Concrete Strength = 35 MPa (350 kg/cm^2)



Typical Cross Section

AASHTO Girder section Design

Optimized Design: Seven NU I-Girder Lines, concrete strength = 84 MPa (840 kg/cm^2)

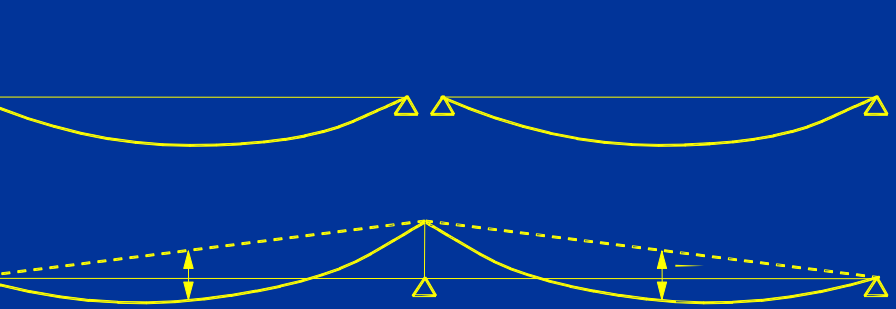


Typical Cross Section

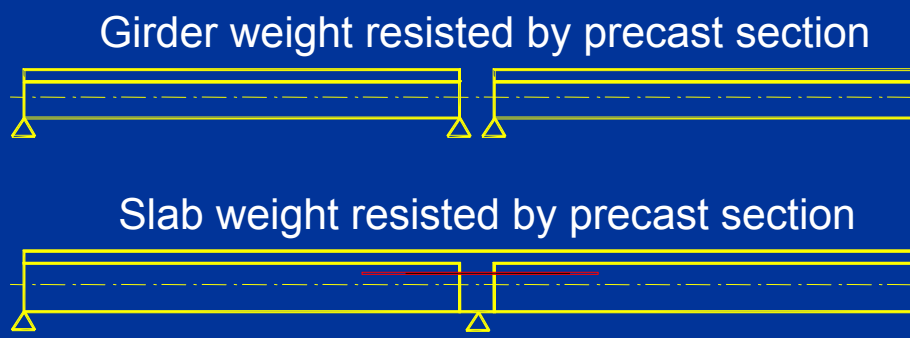
NU Section Girder Design

Precast Concrete Girders Made Continuous for Deck Weight

Threaded Rod Continuity



Bending Moment



Construction Steps

Advantages:

1. ***For the same prestressing and strength level*, span capacity can be increased by about 15%**
2. ***Better structural performance*: Distress at pier diaphragm is eliminated at deck placement and over service life**


Platte River East Bridge


Threaded Rod
Connection

US-75 / N-92 Clarks Viaduct

1st High Performance Concrete Bridge to Use the Threaded Rod Continuity System

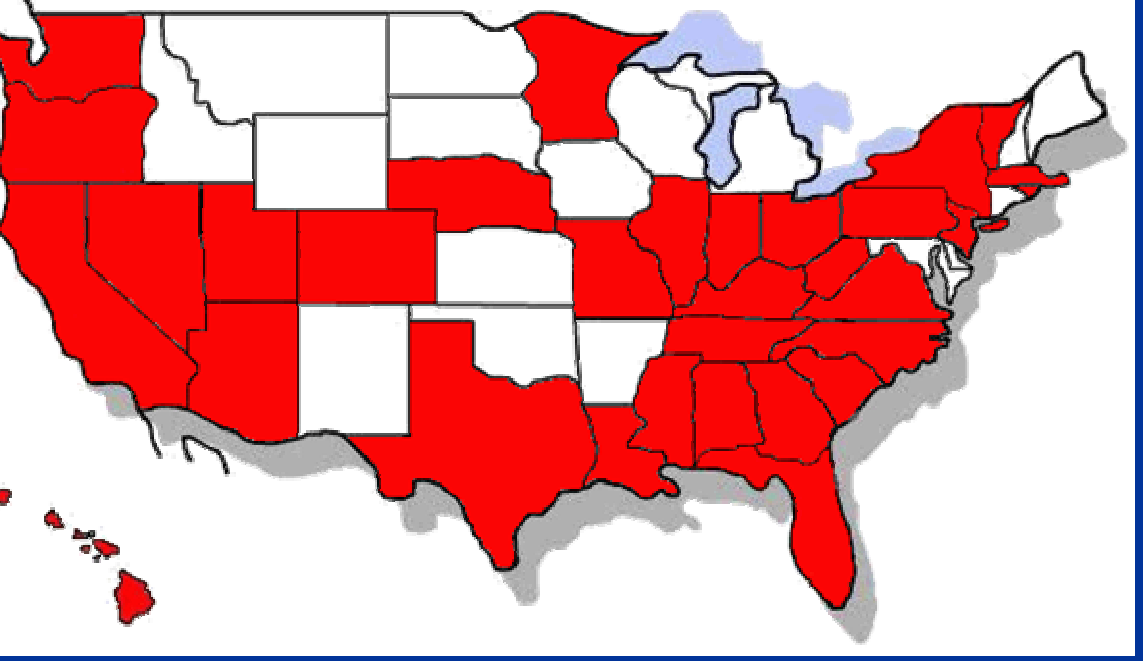
Modified Haunched Girder Threaded Rod System, for Improved Aesthetics

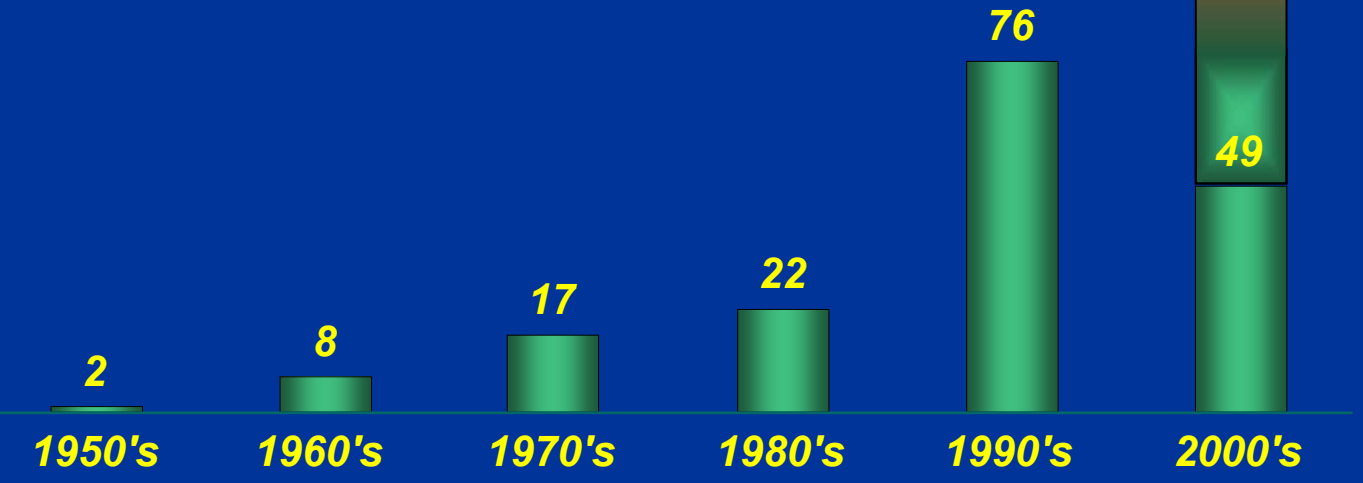
NDOR
Nebraska Department of Roads

UNIVERSITY OF Nebraska Lincoln

Spliced Precast Post-Tensioned I-Girder Bridges

- Pretension short segments in precast concrete plant
- Post-tension the segments at the site to create long continuous spans
- This system is less expensive in the US than segmental box girder bridges (exception: California!)





- 174 Total Bridges in USA
- 32 States
- 67 Bridges in Canada

Dodge Street (US 6) over 204th Street (N31)

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Department of Roads

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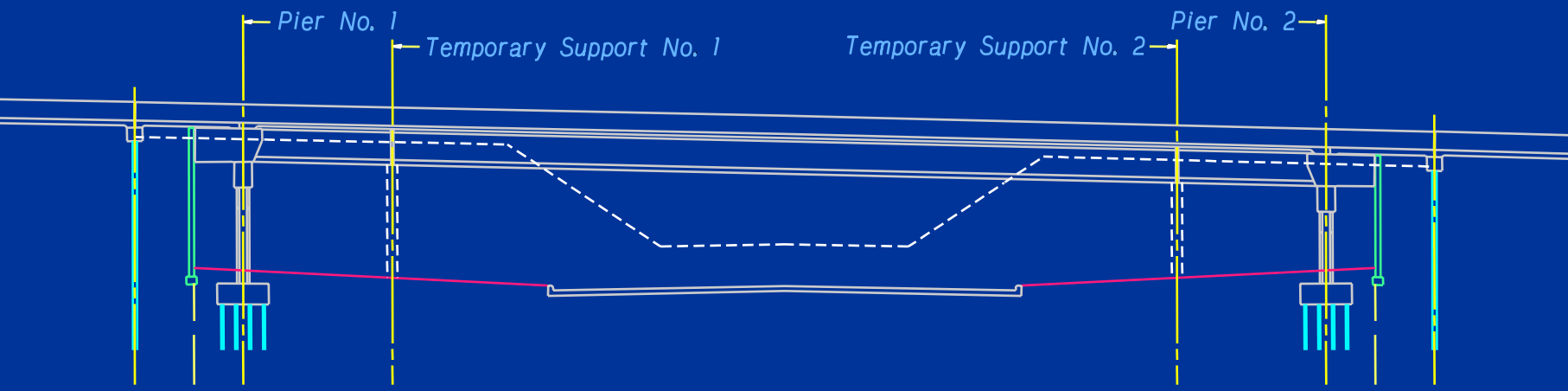
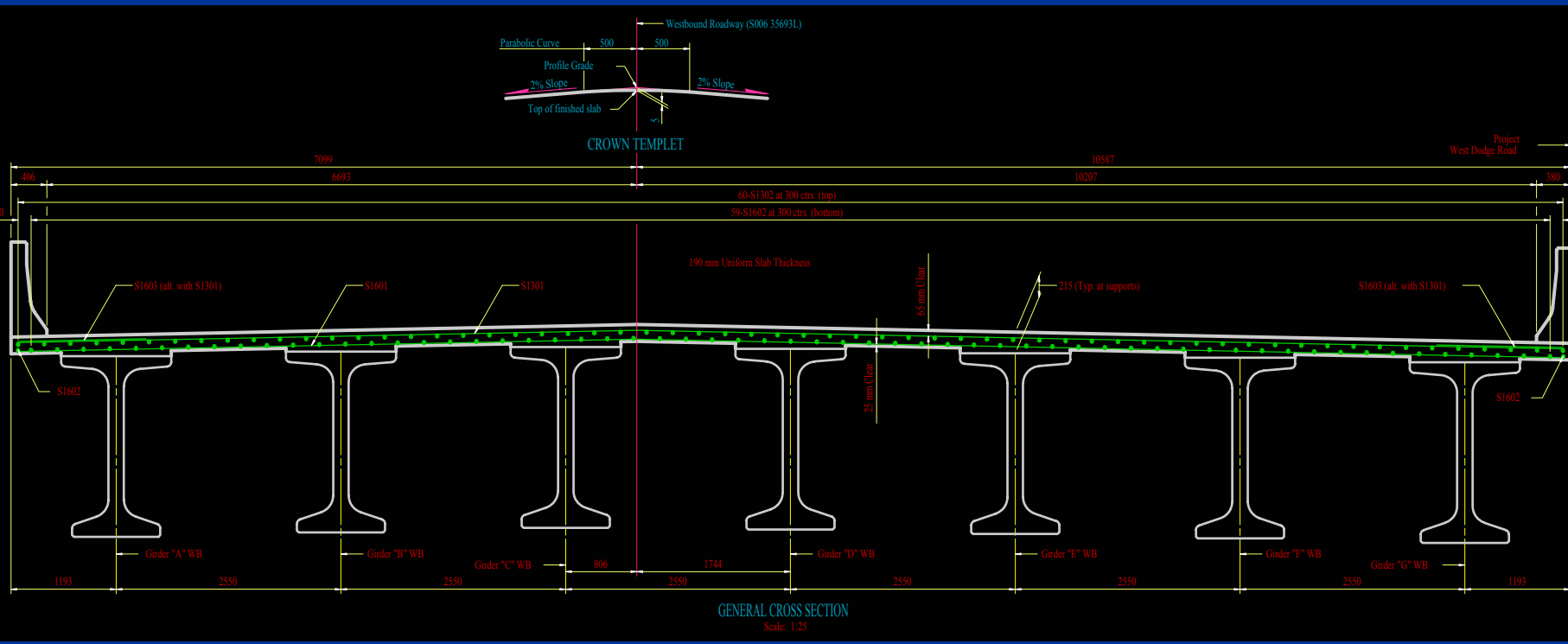
Nebraska
Lincoln

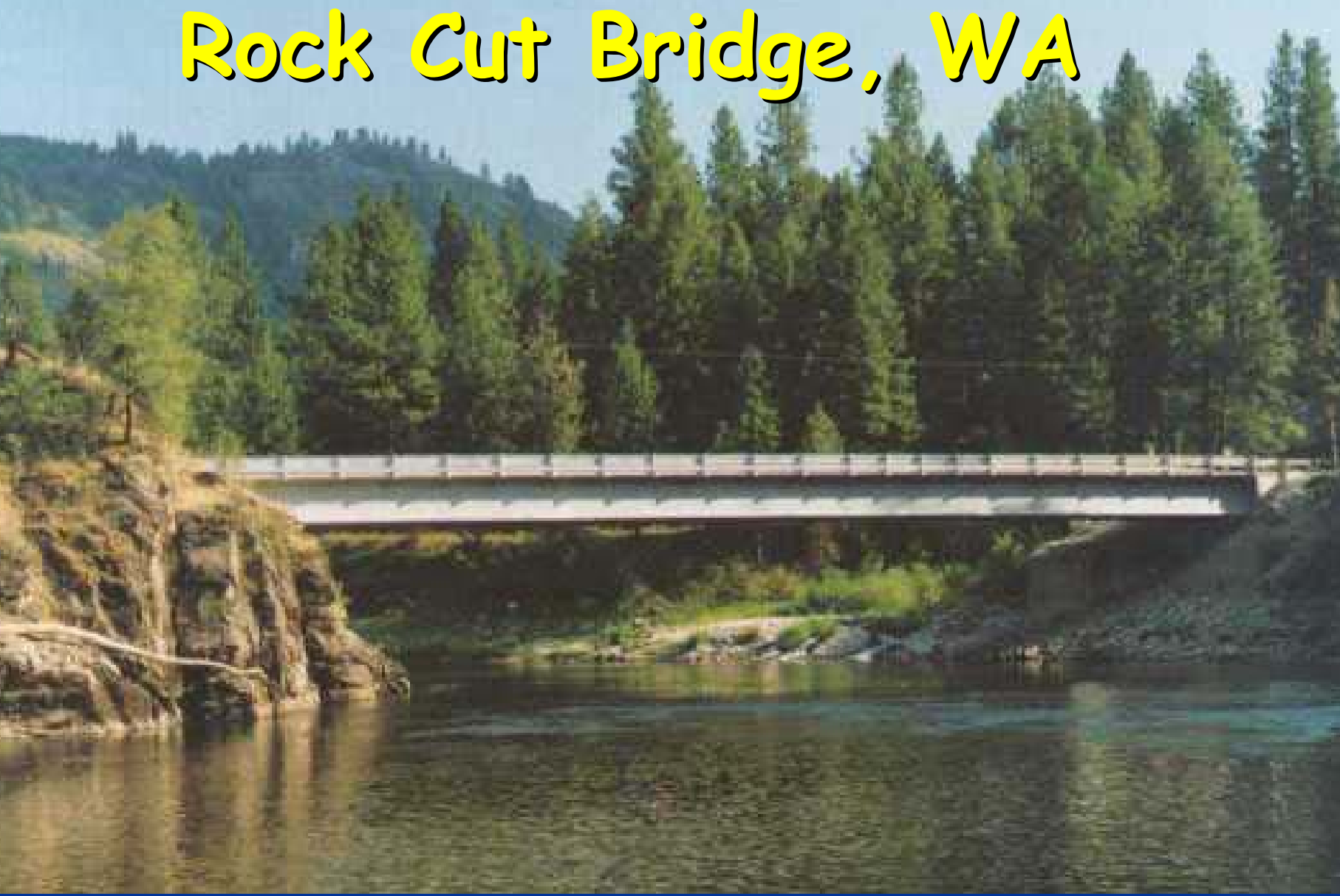

Pier No. 1
Temporary Support No. 1
Temporary Support No. 2
Pier No. 2

Skyline Spliced Girder Bridge Data

- Span = 63 m
- Clear Roadway = 16.9 m
- Girder Concrete = 70 MPa (700 kg/cm^2)
- Cast-in-place Slab = 30 MPa (300 kg/cm^2)
- Strands: Pretension: 46- 15.2mm, Post-tension: 3-15-15.2 mm (each 15 strand tendon in 89 mm duct)
- Auxiliary reinforcement: Welded Wire Fabric
- Span-to-girder depth ratio : 30.7
- Span-to-superstructure depth ratio: 27.8


Westbound Roadway (S006 35693L)
Parabolic Curve
500
500
Profile Grade
2% Slope
2% Slope
Top of finished slab
CROWN TEMPLET
Project
West Dodge Road
7099
10587
406
6693
10207
380
60-S1302 at 300 ctrs. (top)
59-S1602 at 300 ctrs. (bottom)
190 mm Uniform Slab Thickness
65 mm Clear
215 (Typ. at supports)
S1603 (alt. with S1301)
S1601
S1301
S1603 (alt. with S1301)
S1602
S1602
25 mm Clear
Girder "A" WB
Girder "B" WB
Girder "C" WB
Girder "D" WB
Girder "E" WB
Girder "F" WB
Girder "G" WB
806
1744
1193
2550
2550
2550
2550
2550
2550
1193
GENERAL CROSS SECTION
Scale: 1:25

Rock Cut Bridge, WA



I-15 Reconstruction, Salt Lake City, UT

Bow River Bridge, AB

- Built in 2002
- 4 spans: 2 at 174 ft, 2 at 213 ft
- One segment per span
- 211 ft beams weighed 268,000 lb.
- Beams 9.2 ft deep with 6.9 in. web
- 11.65 ft beam spacing
- Very high live load requirements
- Concrete saved 10% over steel girders

Con-Force Structures Limited
Calgary, Alberta

NU Girder 65m (210 ft)
December 2001

Bow River Bridge, AB

U “Tub” Girders

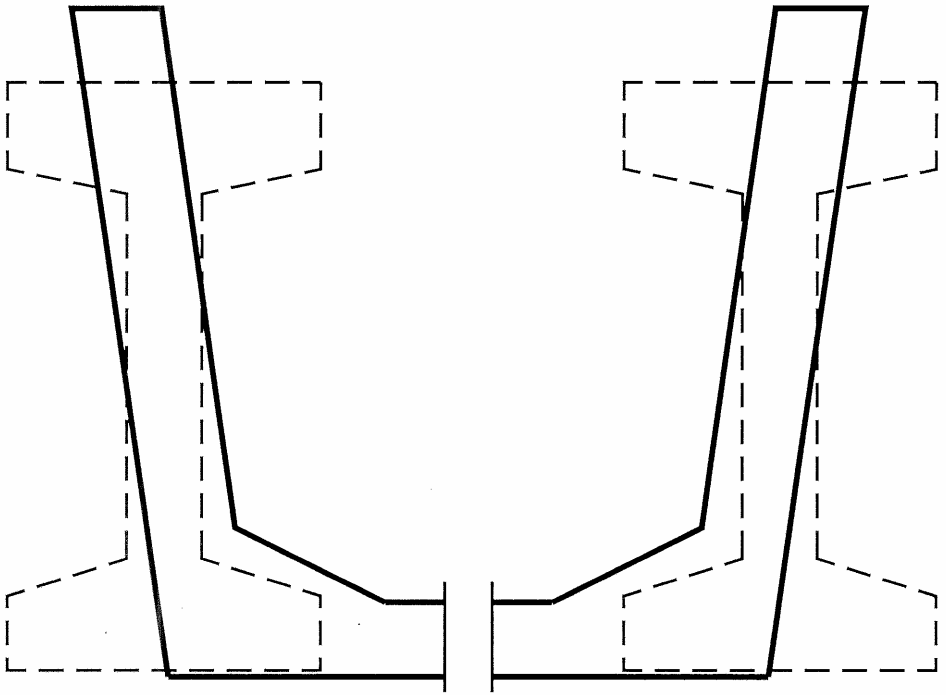
Washington State Standard U "Tub" Girder

Benefits of "U" girders:

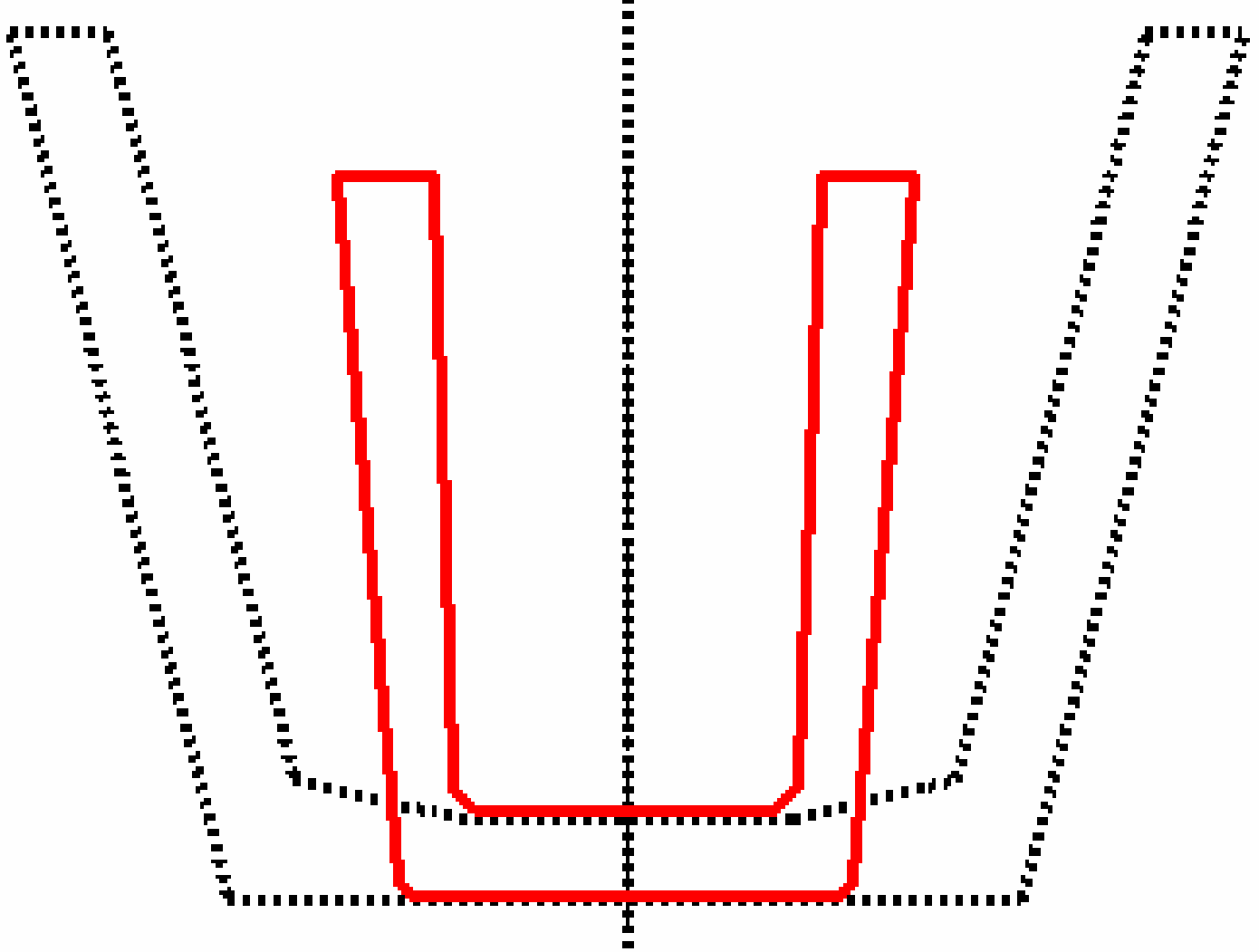
- Aesthetics
- Minimal span-depth ratio
- Mimics other box girder type construction
- Eliminates lines of girders
- Stable for shipment

Disadvantages:

- Heavy weight
- Complicated fabrication
- Difficult field forming of deck



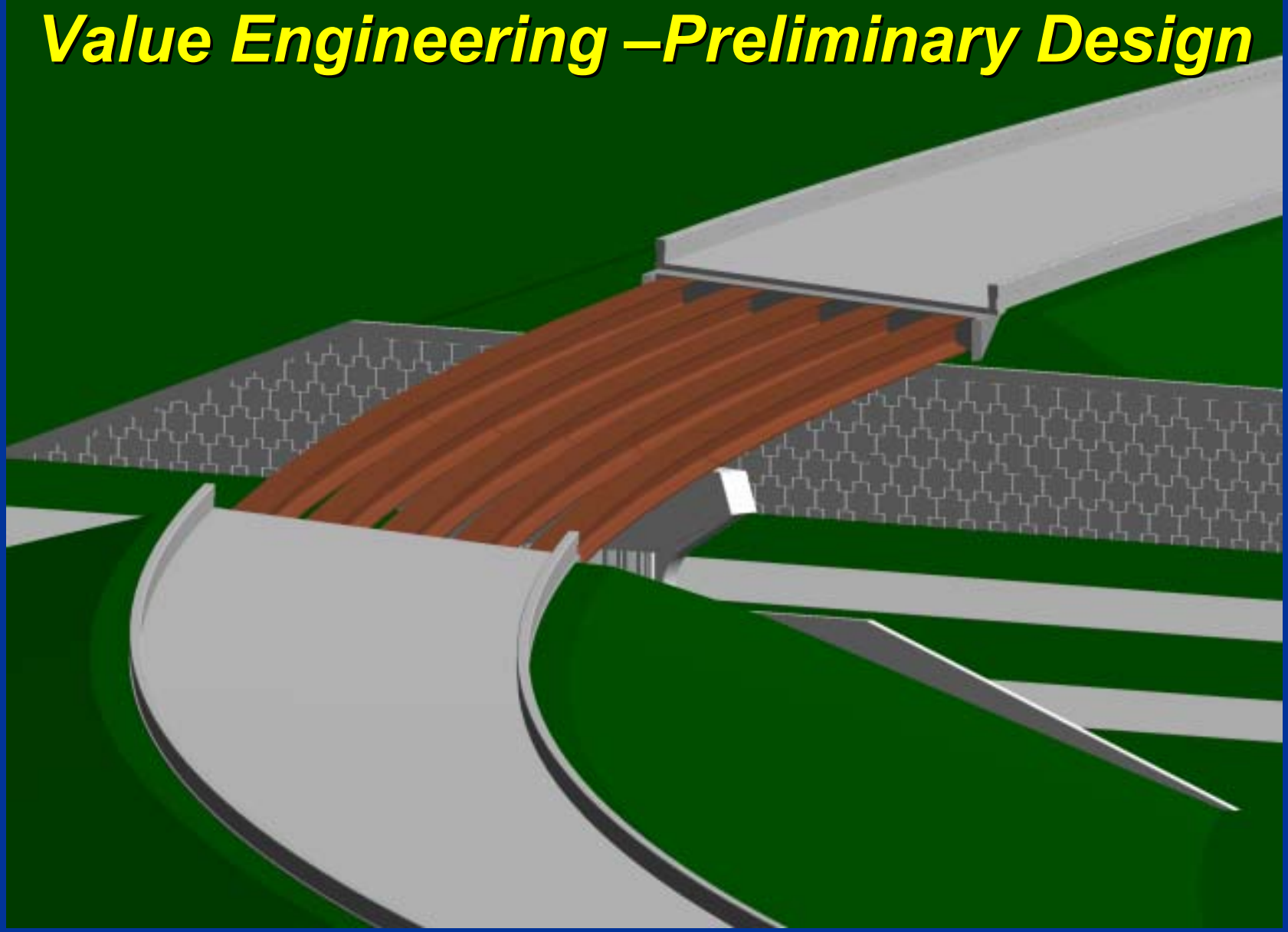
Washington State
Department of Transportation



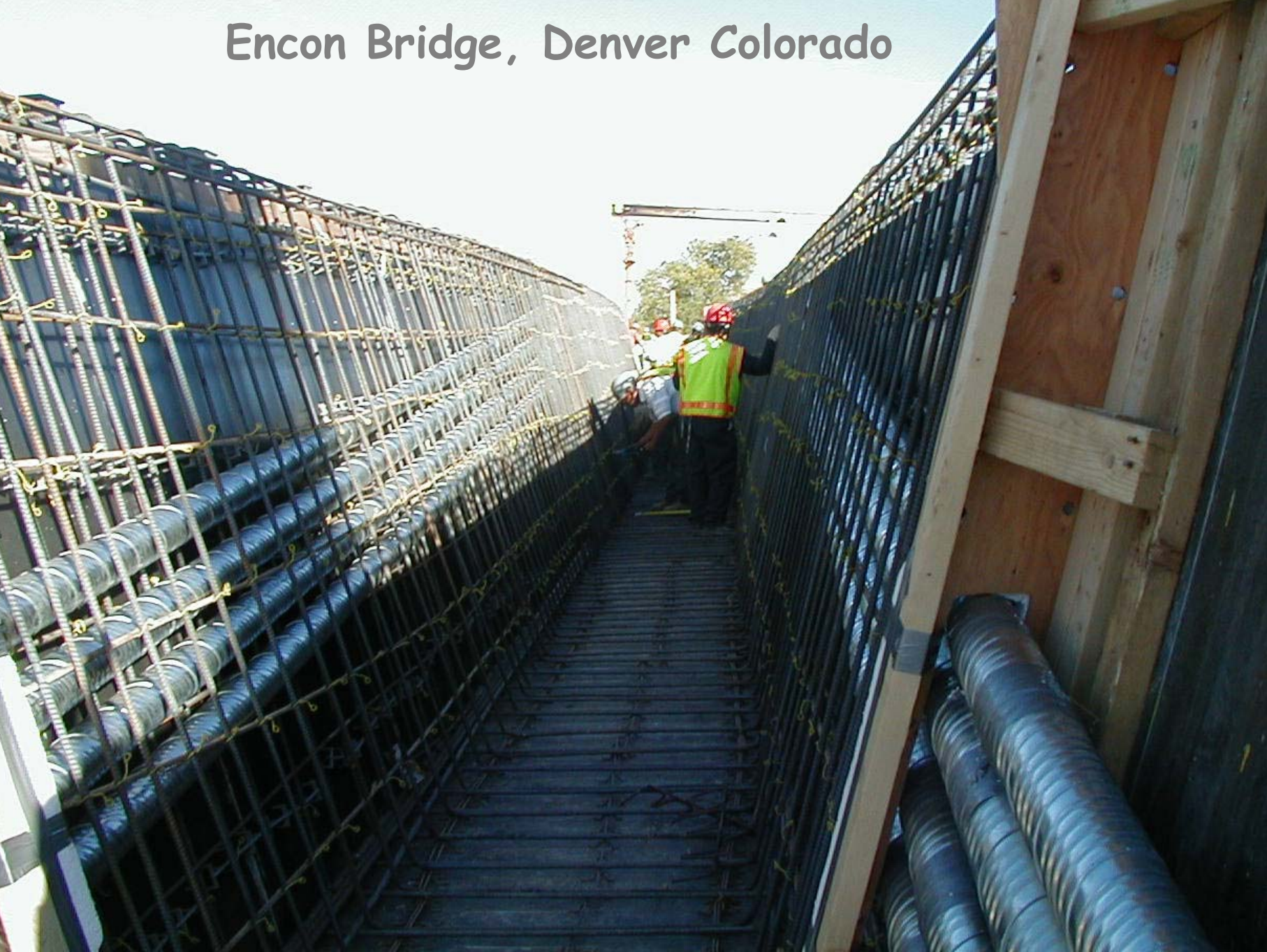
SCAC-TEC Section Versus Washington State Section

Curved Spliced Precast Post-Tensioned I-Girder Bridges

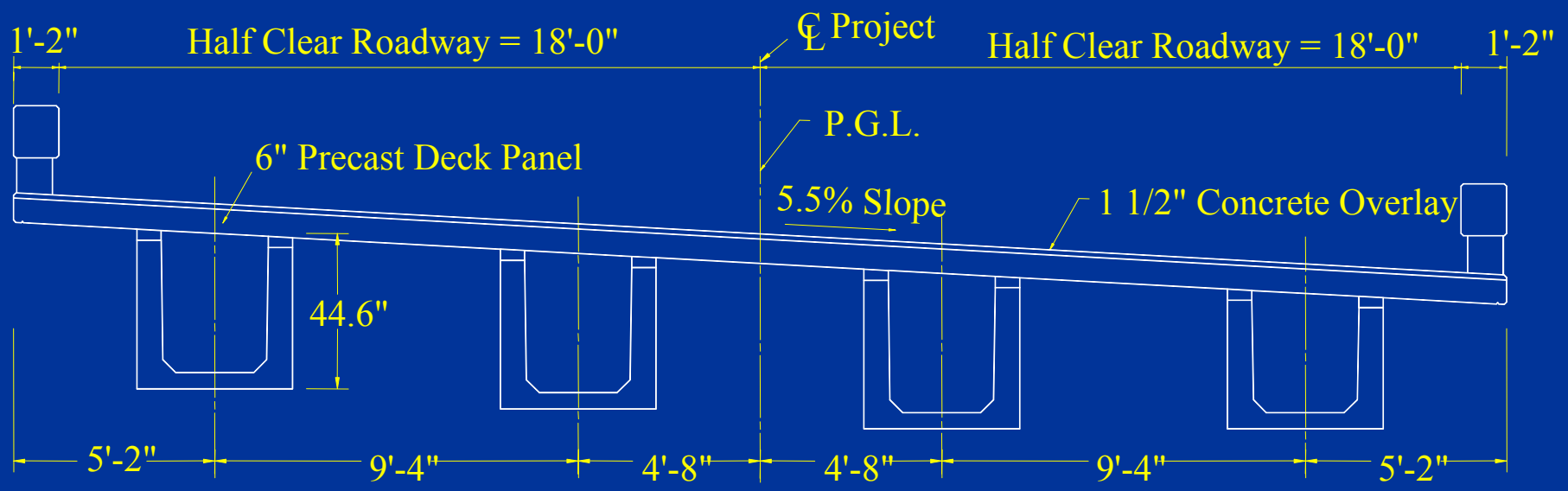
Value Engineering –Preliminary Design



Encon Bridge, Denver Colorado



Arbor Road Bridge



Bridge Cross Section

- Precast U-Girder
- 4 Girder Lines @ 9’-4”
- Precast Deck Panel w/ 1 ½” Concrete Overlay

Bridge at Philadelphia Airport Produced by Schuylkill Company

Bridge at Philadelphia Airport Produced by Schuylkill Company

Precast Concrete Substructures

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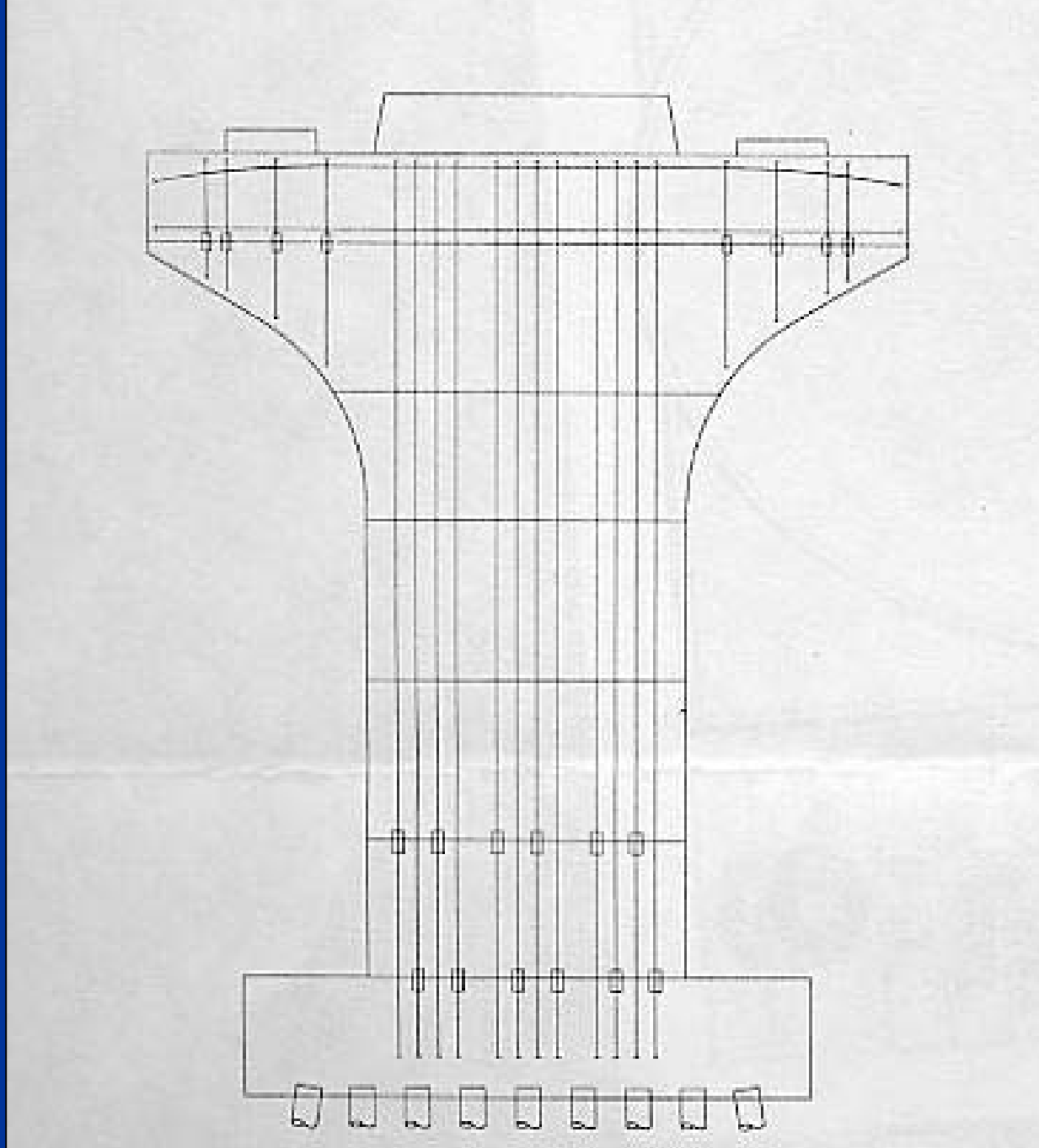
Post Tensioning: P.T. bars are 35 mm inch, Grade 1050 MPa (10500 kg/cm^2, 75 mm diameter galvanized steel ducts



Segments are Match Cast

Hammerhead Segments Ready for Shipping

n fully erected pier: PT rods are inserted, jack stresses bars, and ucts are injected with grout

Precast Pier Caps

Precast Concrete Deck/Barrier System

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Panels Stacked up in Precast Yard

Panel Shipping

Panel Handling

Precast Concrete Full Bridge Superstructure

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Baldorioty Bridges, San Juan

The Challenge…

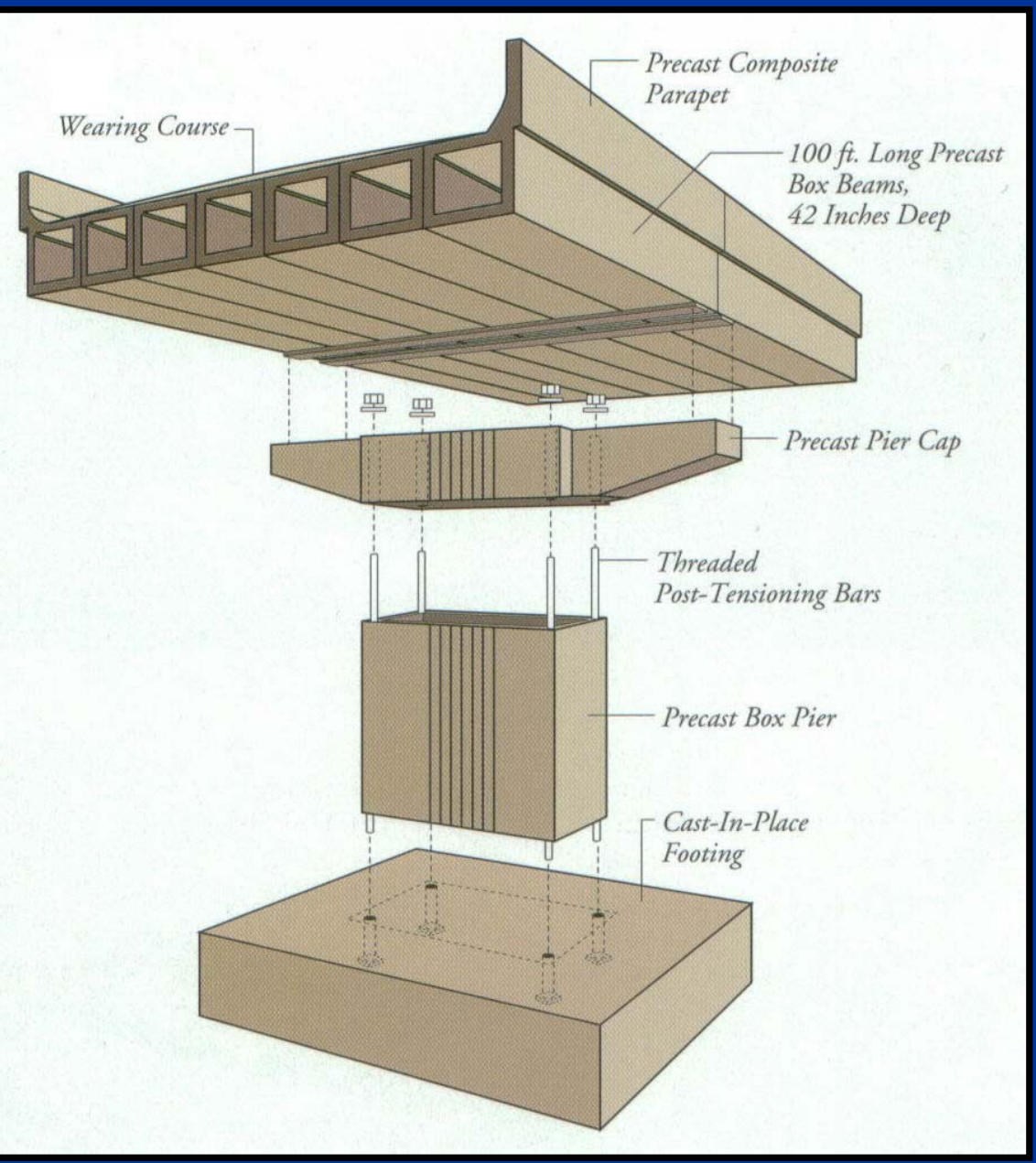
- **Design & Build Four Urban Grade Separations**
  - **2 – 300 m long x 10 m wide**
  - **2 – 210 m long x 10 m wide**
- **Maintain Continuous Traffic**
- **Complete each Bridge in Less than**

~~**72 Days**~~

72 HOURS! (3 Days)

- **$100,000 Penalty, per day, beyond 72 hours**

Concept

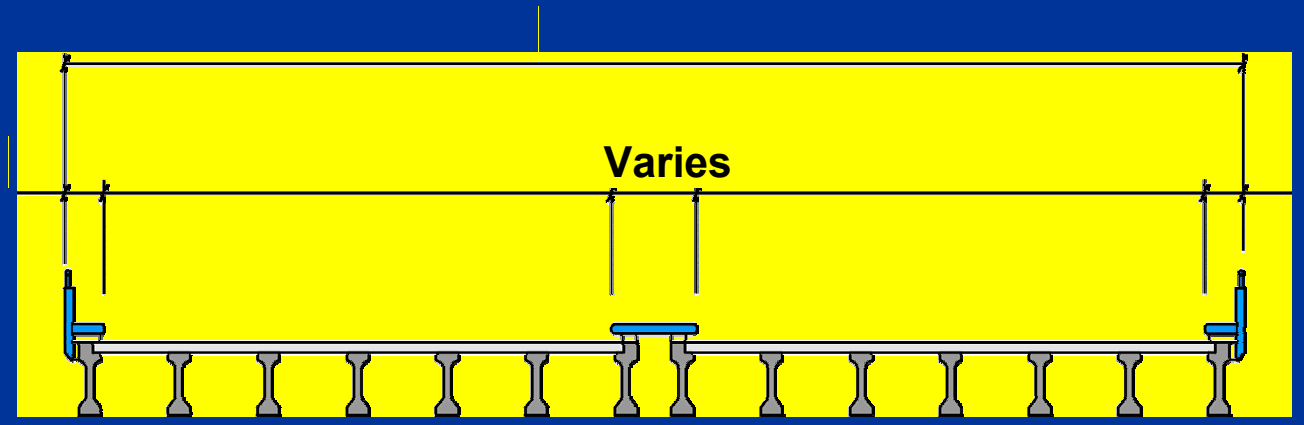


Precast girders

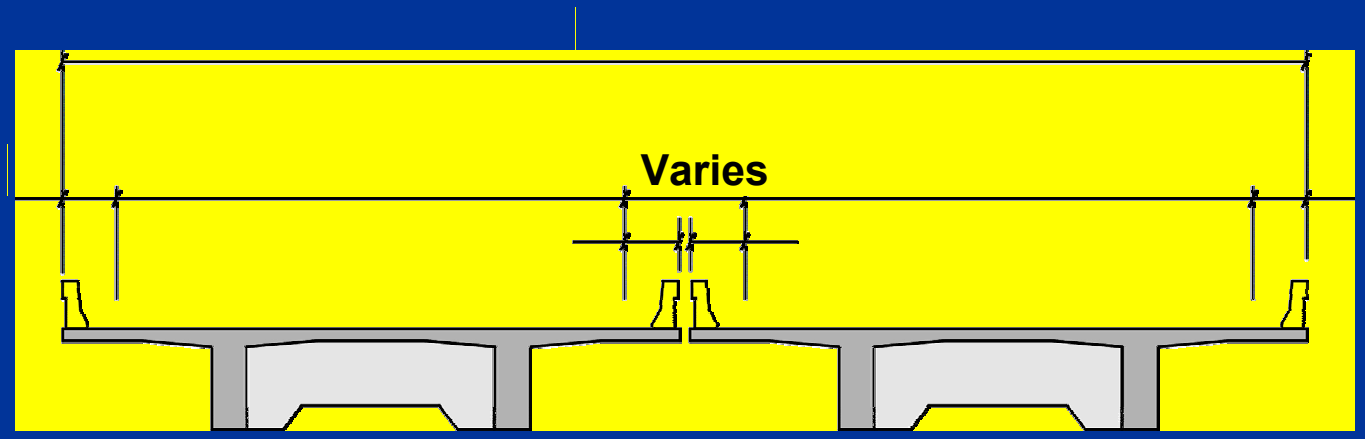
Precast pier & cap

CIP footing

Richmond-San Rafael Bridge, San Francisco, CA

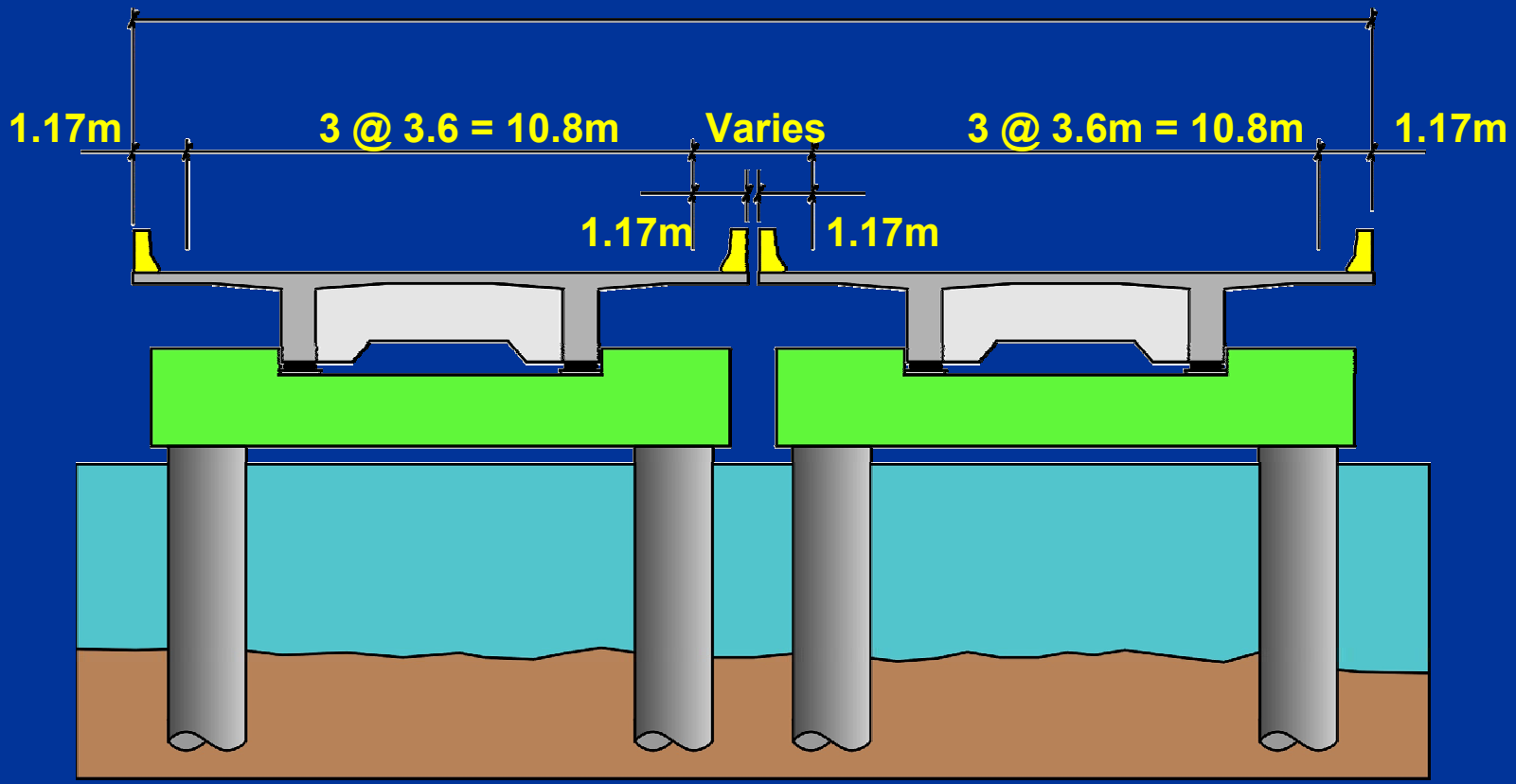


Existing Cross Section



Proposed Cross Section

Typical Section



Concrete Filled Steel Tube Arches

Ravenna Arch Bridge Model, Ravenna, Nebraska

Self Consolidating concrete used to fill the hollow steel elements

Bottom Chord fill mix

- 30 in. spread
- Glenium 30/30
- Easy to pump
- Self leveling in tube


NEBRASKA

THANK YOU