Development of Spliced Precast U Beam Bridge Construction

HSR
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Outline

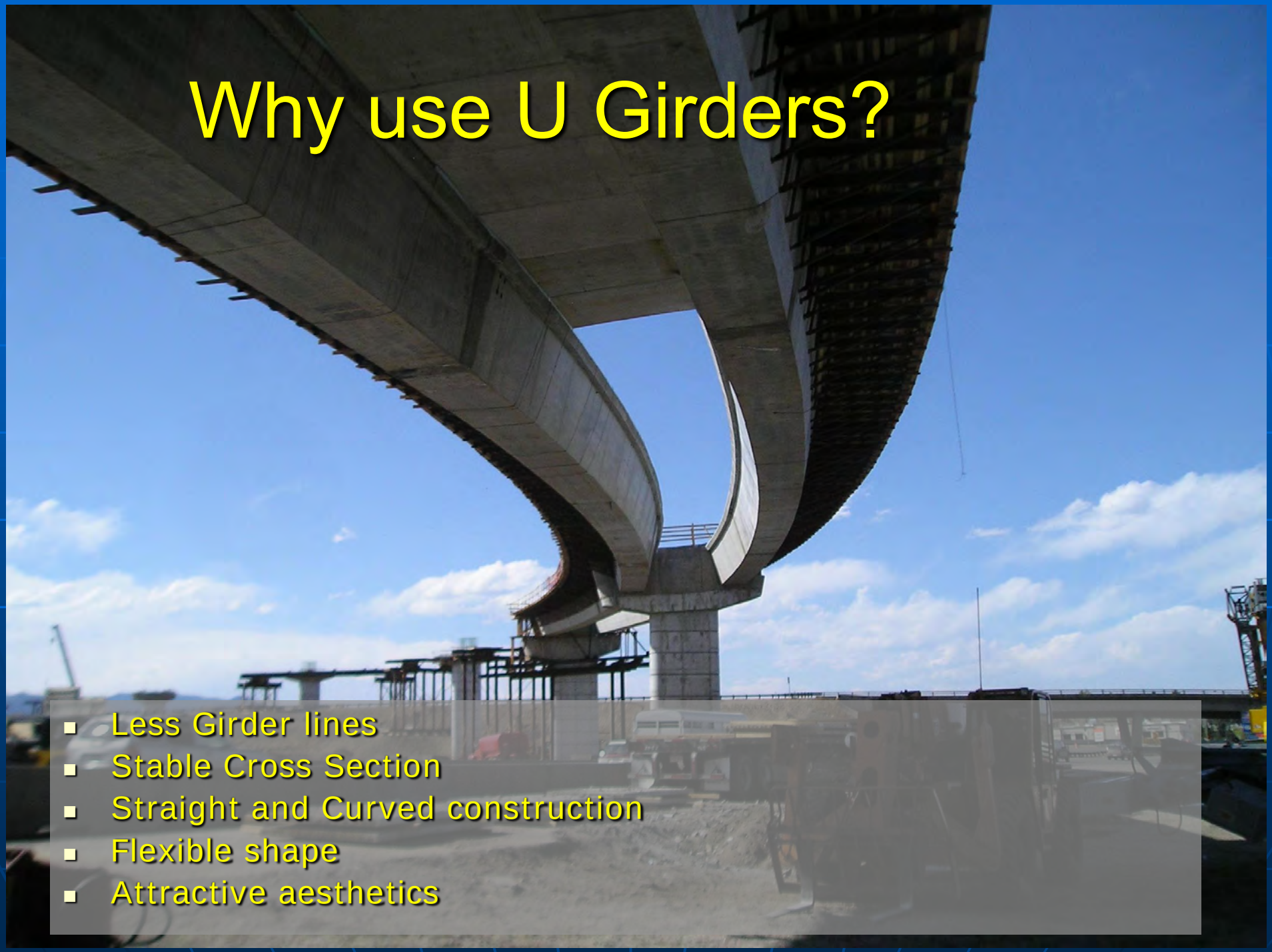
- History
- Details from Colorado Projects
- CPM Schedule
- PCI Zone 6 Standards
- Some team's may elect solutions without any deviation from FDOT Practice
- Others may select the need for Innovative Concept Approval from FDOT during procurement

Past Curved PreTensioned Concrete

Why use Precast Concrete for these Types of Bridges?

- DOT Preference for Concrete Structures.
- Alternative to more traditional designs.
- Longer Spans
- Simplified Shoring
- Nominal Setup Costs.
- Speed of Fabrication
- Aesthetics
- Cost

Why use U Girders?



- Less Girder lines
- Stable Cross Section
- Straight and Curved construction
- Flexible shape
- Attractive aesthetics

U girder dropped during erection

- Crane was destroyed
- U girder was reset in place and is currently in service.
- Little need for internal bracing, I y > I x

Spliced girder construction in Colorado

1992 – Buckley Road over IH76 – 185’ span Spliced Bulb Tee

1995 - Park Avenue Ramp – 230’ span, Site Precast, Curved U girders

1999 – SH52 over IH25, 190’ span, Straight Precast U girders

2000 – Parker Road / IH225, 254’ span, Curved CIP U girders

1995-2000 CDOT Develops Standard Precast U Sections

2003 CDOT Designs Ramp Y Project using Curved U Girders

3/2004 – 270 / IH25 Ramp K

3/2006 – Bijou St. over Monumnent Creek

7/2006 – E470 / IH40 Ramp H

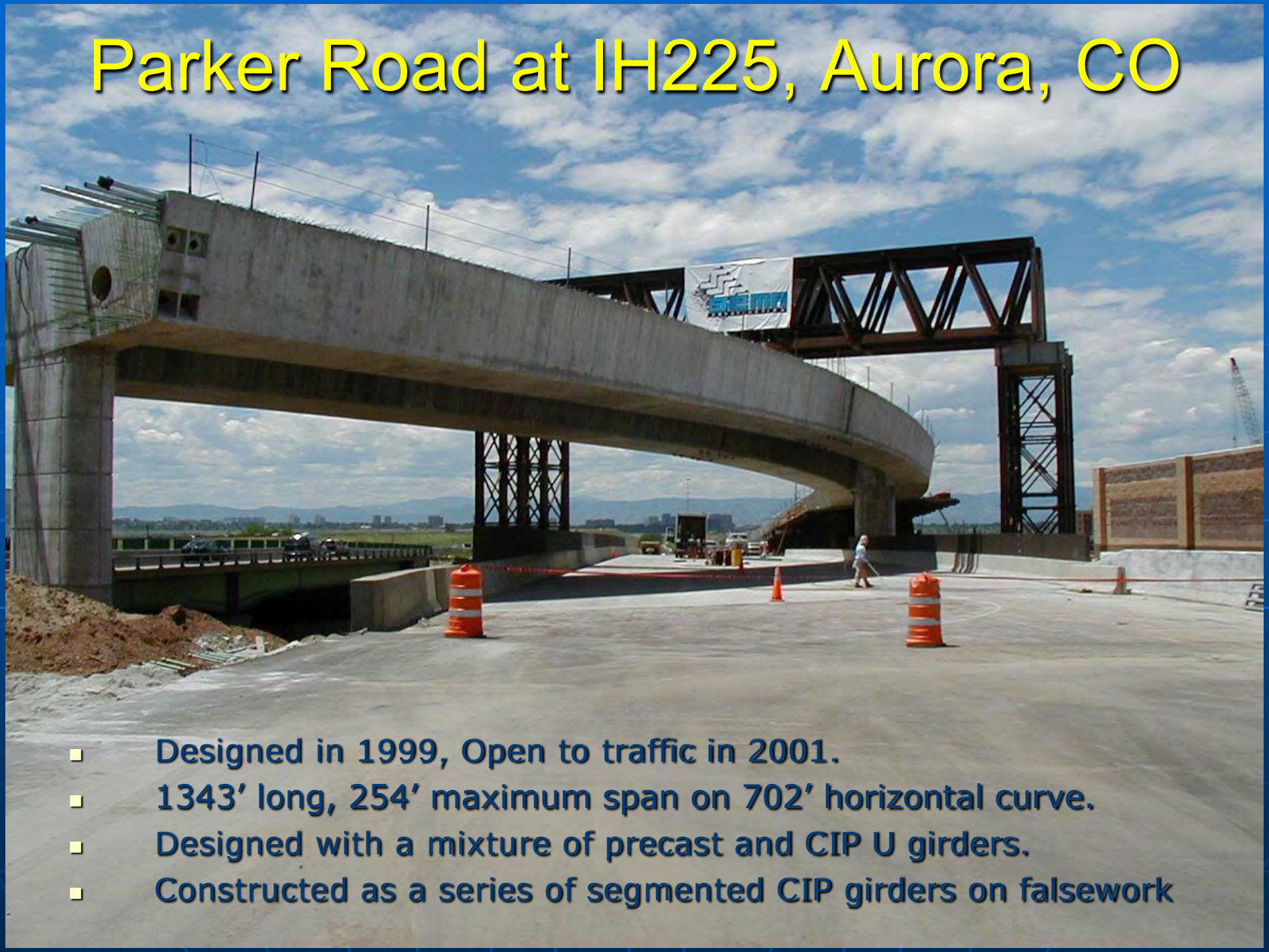
10/2006 – 270 / IH76 Ramp Y

11/2006 – Austin Bluffs over Union

1/2007 – IH25/Trinidad Phase I

3/2007 – SH58 / IH70 Ramp A

Parker Road at IH225, Aurora, CO



- Designed in 1999, Open to traffic in 2001.
- 1343’ long, 254’ maximum span on 702’ horizontal curve.
- Designed with a mixture of precast and CIP U girders.
- Constructed as a series of segmented CIP girders on falsework

Plant Manufactured Precast Concrete U Girder Bridge Quantities since 2004, using curved sections

Project	Bridge S.F.	L.F. Curved Precast
IH25 / SH270 Ramp K	66,740 s.f.	2,840 l.f.
IH76 / SH270 Ramp Y	77,248 s.f.	4,544 l.f.
IH70 / SH58 Ramp A	79,995 s.f.	4,095 l.f.
Austin Bluffs	57,715 s.f.	2,380 l.f.
IH25 Trinidad	65,728 s.f.	4,141 l.f.
IH70 / E470 Ramp H	75,952 s.f.	3,232 l.f.
Total	414,378 s.f.	21,232 l.f.

270 Ramp K

- Contractor Alternate Design to Steel Base Bid
- 1st Project Constructed with curved, standard Precast U Girders
- Design Concept submitted two weeks after bid.
- Involved Close Cooperation Between DOT, Engineer, Sub Contractors and Contractor, Sema Construction.
- 200′ Spans,
- Completed and Open to traffic December 2005

Bijou St. Bridge

- Open to traffic October 2007, Contractor: Rockrimmon Construction.
- Gateway bridge into downtown Colorado Springs
- Deck width varies from 88′ to 178′, Girders kinked at splices
- 28 – U60 Precast Girders, Seven continuous girder lines.
- Span Lengths from 100′ to 150′.
- Strongbacks used to support girders, no shoring supported from ground.

E470 Ramp H

- Contractor Design/Build Project. Open to traffic early 2007.
- Contractor: Lawrence Construction Co, Littleton, CO
- Connector Ramp from E470 Toll Road to Interstate 70.
- 1002’ Horizontal Curve, Spans lengths from 100’ to 200’
- 34 – U84 Girders, 11 Spans

270 Ramp Y

- First bridge designed with standard curved U girders
- Colorado DOT / Contractor VE Design
- Completed in early 2008, Contractor: Edward Kraemer & Sons
- Flyover Connector from EB SH270 to EB Interstate 76.
- 40 Precast Girders, 12 Spans.
- Span Lengths from 100’ to 230’.
- 760’ Radius horizontal curve.

IH25 Viaduct, Trinidad

- Alternate Design to precast segmental
- Open to traffic early 2009, Contractor: Lawrence Construction
- Elevated Viaduct through downtown Trinidad. 24 - U85 Precast Girders, Dual Bridges, 4 Spans, 1200’ Horizontal Radius.
- Span Lengths from 100’ to 256’.

SH 58 Ramp A

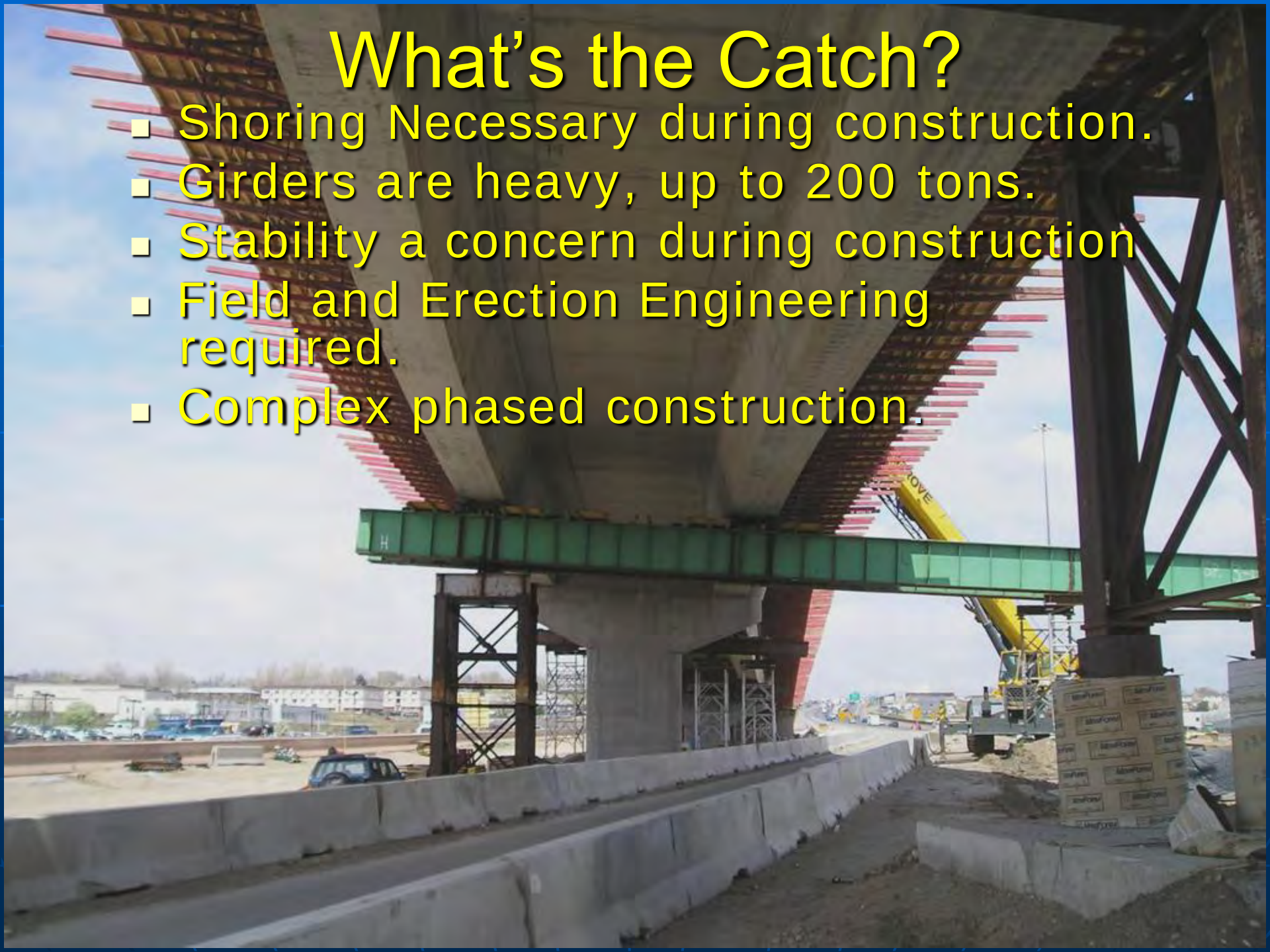
- Open to traffic Nov. 2008, Contractor: Ames Construction
- Connector from EB Interstate 70 to WB SH 58 into Golden.
- 38 - U86 Precast Girders, 11 Spans.
- Span Lengths from 150’ to 235’.
- 820’ Horizontal Curvature.
- Numerous traffic crossings and creek crossing.

270 Ramp Y Cost Comparisons

Item	Steel Design	Curved Precast
Girder Cost	$5,125,000	$3,086,240
Erection Costs	$1,025,000	$890,000
Falsework	$50,000	$250,000
Post Tensioning	$0	$506,000
Total	$6,200,000	$4,732,240
Cost / Ft.	$1393 / lf	$1063

What's the Catch?

- Shoring Necessary during construction.
- Girders are heavy, up to 200 tons.
- Stability a concern during construction
- Field and Erection Engineering required.
- Complex phased construction.

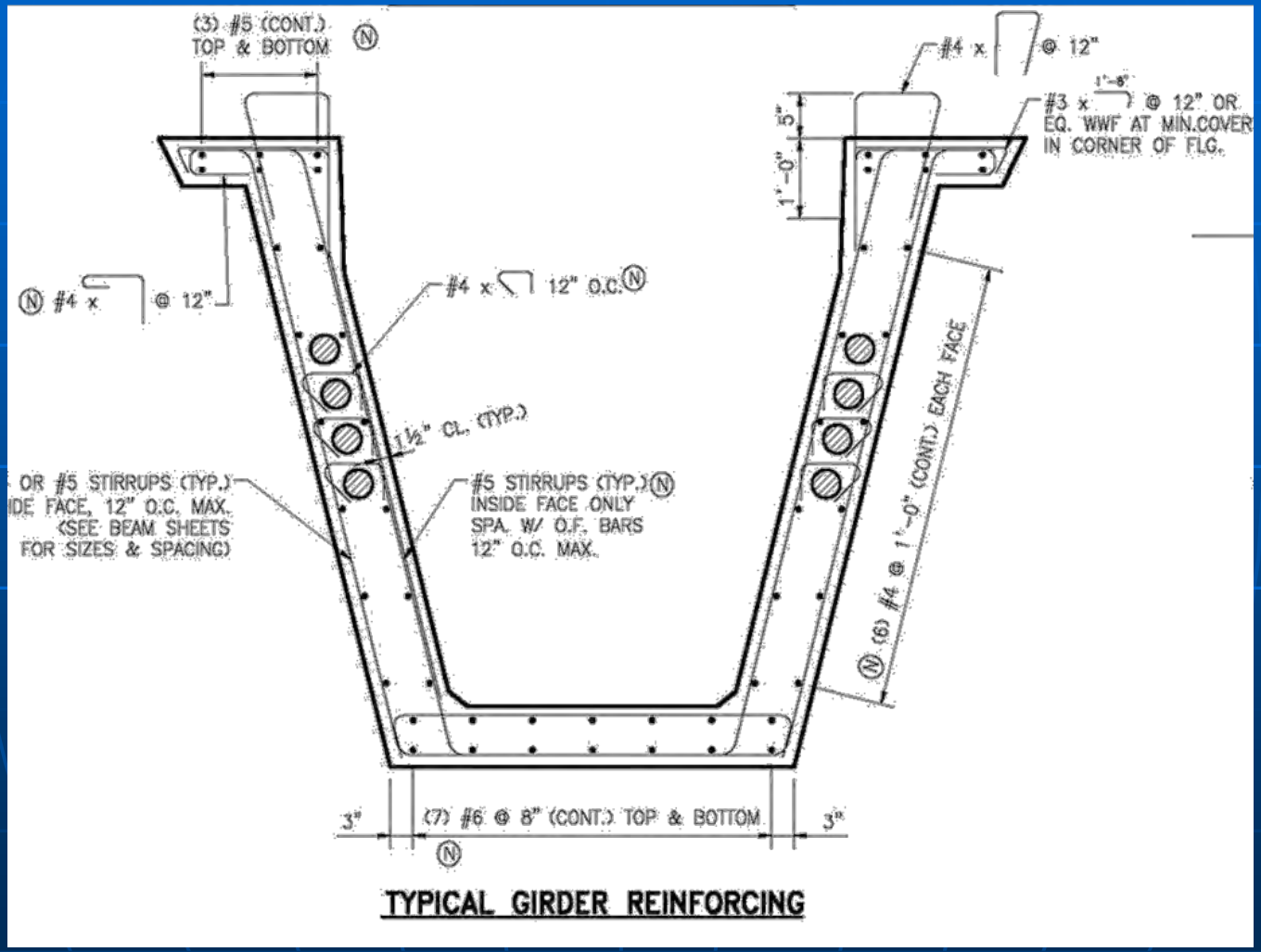


Precasting of U Girders

- 120’ long, 265 Kip max weight in Colorado
- Curved and Straight Forms
- Curved: Post Tensioned, Straight: Pre-tensioned
- Continuity PT in Webs
- End Diaphragms only
- PT Anchor Blocks: Precast or CIP
- Continuous Reinforcing at Splices
- Precast or CIP Haunches over piers
- Lid Slab after erection
- “Tongue” Section at Expansion Diaphragms
- Substructure Connections

Curved Casting Bed

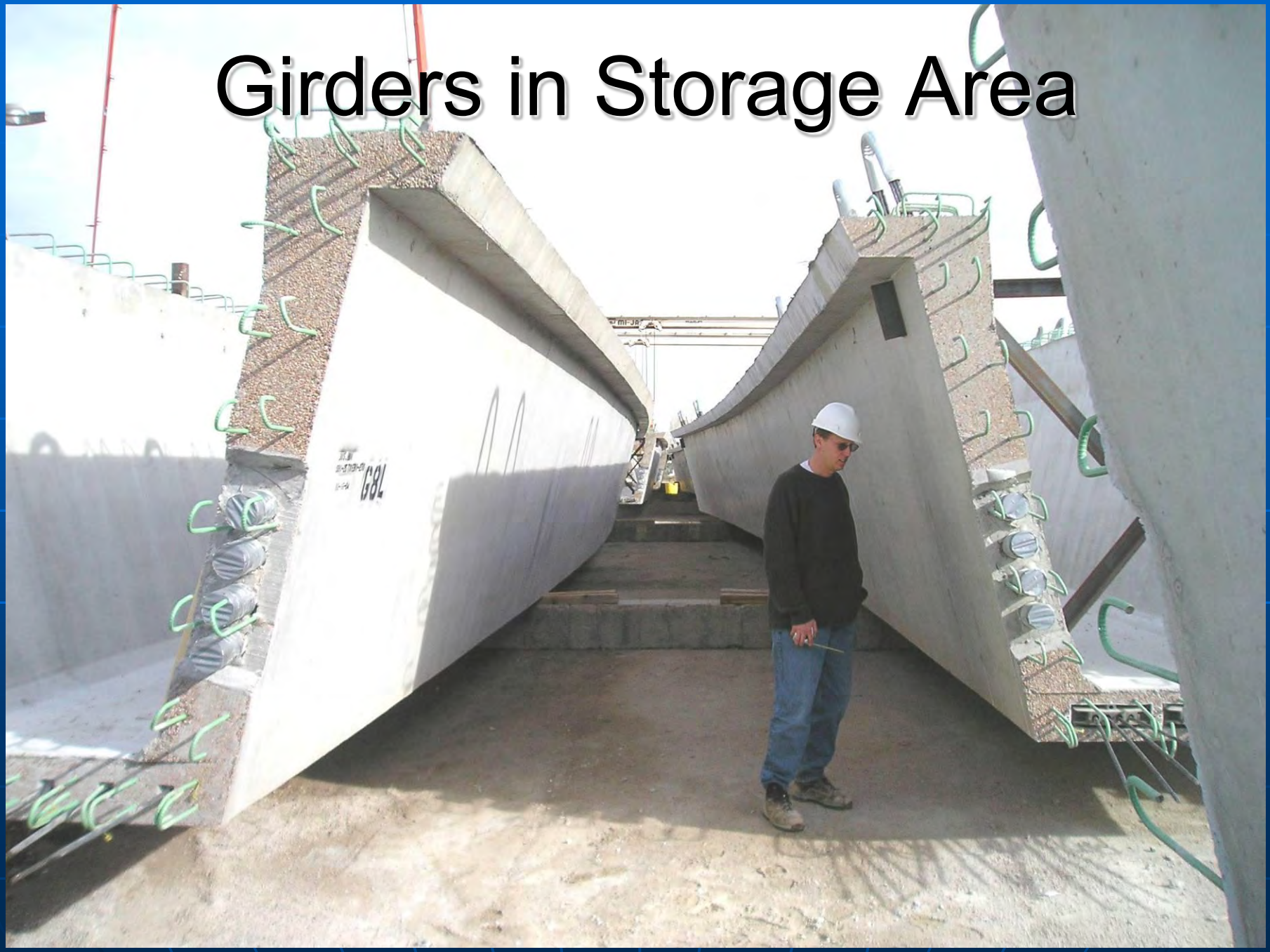
Typical Girder Cross Section – Ramp K
10” Webs – 18 Strand Web Tendons



TYPICAL GIRDER REINFORCING

Reinforcing Cage in Forms Prior to Casting

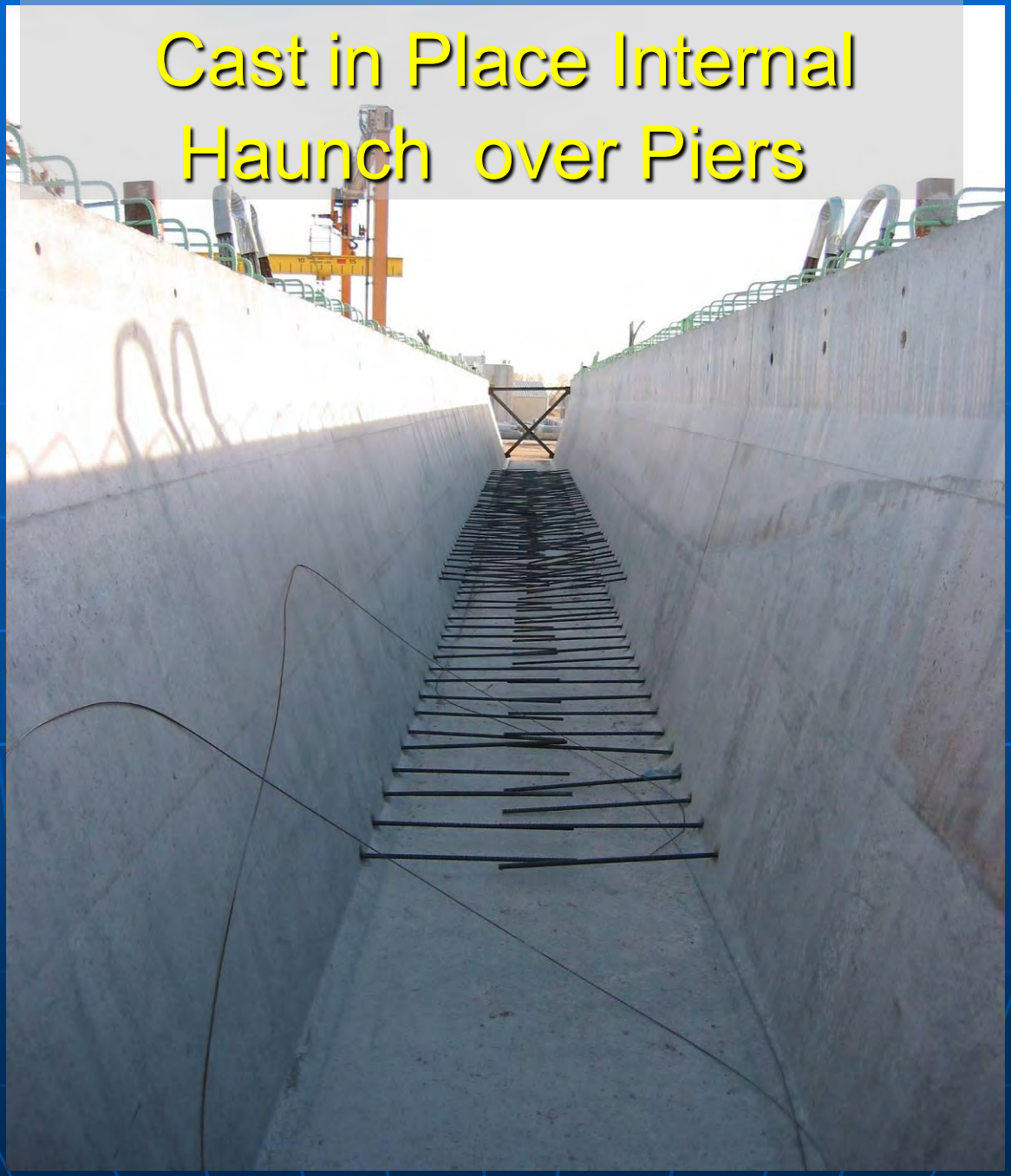
Girders in Storage Area



Precast Design Features: Ramp K, Steel End Diaphragms

Ramp A, Concrete End Diaphragms

Cast in Place Internal Haunch over Piers



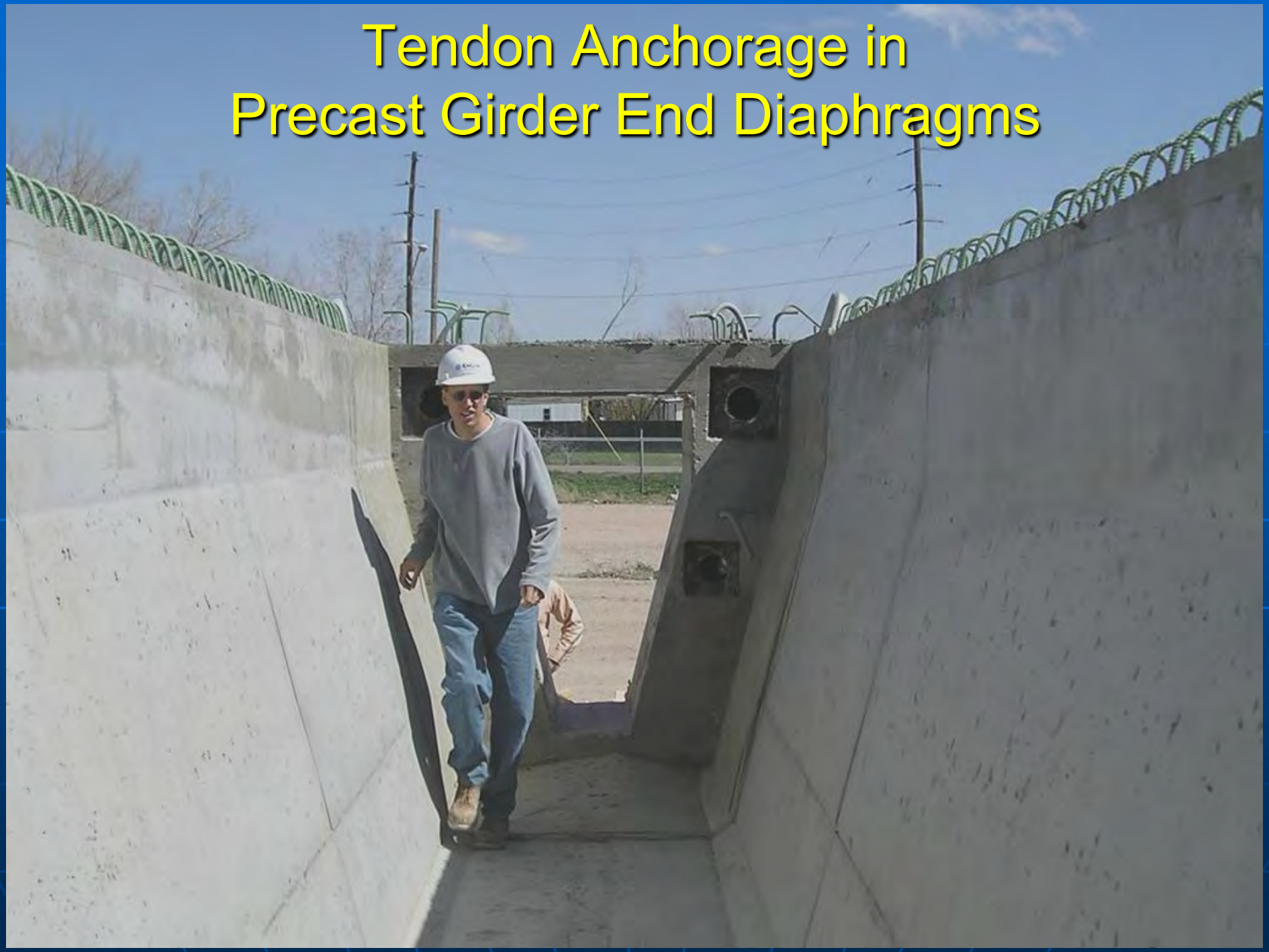
Precast Features of Bijou Bridge

Internal Haunch over Piers, ,Varying Web Thickness
Cantilever PT Anchors in Webs and Shoring Supports


McDonald's
DRIVE-THRU
STOP
Precast External Haunch
for 256’ Clear Span

Notched out Section at end of Girders for CIP Tendon Anchors

Tendon Anchorage in Precast Girder End Diaphragms



Post Tensioning in Girder Forms

“Tongue” Section at Expansion Joints

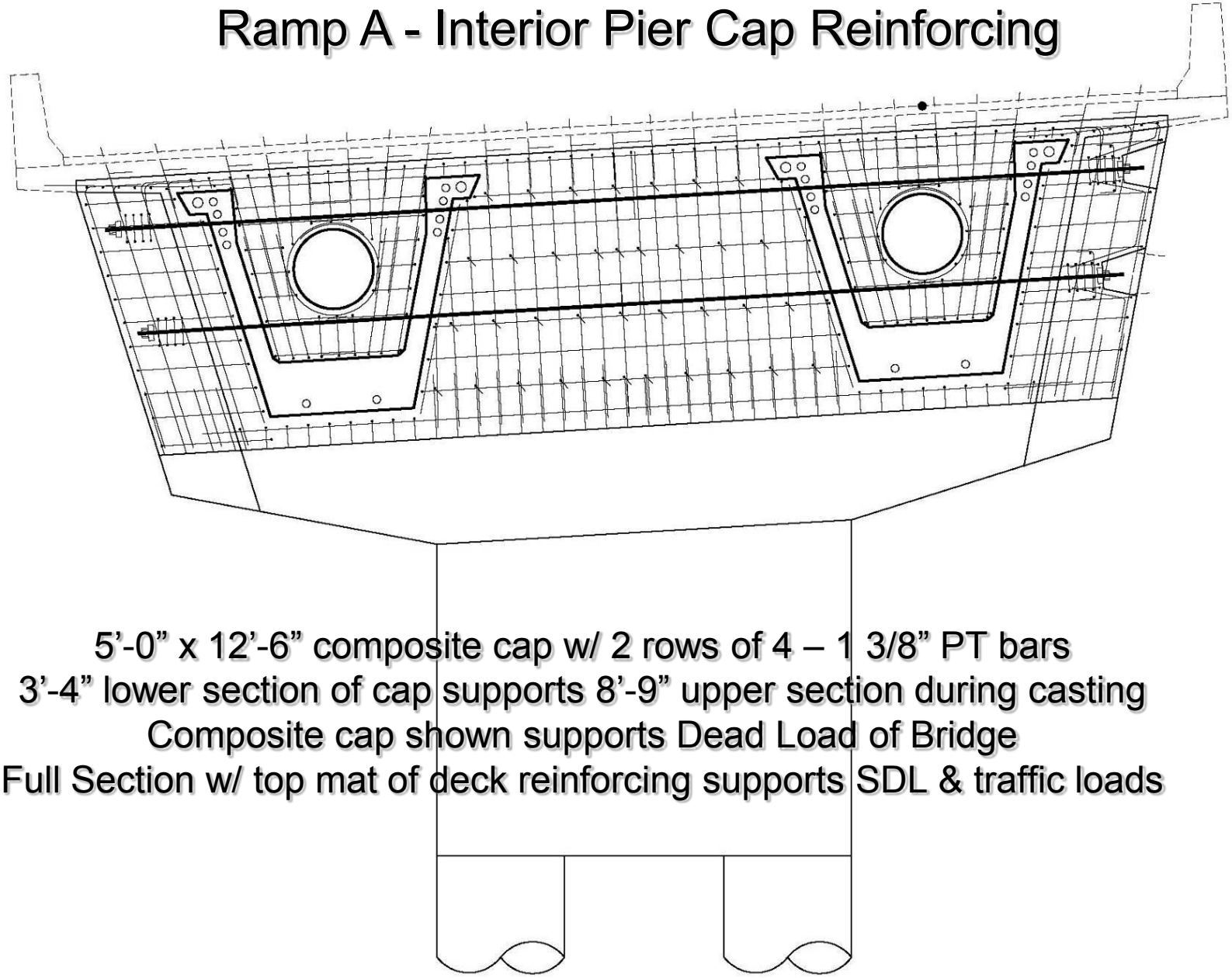
Foundation Design

Integral Abutments and conventional Abutments
Bearings at Abutments and Expansion Piers
Fixed or “Pinned” Interior Piers, No Bearings
Interior Columns typically on side by side Caissons

Foundation Designs
Ramp K – Pinned Connection between Diaphragm and Pier Cap


Ramp A
Erection at Fixed Piers
GROVE
Girders supported on falsework on either side of pier
Bottom section of pier cap supports concrete of upper cap

Ramp A - Interior Pier Cap Reinforcing



5’-0” x 12’-6” composite cap w/ 2 rows of 4 – 1 3/8” PT bars
3’-4” lower section of cap supports 8’-9” upper section during casting
Composite cap shown supports Dead Load of Bridge
Full Section w/ top mat of deck reinforcing supports SDL & traffic loads

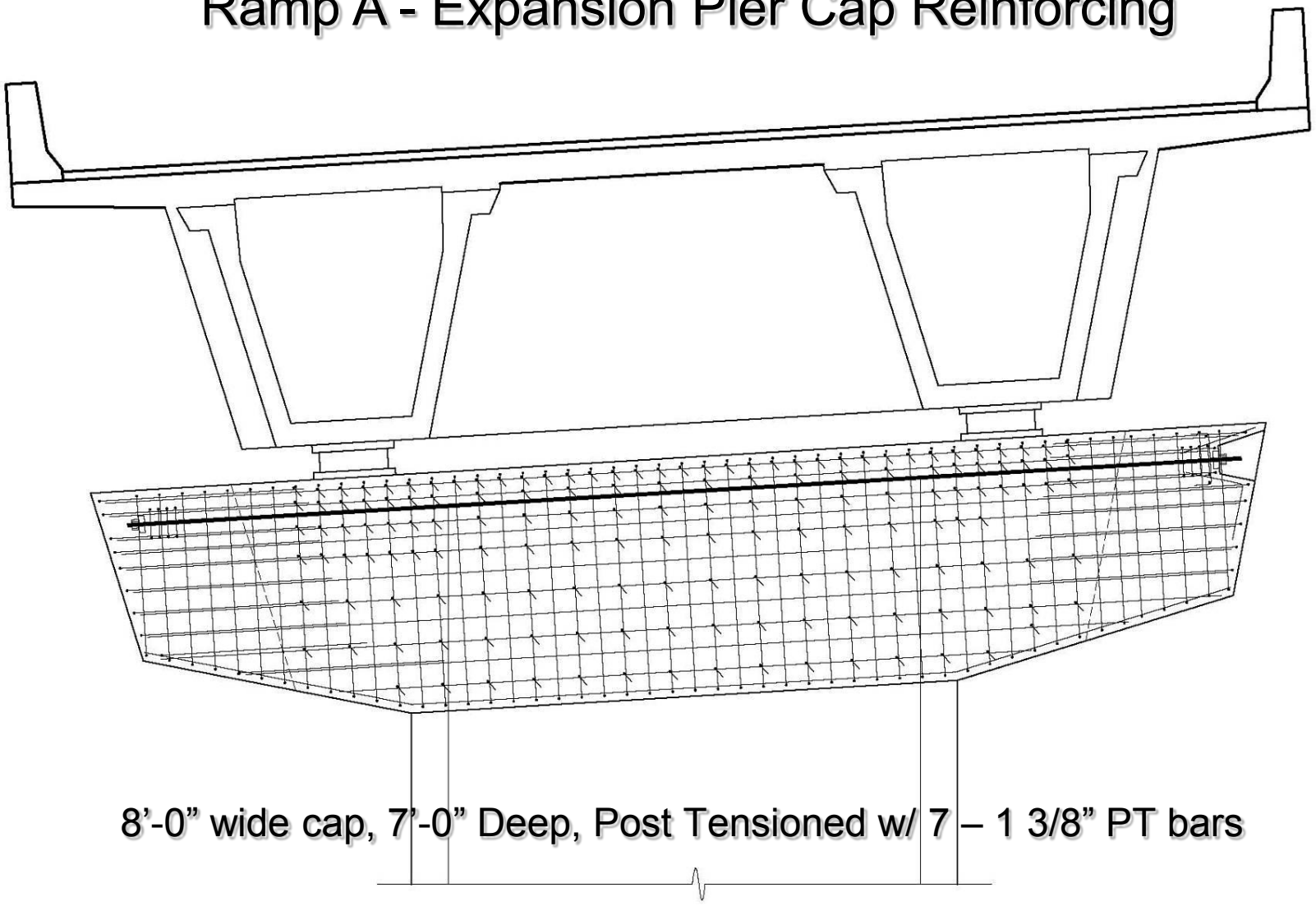
ELEVATION – INTERIOR PIER DIAPHRAGM


Post Tensioned, Fixed Interior Pier Cap
Integral with Superstructure
Bearings eliminated except at expansion joints

Ramp A - Interior Expansion Pier

13’ x 6’ Column on footing and 4 - 36” Caissons
8’ wide cap to accommodate two rows of bearings
Shallow cap post tensioned to match fixed pier aesthetics

Ramp A - Expansion Pier Cap Reinforcing



8’-0” wide cap, 7’-0” Deep, Post Tensioned w/ 7 – 1 3/8” PT bars

ELEVATION – EXPANSION PIER CAP

(TYPICAL DECK, BOTTOM SLAB, HAUNCH AND DIAPHRAGM STEEL NOT SHOWN)

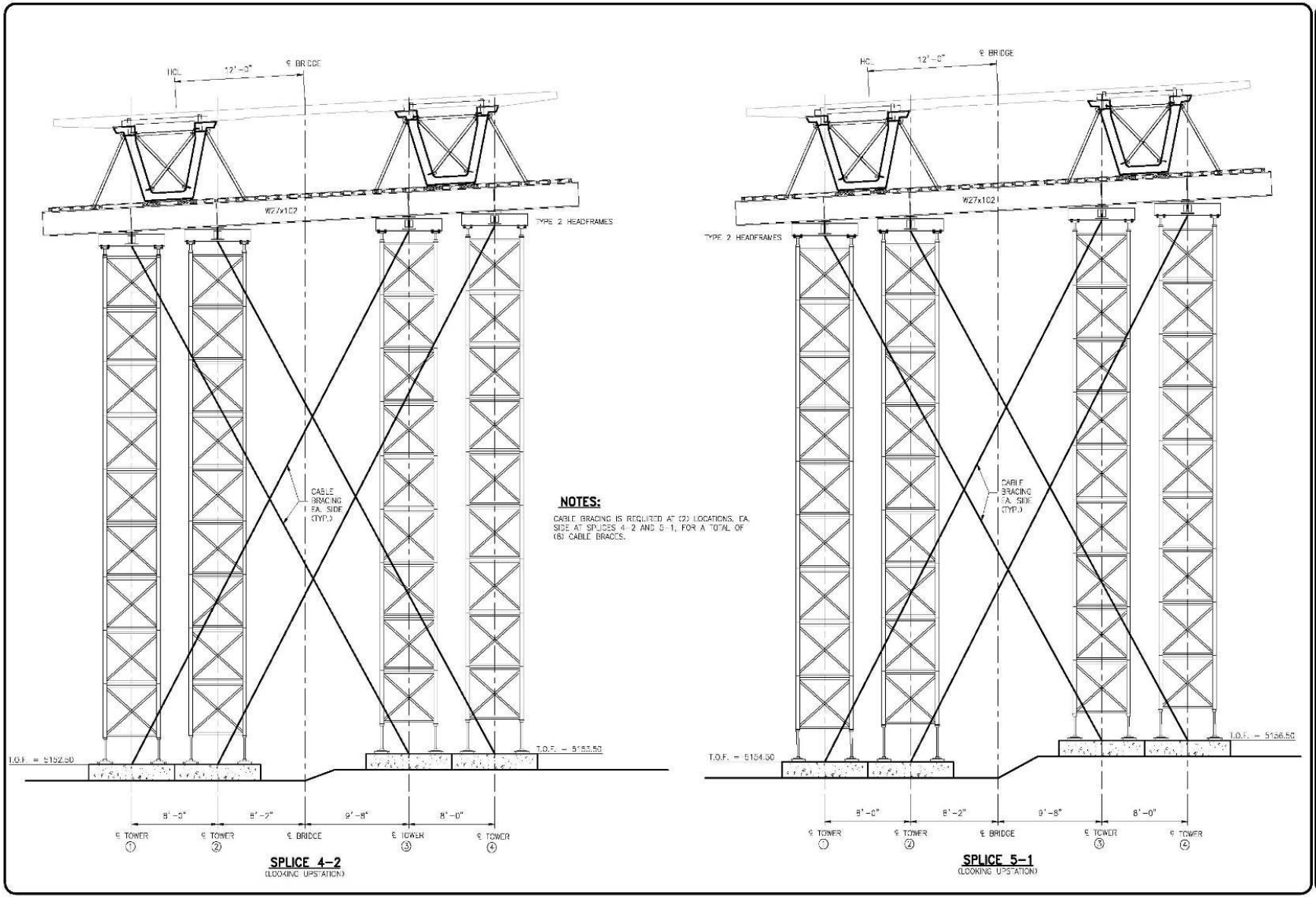
Precast Girder Erection

- Shipping and Handling
- Temporary Shoring
- Heavy erection loads.
- Variable site conditions
- Maintenance of Traffic
- Stability during construction
- Staged Construction.


Girders shipped to job site on
high load, steerable trailers

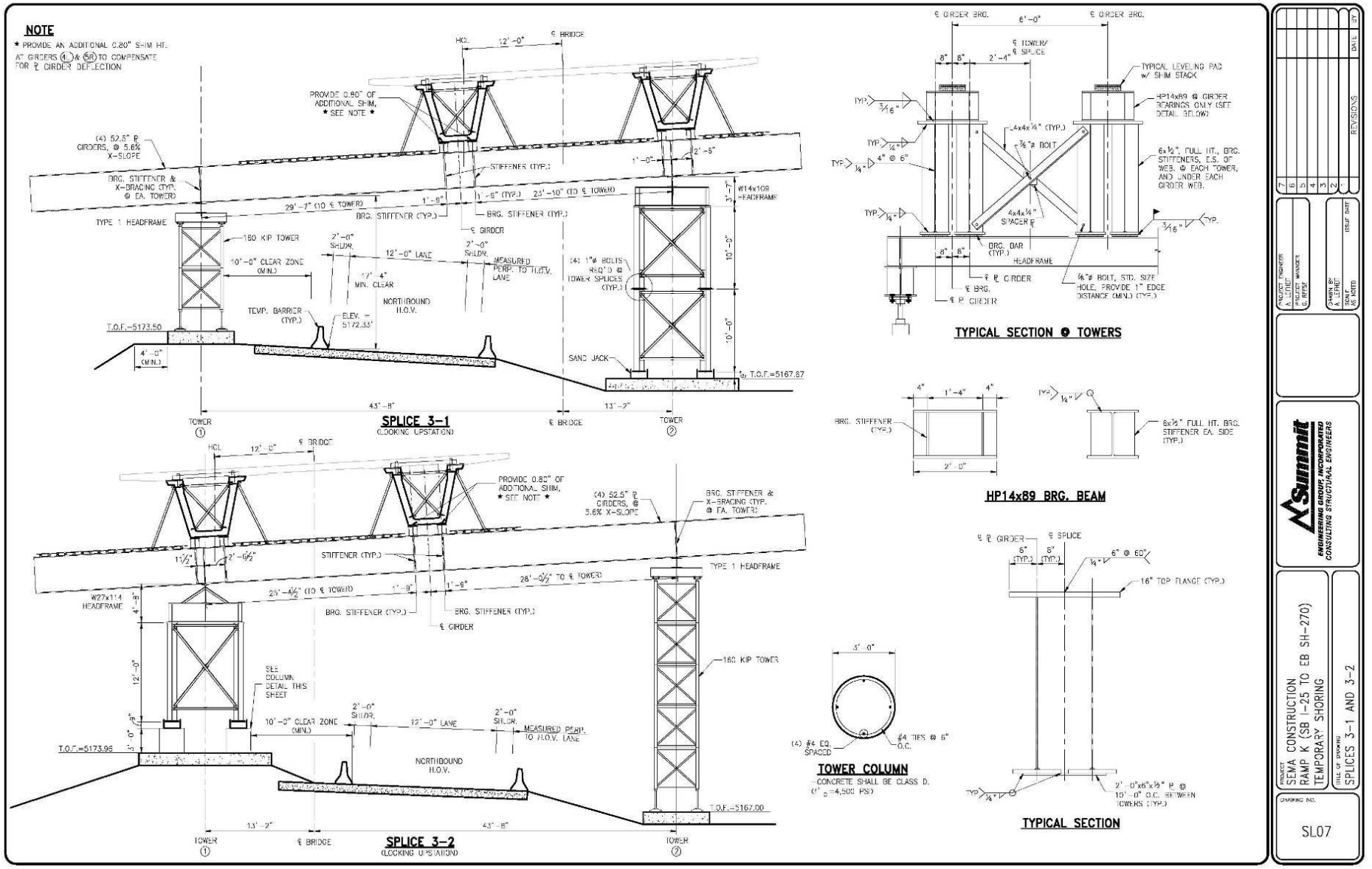
Girders Set with Hydraulic and Crawler Cranes on Falsework

Construction Engineering
Falsework Design – Ramp K at Pier 5



Ramp K on 45’ Falsework Towers @ Pier 5

Maintenance of Traffic
Ramp K - Straddle Bent Design at HOV Lanes




Ramp K – Girders supported on Straddle Bents, HOV lanes open to traffic


Site Conditions are Highly Variable
250 ton Crane Setting Ramp Y Girders
at Braced Retaining Wall


Ramp Y, Unit 2 Erected over IH76 & SH76

Ramp Y Safety Rail protecting
Falsework Bents Adjacent to IH76 Traffic

SH 58 Ramp A over IH70
On Temporary Shoring during construction

Ramp K Cantilevered over existing 270 Bridge during erection

Ramp K Erection completed using strongbacks over IH25 and 270 Bridge

Bijou Street Bridge

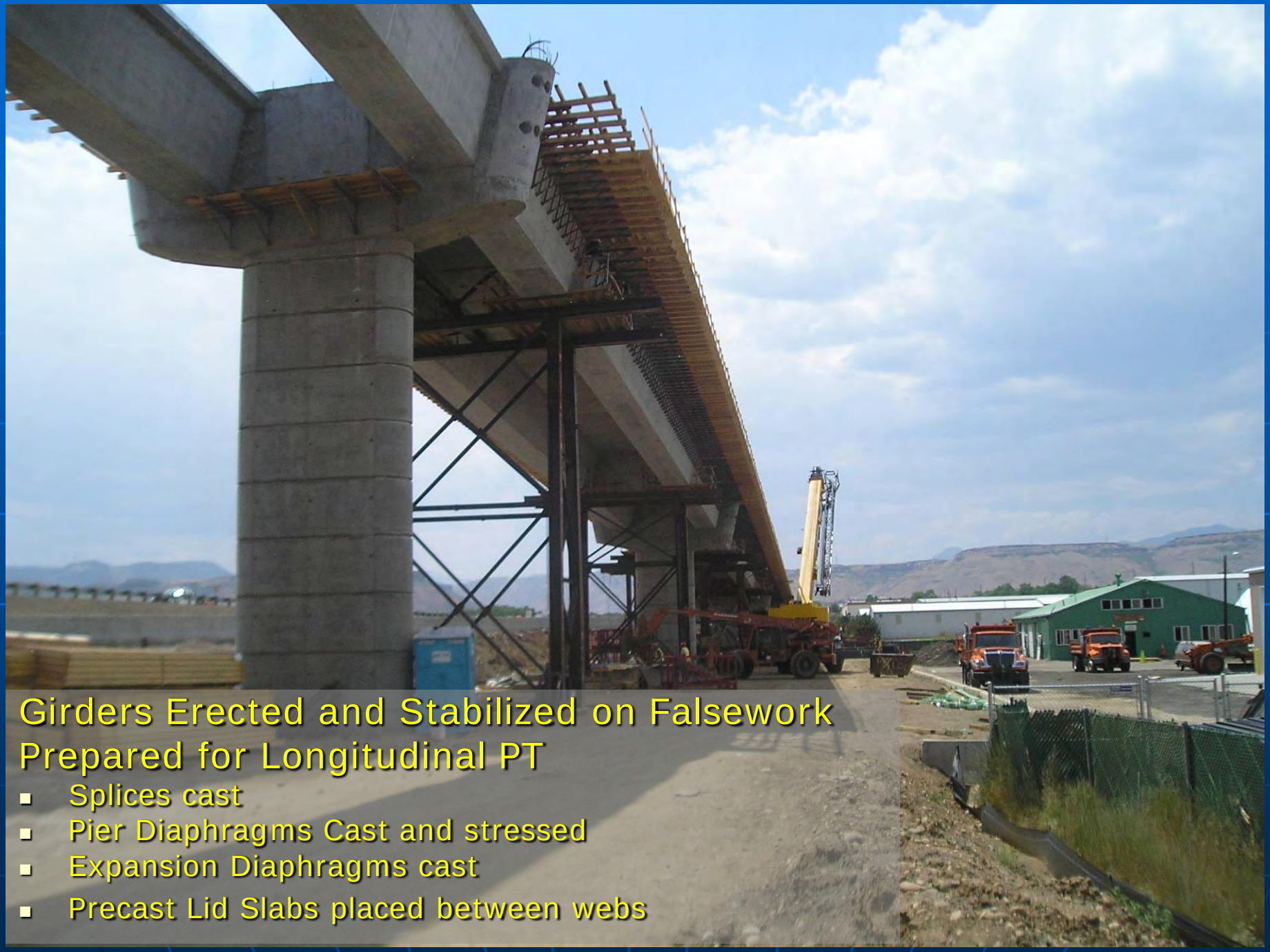
Span 2 & 4 Girders Cantilever into Rail Yard


Bijou Street Bridge
Erection of Span 3 over Rail Yard

Bijou Street Bridge

Span 3 set over Rail Yard, 148’ Clear Opening


Trinidad IH25 Viaduct Erection
Haunched Pier Girders
Drop In supported on strongbacks
256’ clear span opening
Over Rail Yard
McDonald's
BILLIONS AND BILLIONS SERVED
DRIVE-THRU
Link-Belt



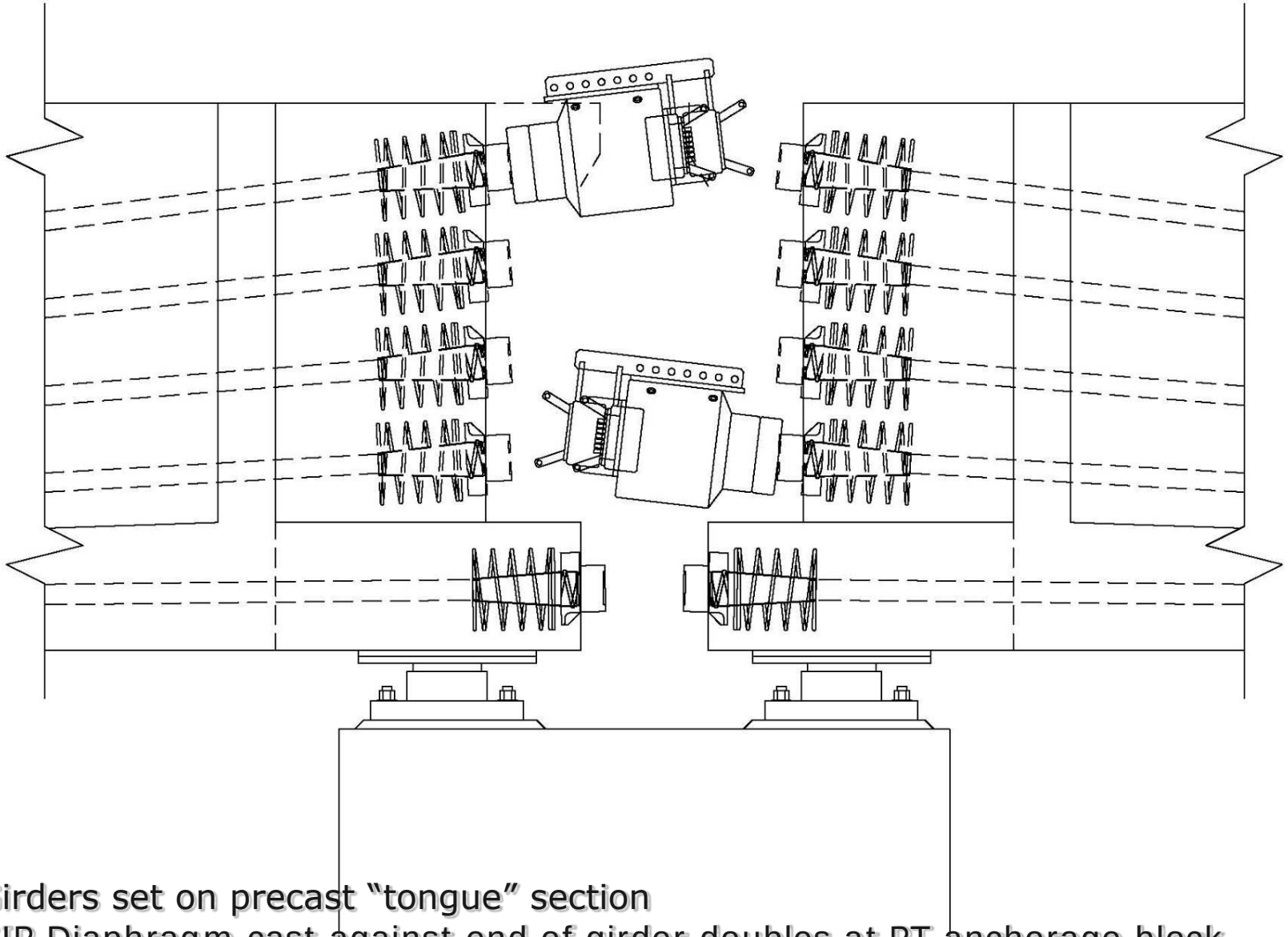
Girders Erected and Stabilized on Falsework Prepared for Longitudinal PT

- Splices cast
- Pier Diaphragms Cast and stressed
- Expansion Diaphragms cast
- Precast Lid Slabs placed between webs

Interior Expansion Pier – Ramp A

- Curved Girders braced against to bracket attached to pier caps
- Girders supported on "tongue" section in notch on permanent bearings
- CIP Diaphragms cast at end of each girder.

Post Tensioning Details at Expansion Piers



- Girders set on precast “tongue” section
- CIP Diaphragm cast against end of girder doubles at PT anchorage block
- Diaphragms designed to allow double end stressing with short stroke ram

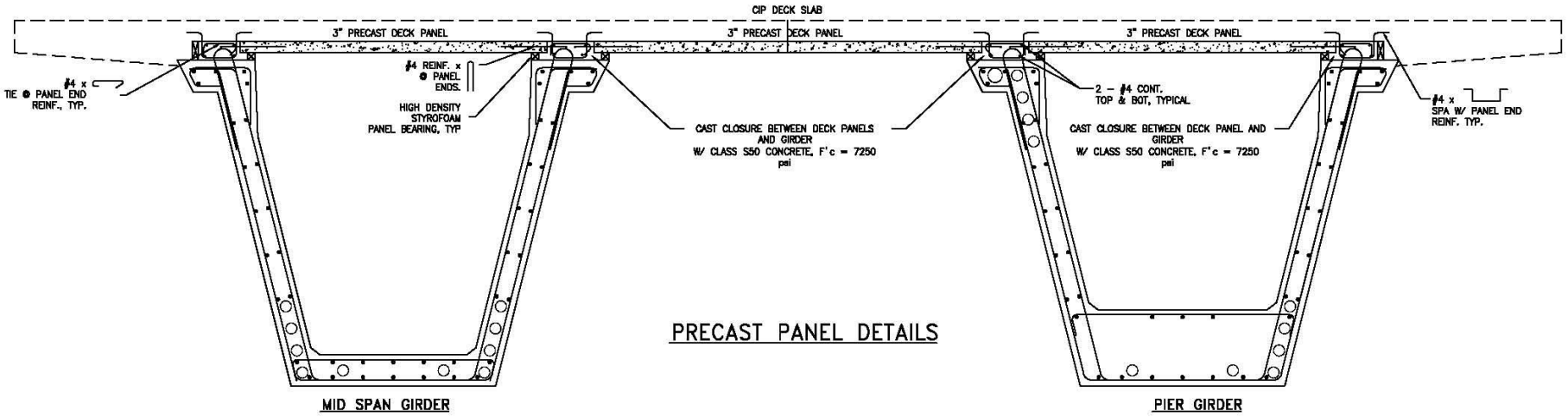
Expansion Pier Diaphragm cast on one side

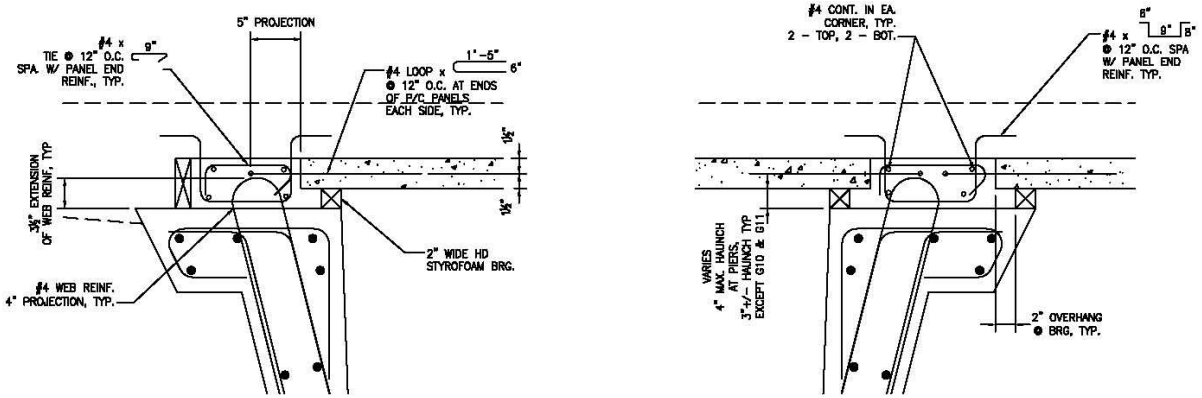

End Girders set and at Abutment
on "Tongue" Section
G19R
G19L

Expansion Pier Diaphragm cast at Abutment w/ PT Anchorages

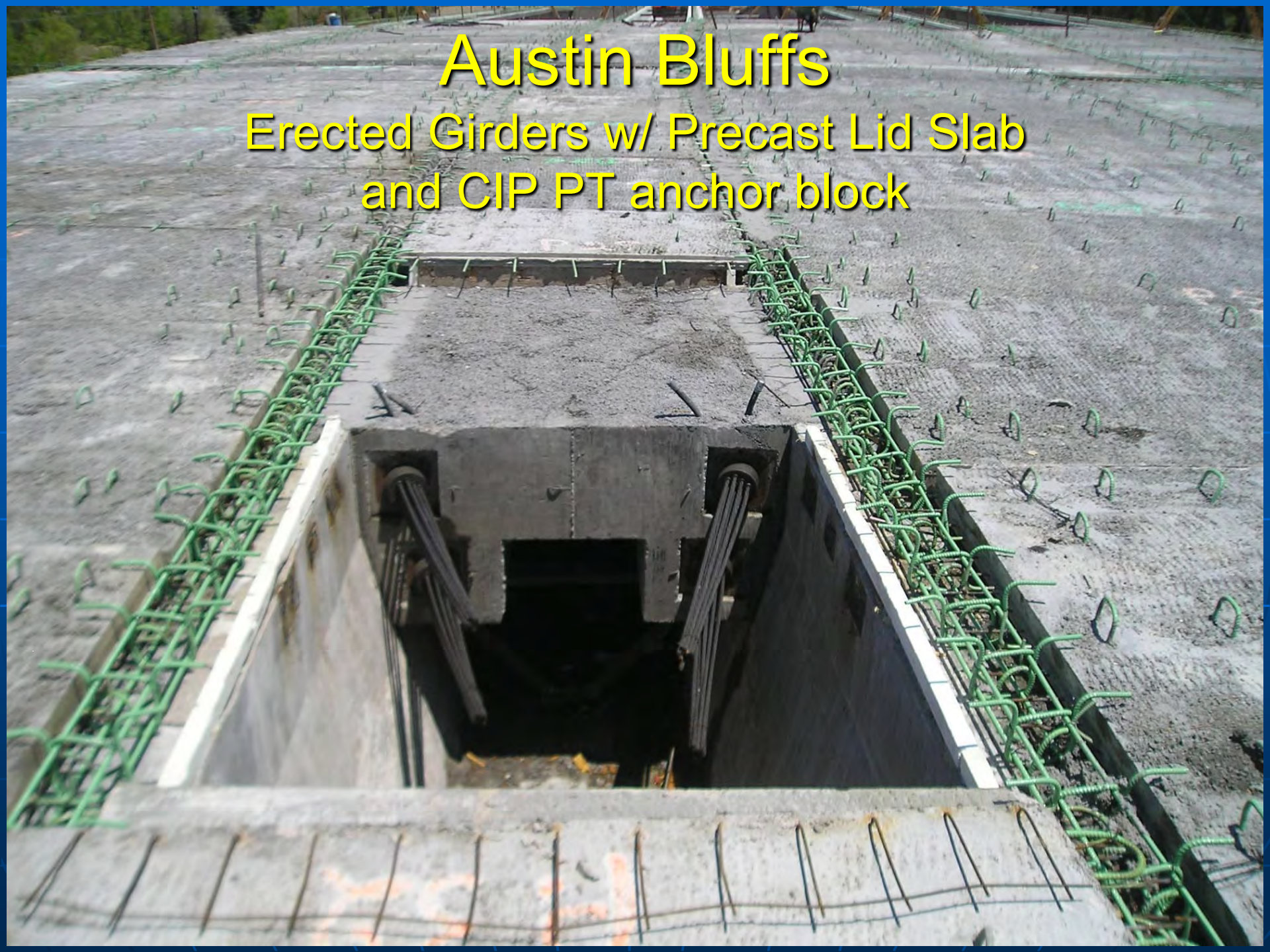
CIP Lid Slab – Ramp K

Precast Girder Lid Slab Details





- Precast Panel set between webs and closure cast and cured prior to post tensioning.
- Lid Slab closes the cross section and greatly increases the torsional strength and stiffness of the cross section


Austin Bluffs
Erected Girders w/ Precast Lid Slab
and CIP PT anchor block

Post Tensioning Stressed
Falsework Removed
No intermediate dipahragms
Replaceable Deck cast in unshored condition

Ramp K - Precast Deck Panels between Girders


Ramp K - Completed December 2005

Ramp A - Completed November 2008

Spliced and Curved Precast U Girder Bridges

- Result of Colorado DOT's vision of establishing precast concrete as a viable design option for complex, long span interchange projects.
- Established a sustainable technology that utilizes standard, commercially available precast concrete products and construction methods.
- Created aesthetically pleasing, durable, cost effective structures.

Opportunities for Future Development

- Seismic Design
- Lightweight Concrete for Longer Spans
- Applications to Larger and more Complex Projects
- Extrados or Cable Stayed applications

PCI Zone 6 Standards

- Southeast details are different thus the PCI Zone 6 standards
- Present Optional Details
- Robust Post-Tensioning systems required in corrosive climates

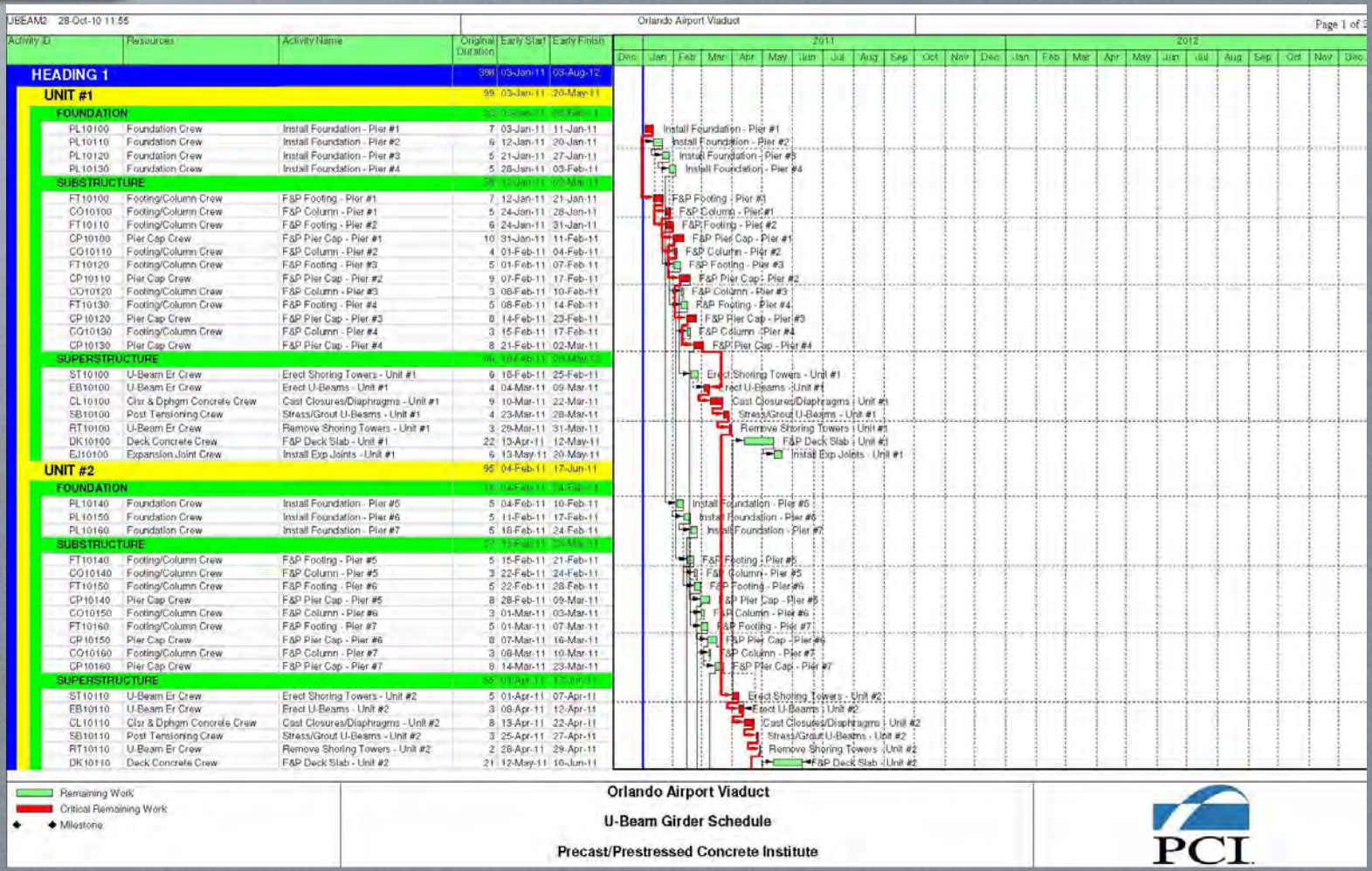
PCI Zone 6 U Beam Go By Sheets

INDEX OF DRAWINGS

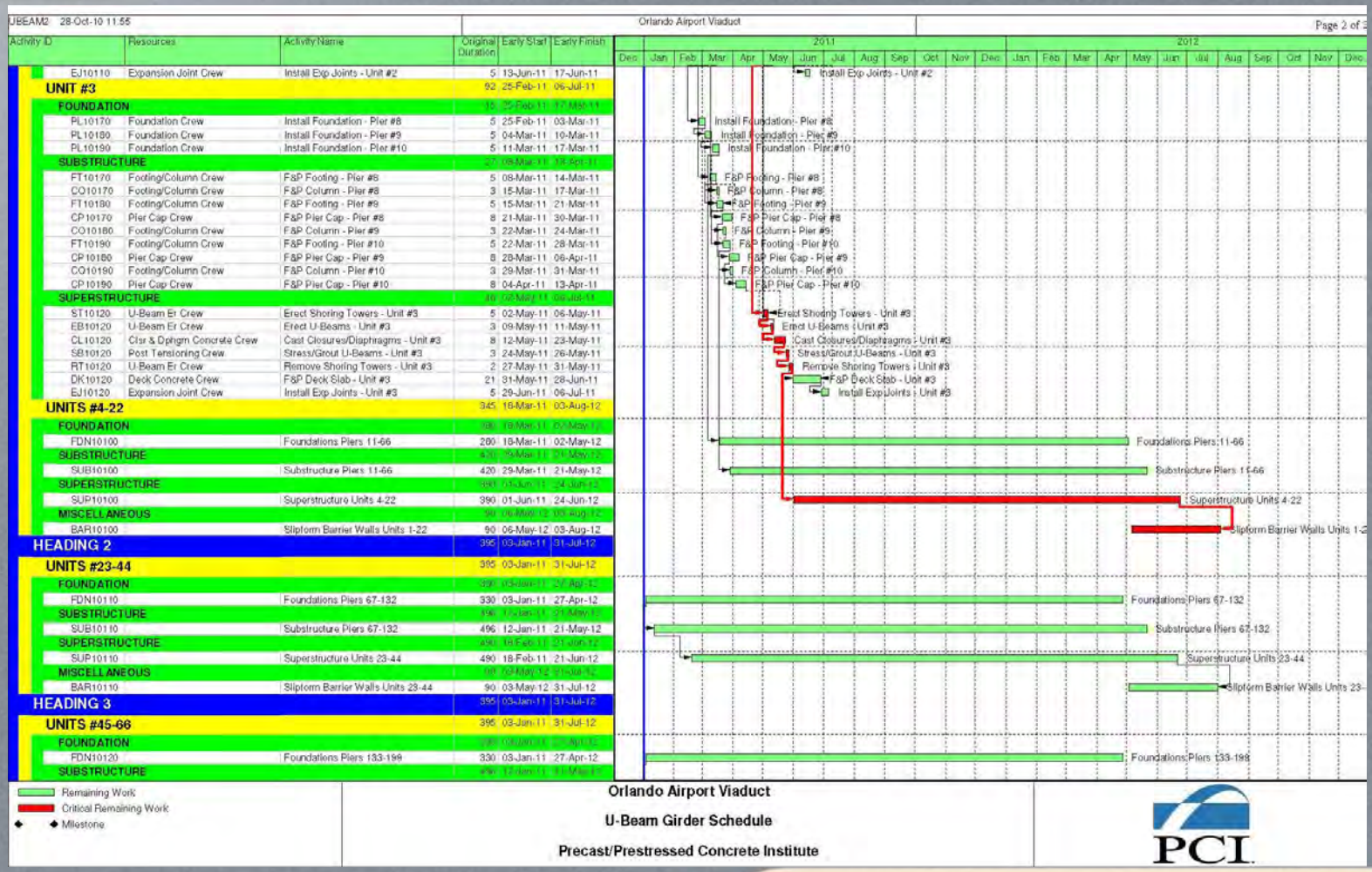
The Schedule

- Multiple Plants to deliver products
- CPM Showing full CIP Deck and substructure
- Based on standard work week
- Presented Schedule generates an appropriately conservative worst case sequencing

15 mile Viaduct in 20 months part1



15 mile Viaduct in 20 months part 2



15 mile Viaduct in 20 months part 3

Summary Schedule

- This example uses average of 200 foots spans in three span units.
- Example did not look at all rail superstructure interaction design criteria
- Seven crews (per heading) from 6 headings can deliver 15 miles in 20 months
- Precast Pretension Deck would expedite construction even faster (Requires a spec change)
- Precast Substructure could also expedite the schedule

After the Break

- How the PCI Zone 6 Go-Bys work
- Quantity Estimates
- Special Details
- Conventional Details
- Considerations for Innovative Concepts approval
- Light Weight Aggregates

Proven Technology from Colorado DOT

Harry H. Edwards
Industry Advancement Award
SH 58, Ramp A
Flyover Bridge
Golden, Colo.

Photo courtesy of Summit Engineering Group Inc.

JUDGES' COMMENTS

Thank you!

PCI

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