

Development of Spliced Precast U Beam Bridge Construction HSR Orlando, FL November 9, 2010

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- 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 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 I.f.
IH25 Trinidad	65,728 s.f.	4,141 I.f.
IH70 / E470 Ramp H	75,952 s.f.	3,232 I.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



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 / If	\$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



Reinforcing Cage in Forms Prior to Casting





Precast Design Features: Ramp K, Steel End Diaphragms



Ramp A, Concrete End Diaphragms





Precast Features of Bijou Bridge Internal Haunch over Piers, Varying Web Thickness Cantilever PT Anchors in Webs and Shoring Supports

COMMUNICACIÓN A COMPANY

Precast External Haunch for 256' Clear Span

McDonald

Notched out Section at end of Girders for CIP Tendon Anchors

Tendon Anchorage in Precast Girder End Diaphragms

TATATA





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



Girders supported on falsework on either side of pier Bottom section of pier cap supports concrete of upper cap

Ramp A

Erection at Fixed Piers



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




Precast Girder Erection

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



05/06/2008

Girders shipped to job site on high load, steerable trailers



Construction Engineering Falsework Design – Ramp K at 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 Girclers at Braced Retaining Wall

Ramp Y, Unit 2 Erected over IH76 & SH76



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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

TOYOTA





Bijou Street Bridge Erection of Span 3 over Rail Yard

Bijou Street Bridge Span 3 set over Rail Yard, 148' Clear Opening

Southernin

Trinidad IH25 Viaduct Erection Haunched Pier Girders Drop In supported on strongbacks 256' clear span opening Over Rail Yard

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



End Girders set and at Abutment on "Tongue" Section

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Expansion Pier Diaphragm cast at Abutment w/ PT Anchorages





Precast Girder Lid Slab Details



CONNECTION OF PRECAST PANELS AT GIRDER FLANGES

- 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

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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

12/12/2008



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

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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



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Milestone

U-Beam Girder Schedule Precast/Prestressed Concrete Institute PCI



15 mile Viaduct in 20 months part 2

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CP 10190	Plet Cap Crew	Fair Mer Cap - Mer #10	8 04-Apr-11	13-Apt-11		3	1		CAP PI	iei cab -	141 #10	1	-	1 1		1	1	1	1		1		1	1	ŝ
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ST10120	U-Beam Er Crew	Erect Shoring Towers - Unit #3	5 02-May-11	06-May-11		3	1		- E	reict Short	ng Towers	s - Unit #	3	1 1	÷.	1	1	1	3	£ 3	1 3	1	1	- 2	- 1
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SB10120	Post Tensioning Crew	Stress/Grout U-Beams - Unit #3	3 24-May-11	26-May-11		1			1 2	Stress	Grout U-E	Beams - I	Upit #3	1 1	1	10	1	1	1	1 1			1	1	1
RT10120	U-Beam Er Crew	Remove Shoring Towers - Unit #3	2 27-May-11	31 May 11		3		1 8		Rem	we Shorin	g Tower	s i Unit i	18	1	1	1	1	1	8 3	1	1	1	1	1
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15 mile Viaduct in 20 months part 3

JBEAM2 28-	Od-10 11:55		1			Orlando Airport Viaduct													Page 3 c									
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Remaining Work

Critical Remaining Work

Orlando Airport Viaduct U-Beam Girder Schedule



Precast/Prestressed Concrete Institute

ast/Prestressed Concrete Institute



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



- 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





Photo courtesy of Summit Engineering Group Inc.

DOT

JUDGES' COMMENTS

PCI



Thank you!



Precast/Prestressed Concrete Institute