CURRENT STATE OF THE ART | Spliced Precast Girder Bridges

- Development of Spliced, Curved U Girder Bridges in CO
- Curved, Spliced Precast U Girder Bridges in Florida
- Innovative Straight Spliced Precast Girder Bridges
- Spliced Precast Bridges in Texas
Summary of Curved Precast U/Box Girder Bridge Projects

**Early Curved Precast Girder Bridges**
- 1960 – Seattle Monorail System
- 1969 – Disney World Monorail
- 1983 – I-95 Airport Ramp Bridge, Philadelphia
- 1986 – Expo 86 Vancouver Sky Train
- 1987 – Detroit Central Area Transit System
- 1994 – Getty Center Tramway
- 1998 – Park Avenue Overpass at IH25, Curved Site Precast U girders
- 2000 – Parker Road / IH225, Curved CIP U girders
- 2006 – Arbor Road Overpass, Lancaster County, Nebraska

**Colorado**
- 2005 – 270 / IH25 Ramp K
- 2008 – E470 / IH70 Ramp H
- 2008 – 270 / IH76 Ramp Y
- 2008 – Austin Bluffs over Union
- 2008 – IH25/Trinidad Phase I
- 2009 – SH58 / IH70 Ramp A
- 2010 – IH25/Trinidad Phase II
- 2012 – C470 @ Santa Fe Drive
- 2013 – I25 Ramp 1 @ Santa Fe Drive
- 2015 – I25 Ramp 5N, (Designed)

**Florida**
- 2015 – Boggy Creek Interchange, Orlando FL
- 2016 – J T Butler Expressway Flyover 1, (Under Construction)
Recent Projects Using Straight, Post Tensioned Precast Girders

Straight Spliced Precast Girders on Straight Bridges - Colorado
- 2008 – SH66 over IH25, Longmont CO, U Girder
- 2011 – IH25 over the Platte River, Bronco Bridge, U Girder
- 2011 – Light Rail Bridge and Station over Wadsworth Blvd., Bulb Tee
- 2013 – SH120 over the Arkansas River, U Girder

Straight Bulb Tee Girders – Straight Bridges – Texas
- 2010 – DART Light Rail Bridge over Trinity River Levee, Dallas
- 2012 – Sylvan Avenue over the Trinity River, Bulb Tee, Dallas
- 2015 – Dallas Horseshoe Bridges over the Trinity River, Dallas
- 2016 – IH10 Access Road over UPRR, Seguin
- 2016 – IH35 Access Ramps over UPRR, Round Rock

Straight Precast Girders – Curved Bridges, Colorado & Texas
- 1997 – IH70 over Washington Street, Bulb Tee
- 2006 – Bijou St. over Monument Creek, U Girder
- 2013 – I25 Overpass at Santa Fe Boulevard, U Girder
- 2015 – Santa Fe Drive over the Platte River, U Girder
- 2016 – E470 / Cherry Creek Ramp Bridge, (in Design), U Girder
EARLY SUCCESS | Spliced Precast Girder Bridges in Colorado

Owner Developed Concept
Cooperation between stakeholders
Projects constructed with local Forces
Existing means and methods.
Multiple precast plants in the area led to competitive pricing.
Contractor driven delivery results in constructible solutions

IH70 / SH58 Ramp A Bridge, Denver
## Project Delivery of Spliced Girder Bridge Projects

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Alternate Delivery System</th>
<th>Traditional Design/Bid/Build</th>
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<tbody>
<tr>
<td>Curved Bridge / Curved U Girders</td>
<td>9</td>
<td>5</td>
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<tr>
<td>Curved Bridge / Straight Precast Girders</td>
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<td>Straight Bridge / Straight Precast Girders (CO)</td>
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<td>Total Projects</td>
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**EARLY PROJECTS** | **Curved Bridges with Spliced U Girders in Colorado**

- 96” Straight U Girders, 6 Spans
  - 230’ Main Span over IH25, Site Cast Precast Girders
  - Completed 1998

- 84” Curved U Girders, 8 Spans
  - 250’ Main Span, 750’ Radius
  - Completed in 2000

Parker Road / IH225 Flyover, Denver

Park Avenue Bridge over IH25 - Denver
EARLY PROJECTS | Curved Bridges with Spliced U Girders in Colorado

60” Straight U Girders, 4 Spans
150’ Main Span over UPRR, Constructed without Shoring
Completed 2005

84” Curved U Girders, 8 Spans
200’ Span Length, 800’ Radius
Completed in 2005

IH25 / SH70 Ramp K Bridge, Denver

Bijou Street Bridge – Colorado Springs
EARLY PROJECTS | **Curved Bridges with Spliced U Girders in Colorado**

84” Curved and Straight U Girders, 4 Spans
220’ Main Span, 700’ Radius, 98’ Deck
Completed 2008

84” Curved U Girders, 2 Units, 12 Spans
230’ Span Lengths, 765’ Radius, 38’ Deck
Completed in 2005

IH76 / SH70 Ramp Y Bridge, Denver

Austin Bluffs Overpass - Colorado Springs
**EARLY PROJECTS** | **Curved Bridges with Spliced U Girders in Colorado**

- 84" Straight and Curved U Girders, 2 Phase Project
  - 256’ Main Span over UPRR, 1200’ Radius
  - Completed 2009

- 84" Curved U Girders, 3 Units, 10 Spans
  - 230’ Main Span over IH70, 800’ Radius
  - Completed in 2008

**IH70 / SH58 Ramp A Bridge, Denver**

**IH25 Viaduct – Trinidad Colorado**
## COST ANALYSIS

### STEEL TRAPEZOIDAL BOX GIRDER vs. SPLICEU GIRDERS

<table>
<thead>
<tr>
<th>Item</th>
<th>Steel Design</th>
<th>Curved Precast</th>
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<tr>
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<td>Erection Costs</td>
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<td>Falsework</td>
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<tr>
<td>Post Tensioning</td>
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<td><strong>Cost / Ft.</strong></td>
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COST ANALYSIS | STEEL PLATE GIRDER vs. SPLICED U GIRDERS

Steel Plate vs. Precast U-Girder Cost Comparison
(Assuming Steel = $1.25/lb, Varying Precast = $400 to $800/ft. PT = $2.00/lb)

Superstructure Costs Based on Average Values and Actual Data
COST ANALYSIS | STEEL TRAPEZOIDAL BOX GIRDER vs. SPLICED U GIRDER

Steel Tub vs. Precast Girder Cost Comparison
(Assuming Steel = $1.50/lb, Precast Cost $400 to $800/ft. PT = $2.00/lb)

| Wash DOT Data - Single Span - Steel |
| Wash DOT Data - 2 Span - Steel |
| TexDOT Steel Bridge Data |
| Initial Precast Girder Cost w/ PT |
| Average Precast Girder Cost w/ PT |
| Lower Bound Precast Girder Cost w/ PT |

Superstructure Costs Based on Average Values and Actual Data
Girder Forms
Single girder casting,
Low Volume, specialty item
One setup for girders in bridge cross section
Sweep is small due to shorter girder length.

Reinforcing Cage
Main tendons in the girder webs
Lighter reinforcing / cubic yard of concrete
Typically removed from bed unstressed
Bottom PT for handling, stressed before shipping
Embedded Design Features
- Thickened bottom slab over piers
- Varying web thickness
- Erection PT anchors embedded in webs
- Holes in webs for pier diaphragm reinforcing
- Anchor slabs for erection strong backs

Girders in Storage
- Designed for handling w/o prestressing
- Bunked to balance self weight in storage
- Bottom tendons stressed and grouted prior to shipping at one time by supplier.

Precast Girders in Casting Yard Storage
Hauling limitations are one of the biggest obstacles in using this type of construction.

Special heavy haul trailers used for heavier girders.

Designed to limit the number of splices.

Typical Girder weighs 200 to 300 kips.
Girders lifted with two cranes.

Motor and Crawler Crane sizes range from 175T to 400T

Spreader bars biased to balance girder roll.

Lifting inboard from the ends is also used to balance against rolling

Precast Girder Erection at the Jobsite
Shoring typically set at Girder Splices
Design Gravity Loading between 600 to 800 kips
Conventional or Custom Shoring used.

Platforms designed at splices to accommodate Girder bearings, torsional bracing and to provide work space.
Variable Site Conditions affect Shoring Designs

Close proximity of shoring to Traffic requires protection from Impact loading.

Retaining Wall Braced to resist Crane Loadings

Shoring Tower Foundation in the middle of Boggy Creek
Many projects are third and fourth level flyovers that must accommodate existing site conditions and traffic.

Girders are braced at each end to the shoring to prevent rolling.
Maintenance of Traffic is key to the success of the project.

Straddle Bents allow support over traffic.

Strong backs allow full traffic opening over IH25.
Continuous units are typically double end stressed. Stressing Jack Clearance is detailed for a short stroke jack for second stressing.

Girders are set on Permanent Bearings during erection. End of girders in notched to allow stressing.
After girders are erected, closures, pier diaphragms and lid slabs are cast.

Every casting operation makes the girder lines stronger and more stable.

Once concrete reaches design strength, longitudinal post tensioning is stressed.
After girders are stressed, all shoring is typically removed and deck forms are placed.

Continuous, closed box girder lines are extremely stiff both flexurally and torsionally.

Deck slabs are cast in unshored condition.

Cambers are much smaller than comparable steel or prestressed beam bridges.
Completion of Construction

Deck slab and barriers are cast.

Bridge is ready to open to traffic.
RECENT DEVELOPMENTS | Spliced Precast Girder Bridges

COMPLEX SPLICED PRECAST BRIDGES DESIGNED USING STRAIGHT BULB TEE AND U GIRDERS

5 MAJOR PROJECTS IN TEXAS DESIGNED USING SPLICED PRECAST GIRDERS THE LAST 5 YEARS

Sylvan Avenue over the Trinity River – Dallas Texas

IH25 / Santa Fe Interchange, Denver CO
Straight Spiced Girder Bridges – Straight Girders

Wadsworth Light Rail Bridge and Station, Denver Colorado
Original Steel Design

- 10 Haunched Steel Plate Girders, 48” to 84” Web Depth
- Varying Cambers for each girder line
- Drop Cap Bent with bearings and CIP Diaphragm
- 12 Drilled Shafts and Footing foundation

Precast Concrete Alternate Design

- 8 Continuous, Spliced Precast Concrete Girders, 48” to 84” Deep
- Uniform Cambers
- Drop Cap w/ Integral Diaphragm, no bearings
- Single Drilled shaft at each pier
Girder Post Tensioning Stress in one stage

Diaphragms and Splices formed and cast
Platforms & Station integral with Bridge Deck

Spliced Precast Bulb Tee Girder Bridges
Bridge Completed in 2010, Live traffic began in 2013

Spliced Precast Bulb Tee Girder Bridges
## IH25 Bronco Bridge over the Platte River

### Precast Piers and Full Depth Precast Deck

<table>
<thead>
<tr>
<th>Phase</th>
<th>Start Date</th>
<th>End Date</th>
<th>Duration</th>
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<tr>
<td>1</td>
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<td>May 4, 2012</td>
<td>164</td>
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<tr>
<td>2</td>
<td>May 7, 2012</td>
<td>Aug. 19, 2012</td>
<td>104</td>
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<tr>
<td>4</td>
<td>Dec. 4, 2012</td>
<td>April 4, 2013</td>
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</tbody>
</table>
IH25 Bronco Bridge over the Platte River

Precast Piers and Full Depth Precast Deck

Deck panels set on girder flanges.

Precast Piers Erected on Shoring
IH25 Bronco Bridge over the Platte River

Fully Precast Bridge with No Bearings
IH25 Overpass at Santa Fe Drive

Straight U Girders kinked to accommodate curved alignment
Texas Looks to the Future with Spliced Precast Construction

4 Projects completed or under construction in the last 5 years
All projects from Design / Build and City Improvement Projects
Trinity River Corridor between Dallas and Fort Worth
2 New Precaster initiated projects under way.
Dallas Area Rapid Transit Bridge
Bridge design was based around limiting construction loading on the Trinity River levee

Stong backs used to hang 160’ long Drop In Girders weighing 214 kips
Precaster’s Modified Pier Girder Cross Section:

Original Pier Girder Cross Section

Girder Cross section modified to reduce shipping weight

Spliced Precast Bulb Tee Girder Bridges
Sylvan Avenue Bridge, Dallas Texas
Variable Depth Pier Girders

- TX82 to 130” deep Section
- Supplemental Post Tensioning in Top Flange
- Web Tendons harped to high point over pier
- 6’ long tapered End Blocks in Pier Girders
- Steel Corbels embedded in End Blocks to support adjacent girders during erection
- Corbels replace conventional strong backs and are permanently embed in splices
CASE STUDY | Wadsworth Light Rail Bridge and Station

Precast Girder Erection

Spliced Precast Bulb Tee Girder Bridges
Bridge Completed in 2013

Spliced Precast Bulb Tee Girder Bridges
Clear Fork Bridge over the Trinity River
Fort Worth, Texas

Spliced Precast Bulb Tee Girder Bridges
Twin Bridges are part of Trinity River Basin Development
Each Bridge consists of a 3 span unit with a 220’ main span
Bridges support four lanes of traffic and hanging pedestrian bridge
CASE STUDY | Clear Fork Bridge, Fort Worth Texas

Bridge Completed in 2012

Spliced Precast Bulb Tee Girder Bridges
Dallas Horsehoe Bridges over the Trinity River
Dallas, Texas
Dallas Horseshoe Bridges over the Trinity River, Dallas, Texas

Twin 1200’ span Arches support pedestrian bridges on either side of the project.
CASE STUDY | Dallas Horseshoe, Dallas Texas

Bridge Configuration

- 6 Bridges with Spliced Precast Concrete Superstructure and Simple Span approaches.
- Continuous 4 span Spliced Girder Units
- Typical Span Arrangements
  - 240’ – 260’ – 260’ – 240’
  - 250’ – 250’ – 250’ – 250’
  - 240’ – 270’ – 270’ – 240’
- Variable Pier Girders
- Multiple Column Bents with Pot and Expansion Bearings
- Cast-in-place Deck, Unshored.

Spliced Precast Bulb Tee Girder Bridges
CASE STUDY | Dallas Horseshoe, Dallas Texas

Spliced Precast Bulb Tee Girder Bridges

Construction Progress Photos
CASE STUDY | Dallas Horseshoe, Dallas Texas

Precast Girder and Arch Bridge Construction

Spliced Precast Bulb Tee Girder Bridges
Project Scheduled for Completion in 2017
New Bridge Design – Seguin Texas
Precaster Initiated Alternate Design

123’, 200’, 126 Simple Span arrangement converted to 3 span continuous unit using existing TX82 forms
All Girders are Constant Length and Depth
Post Tensioning Layout

Each Girders Line is Unique due to skewed Interior Piers
Design optimizes pretensioning and debonding in bottom and top flanges to minimize Post Tensioning.
Only 2 – 12 strand tendons per web necessary.
Construction Sequencing

End Girders Set on Piers, Drop In Girders Set on Erection Corbels
No Shoring Required

CASE STUDY | IH10 Access Road over UPRR, Seguin Texas

Spliced Precast Bulb Tee Girder Bridges
Summary - Current State of the Art

Spliced Precast is a viable, attractive design option

- Successful Projects utilize existing means and methods
- Repetition leads to more economy over time.
- Experience and Common Sense are vital for successful designs
- For Creative Engineers there are many more things to be discovered

Challenges to Innovation

- Different States – Different Priorities
- Lack of Funding. Innovation is difficult in an environment of scarcity.
- Penalties more prevalent than incentives
- Cheaper and faster is the desired end result.
- Play it safe mentality causes slow acceptance of new ideas even they are economically compelling

End result: Innovation is slow and incremental but the economics are compelling. It’s a matter of time.

Thank You.