



Boggy Creek Interchange – Orlando Florida



**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)
- 2017 – S.R. 429 Wekiva Parkway Systems Interchange (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

Project Delivery of Spliced Girder Bridge Projects

Project Type	Alternate Delivery System	Traditional Design/Bid/Build
Curved Bridge / Curved U Girders	9	5
Curved Bridge / Straight Precast Girders	3	3
Straight Bridge / Straight Precast Girders (CO)	6	3
Total Projects	18	11

EARLY PROJECTS | Curved Bridges with Spliced U Girders in Colorado



84" Curved U Girders, 8 Spans
250' Main Span, 750' Radius
Completed in 2000

Parker Road / IH225 Flyover, Denver

96" Straight U Girders, 6 Spans
230' Main Span over IH25, Site Cast Precast Girders
Completed 1998



Park Avenue Bridge over IH25 - Denver

EARLY PROJECTS | Curved Bridges with Spliced U Girders in Colorado



**84" Curved U Girders, 8 Spans
200' Span Length, 800' Radius
Completed in 2005**

IH25 / SH70 Ramp K Bridge, Denver

**60" Straight U Girders, 4 Spans
150' Main Span over UPRR, Constructed without Shoring
Completed 2005**



Bijou Street Bridge – Colorado Springs

EARLY PROJECTS | Curved Bridges with Spliced U Girders in Colorado



**84" Curved U Girders, 2 Units, 12 Spans
230' Span Lengths, 765' Radius, 38' Deck
Completed in 2005**

IH76 / SH70 Ramp Y Bridge, Denver

**84" Curved and Straight U Girders, 4 Spans
220' Main Span, 700' Radius, 98' Deck
Completed 2008**



Austin Bluffs Overpass - Colorado Springs

EARLY PROJECTS | Curved Bridges with Spliced U Girders in Colorado



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

IH70 / SH58 Ramp A Bridge, Denver

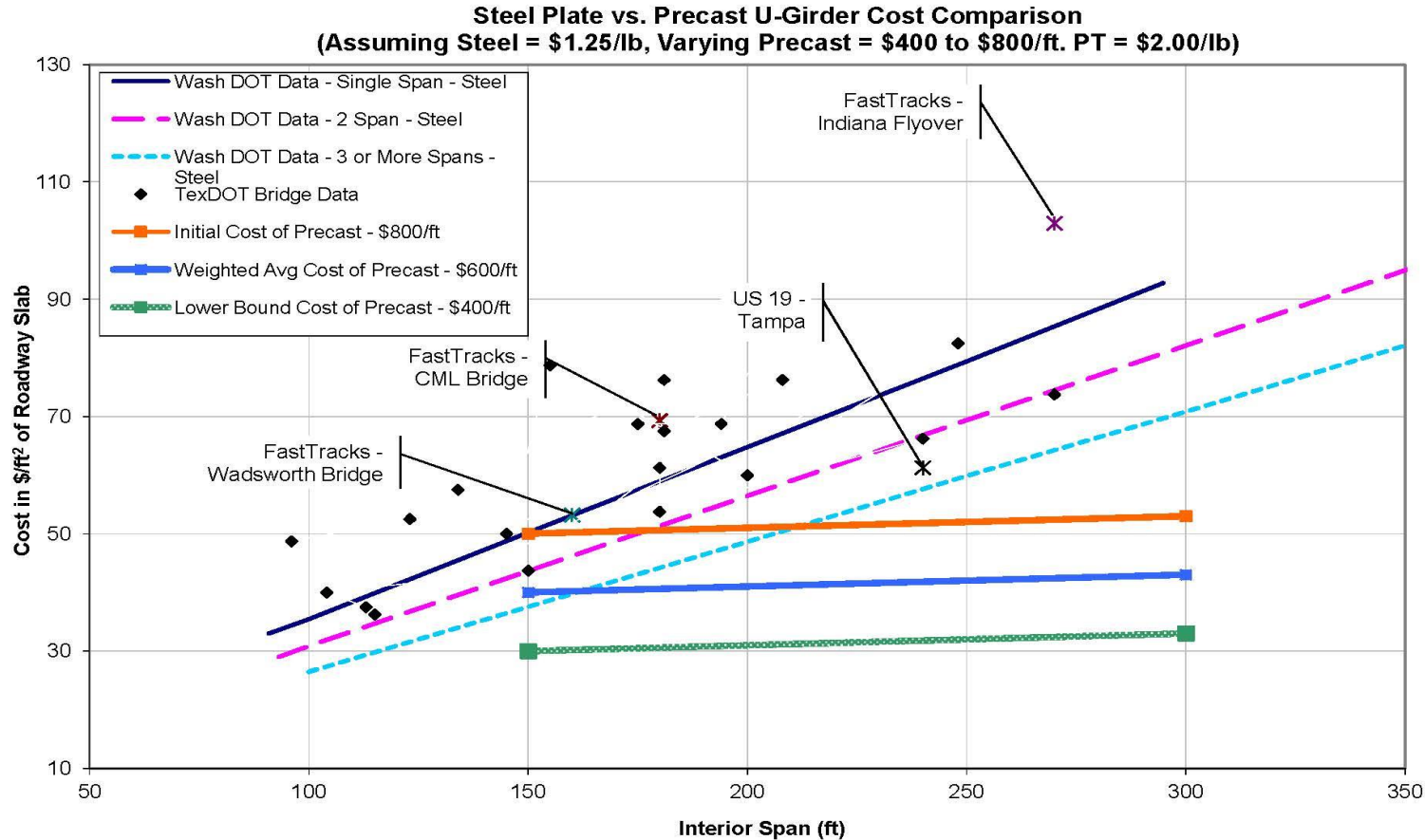
**84" Straight and Curved U Girders, 2 Phase Project
256' Main Span over UPRR, 1200' Radius
Completed 2009**



IH25 Viaduct – Trinidad Colorado

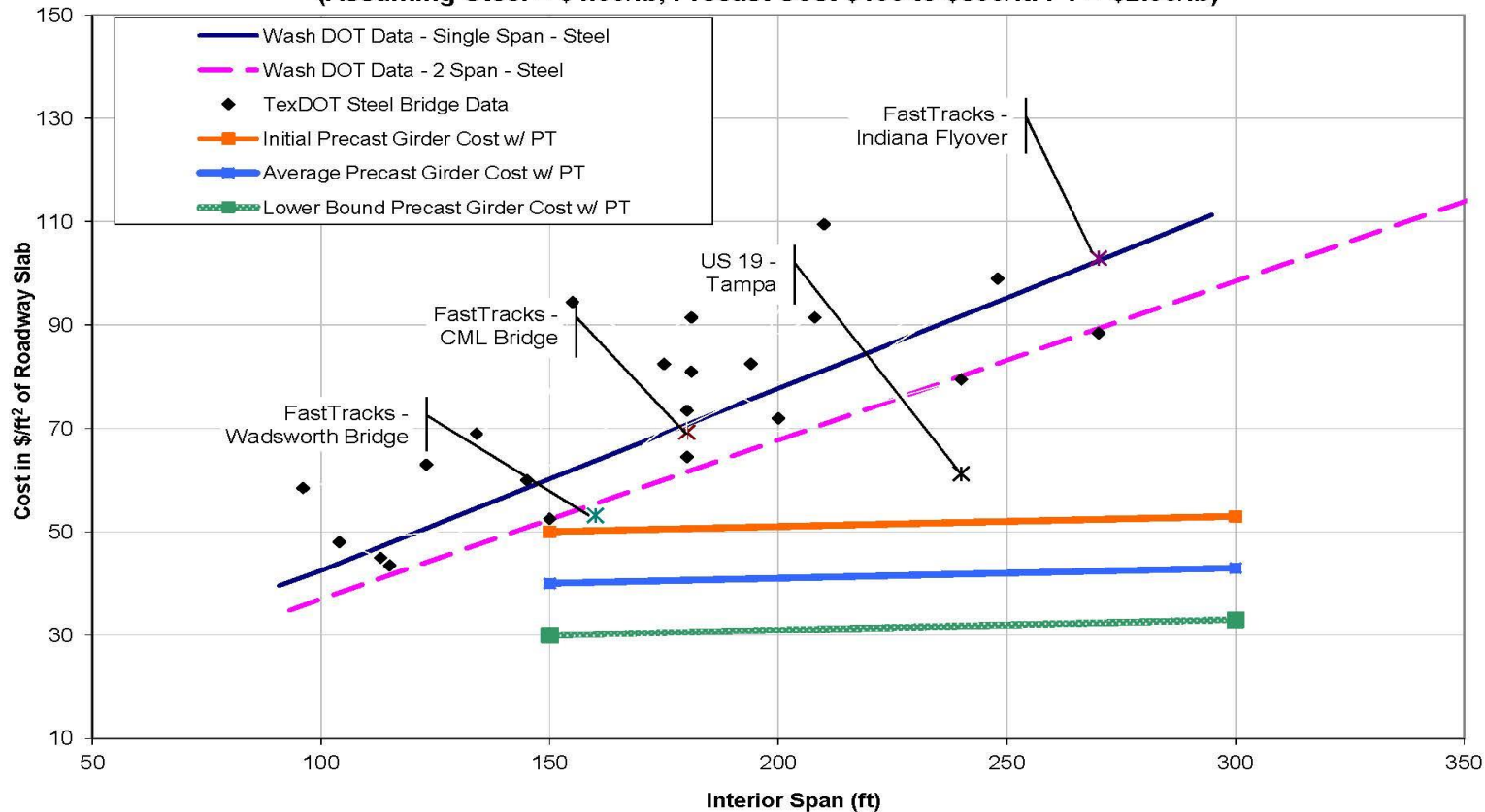
CO SH270 / IH76 Ramp Y Bid Tabs

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



Superstructure Costs Based on Average Values and Actual Data

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



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

Girder Casting Yard and Forms

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

Shipping Precast Girders to the Jobsite

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

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

Temporary Shoring

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

Site Conditions - Temporary Shoring

Many projects are third and fourth level flyovers that must accommodate existing site conditions and traffic



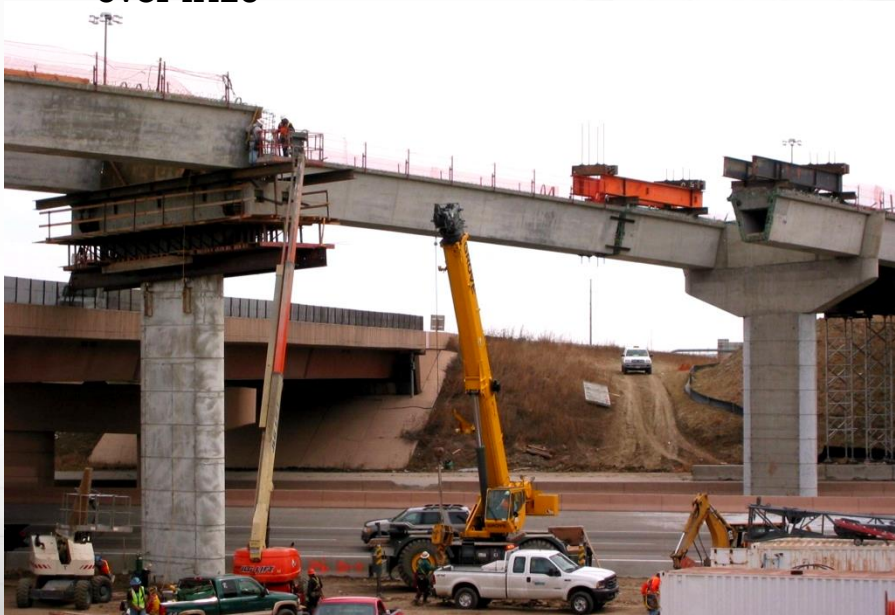
Girders are braced at each end to the shoring to prevent rolling

Girder Erection on Temporary Shoring

Maintenance of Traffic is key to the success of the project.

Straddle Bents allow support over traffic.

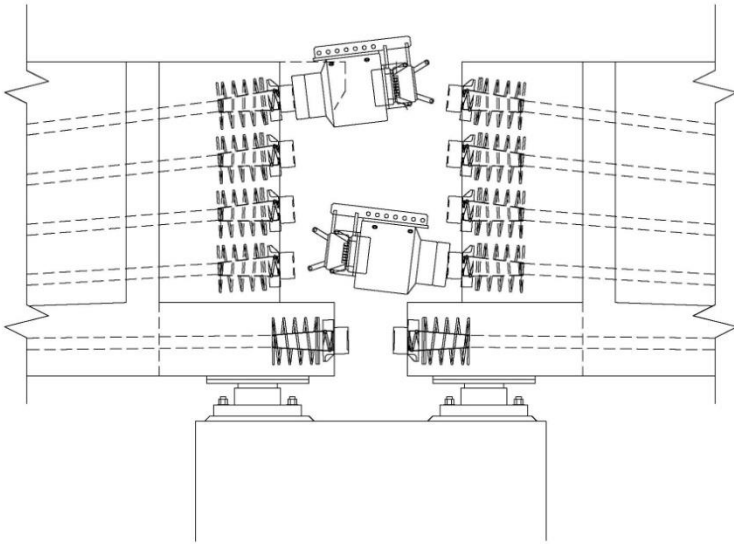
Strong backs allow full traffic opening over IH25



Traffic Crossings during Construction - Temporary Shoring

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 is notched to allow stressing

Girder Details at Expansion Piers

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



Casting of Splices, Diaphragms and Lid Slabs prior to stressing PT

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

Casting of Splices, Diaphragms and Lid Slabs prior to stressing PT



Deck slab and barriers are cast.

Bridge is ready to open to traffic.

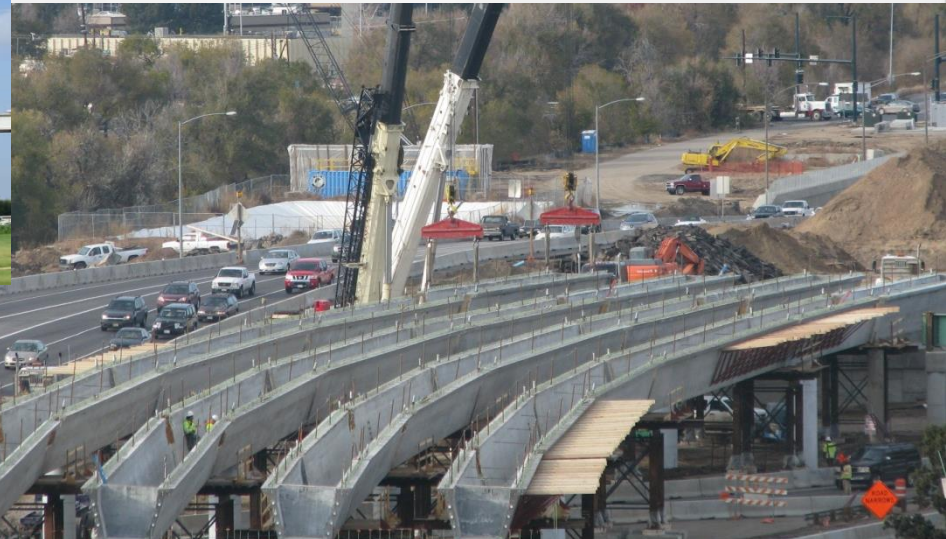
Completion of Construction

RECENT DEVELOPMENTS | Spliced Precast Girder Briges



**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

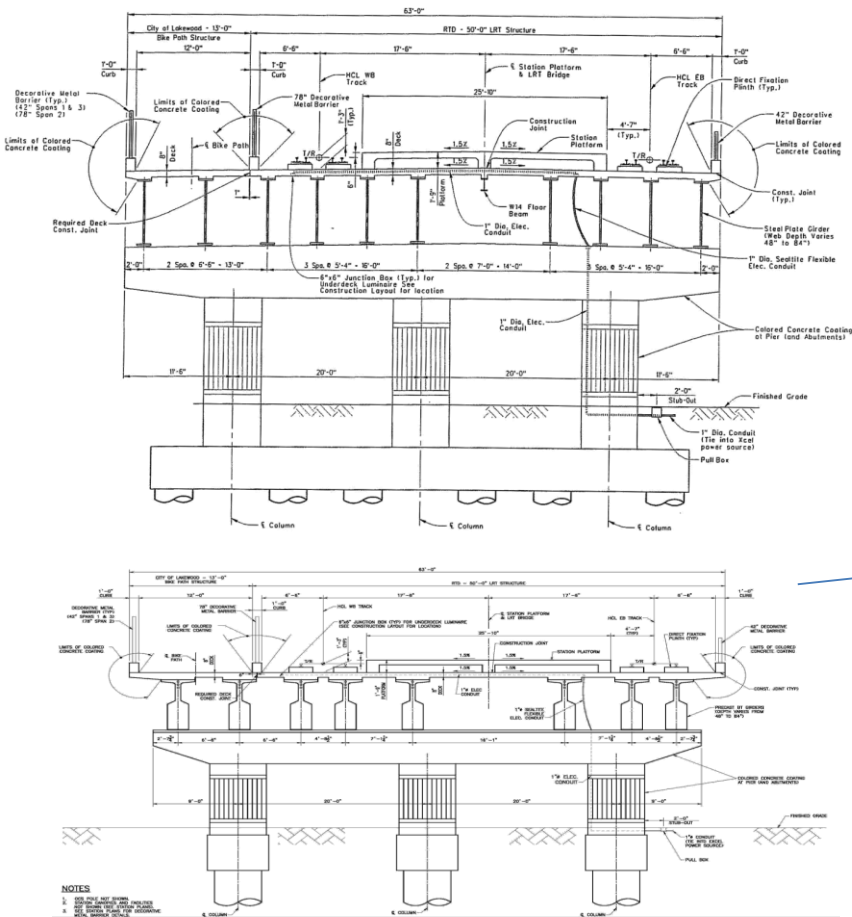
Design

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



Spliced Precast Bulb Tee Girder Bridges

Precast Girders set on Temporary Shoring

- Girder Post Tensioning Stress in one stage
- Diaphragms and Splices formed and cast



Spliced Precast Bulb Tee Girder Bridges

Platforms & Station integral with Bridge Deck



Bridge Completed in 2010, Live traffic began in 2013



IH25 Bronco Bridge over the Platte River

Construction Schedule

Phase	Start Date	End Date	Duration
1	Nov. 22, 2011	May 4, 2012	164
2	May 7, 2012	Aug. 19, 2012	104
3	Aug. 23, 2012	Dec. 3, 2012	102
4	Dec. 4, 2012	April 4, 2013	121



Precast Piers and Full Depth Precast Deck

IH25 Bronco Bridge over the Platte River



Deck panels set on girder flanges.

Precast Piers Erected on Shoring



Precast Piers and Full Depth Precast Deck

IH25 Bronco Bridge over the Platte River



Fully Precast Bridge with No Bearings

IH25 and Santa Fe Drive Intersection Bridges



Ramp 1 Flyover

IH25 Overpass at Santa Fe Drive

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.



2013/07/21 21:18

Dallas Area Rapid Transit Bridge

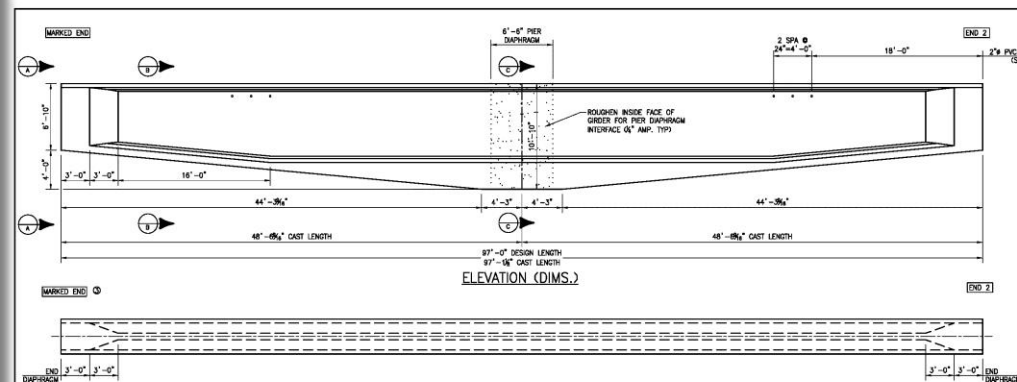
Bridge design was based around limiting construction loading on the Trinity River levee



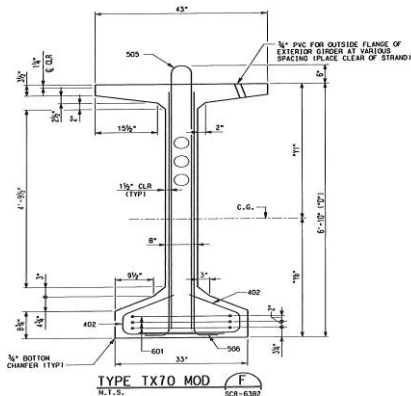
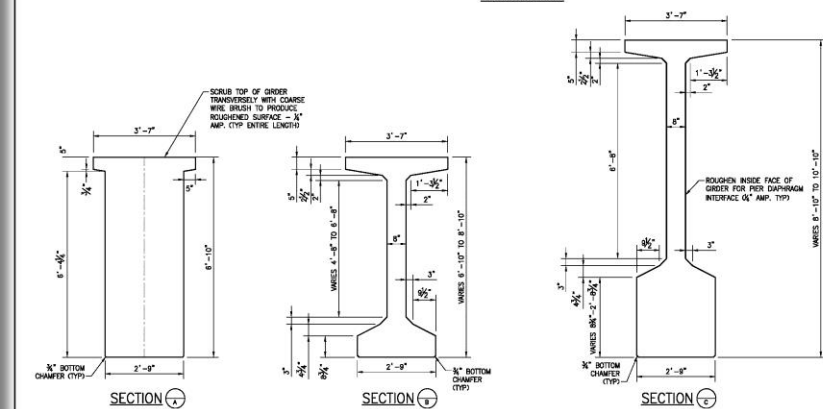
Stong backs used to hang
160' long Drop In Girders
weighing 214 kips

Spliced Precast Bulb Tee Girder Bridges

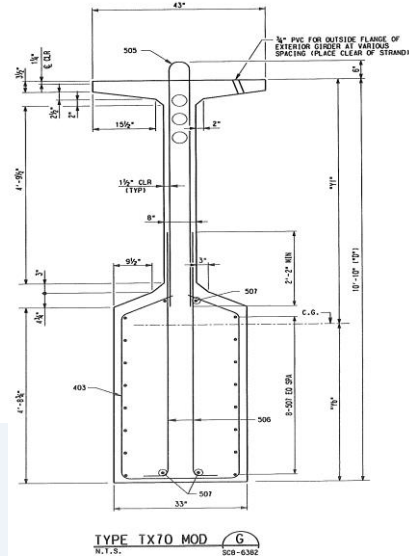
Precaster's Modified Pier Girder Cross Section:



PLAN (DIMS.)



Original Pier Girder Cross Section



FOR APPROVAL
JANUARY 11 2010
BEXAR CONCRETE WORKS, L. Ltd.

TYPE TxB2 MODIFIED ORDER MARK	= TxB2-7
ORDER QUANTITY THIS SHEET	= 1
LINEAR FOOTAGE THIS SHEET	= 97.09
CONCRETE RELEASE STRENGTH, f'_d	= 5000psi
CONCRETE 28 DAY STRENGTH, f'_c	= 8500psi

GIRDER 7 FABRICATION SHEET (1 OF 5)									
FABRICATOR/PREPARED BY BEXAR CONCRETE WORKS I, LTD.								ROW # 3600	
CONTRACTOR KSWRF									
STATE DISTRICT		FEDERAL REGION		STATE		PROJECT			
6		TEXAS		1-35/TRINITY RIVER AERIAL STRUCTURE 1-1					
COUNTY COLLIN		CONTROL LINE 1-1		SECTION		JOB		HIGHWAY	
								1-35	
DRAWN BY TLF		CHECKED BY GAR		DATE 1-11-10		SHEET 1x82-7A			

**Girder Cross section
modified to reduce
shipping weight**

Spliced Precast Bulb Tee Girder Bridges

Sylvan Avenue Bridge, Dallas Texas

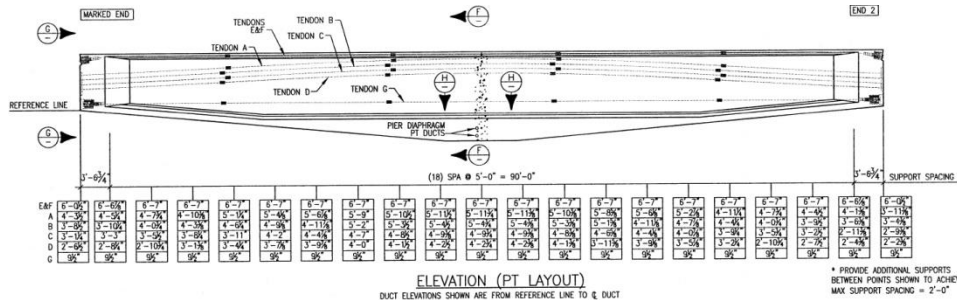
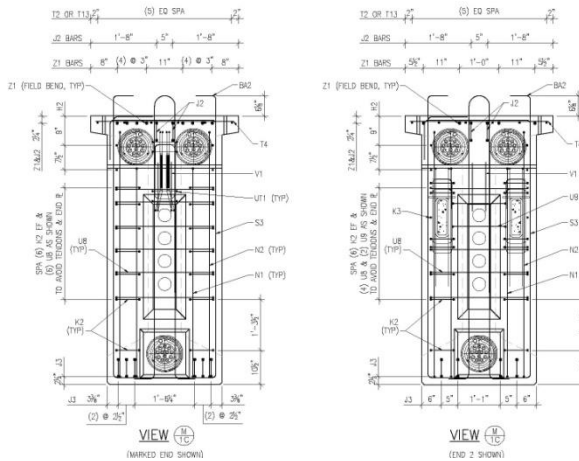


Spliced Precast Bulb Tee Girder Bridges

Design

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



Precast Girder Erection



2013/07/21 21:23



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



Spliced Precast Bulb Tee Girder Bridges

Bridge Completed in 2012



Dallas Horseshoe Bridges over the Trinity River Dallas, Texas



Spliced Precast Bulb Tee Girder Bridges

Dallas Horseshoe Bridges over the Trinity River, Dallas, Texas

Twin 1200' span Arches support pedestrian bridges on either side of the project



Spliced Precast Bulb Tee Girder Bridges



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



Construction Progress
Photos



Precast Girder and Arch Bridge Construction



Spliced Precast Bulb Tee Girder Bridges

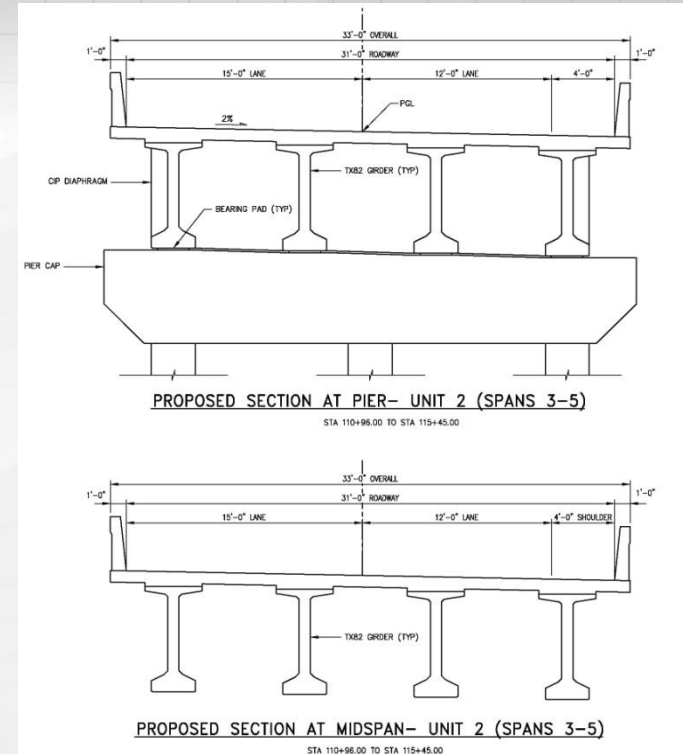
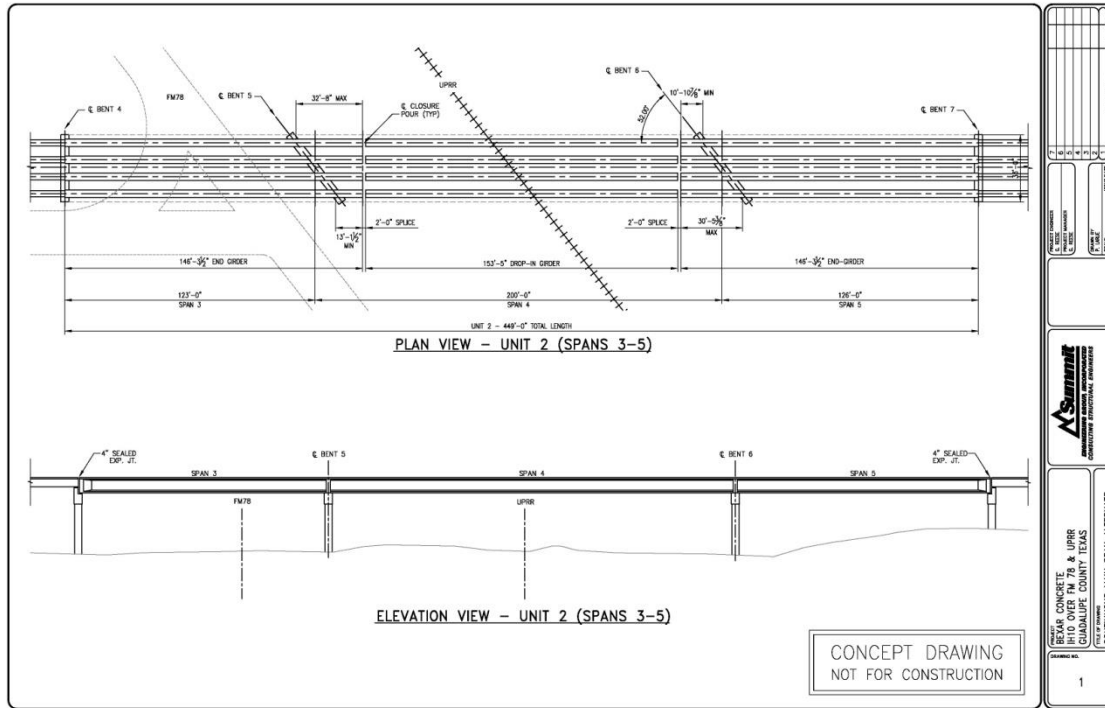
Project Scheduled for Completion in 2017



Spliced Precast Bulb Tee Girder Bridges

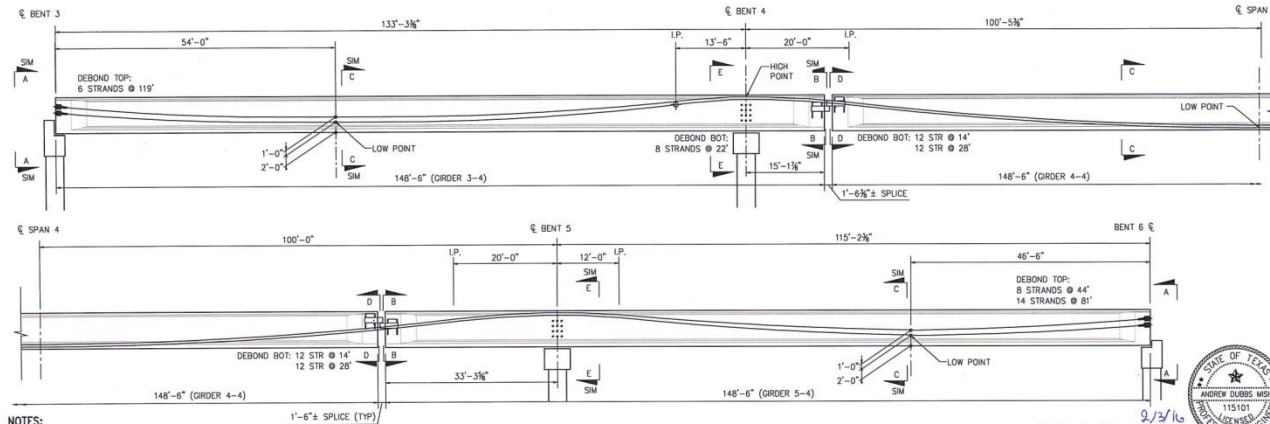
New Bridge Design – Seguin Texas

Precaster Initiated Alternate Design



**123', 200', 126 Simple Span arrangement converted to
3 span continuous unit using existing TXB2 forms
All Girders are Constant Length and Depth**

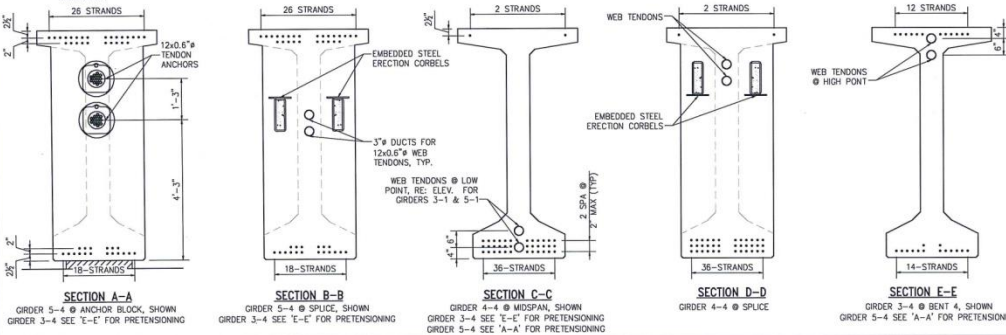
Post Tensioning Layout



NOTES:

1. RE: SHEET 646A FOR PRESTRESSING, POST TENSIONING, AND BEARING DATA.
2. DEBOND PRETENSIONING STRANDS STARTING WITH THE UPPER LAYERS OF BOTTOM FLANGE AND BOTTOM LAYER OF TOP FLANGE. DEBOND OUTSIDE STRANDS FIRST, WORKING SYMMETRICALLY INWARD TOWARD THE CENTER OF GIRDER.
3. RE: SHEET 626A FOR NOTES ON PRESTRESSING AND POST TENSIONING.

ELEVATION VIEW - GIRDER LINE 4



SUBMITTED FOR APPROVAL
10-03-16
NOT FOR CONSTRUCTION

NOTE: SEE SHEET 627 FOR ALTERNATE DESIGN NOTES

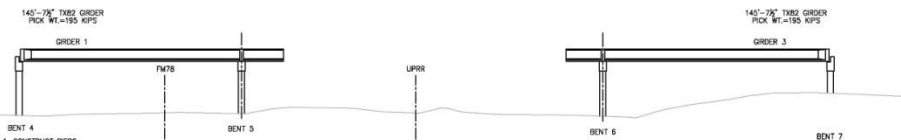
NO.	DATE	REVISION	APPROVE
<p>Summit ENGINEERING GROUP, INCORPORATED CORPORATE STRUCTURAL ENGINEERS TEMA REGISTERED ENGINEERING FIRM # 016</p>			
<p>TEXAS DEPARTMENT OF TRANSPORTATION</p> <p>IH 10 WB FLYOVER UPRR OVERPASS UNIT 2 - GIRDER LINE 4 PRESTRESSING LAYOUT</p>			
FIG. NO. 6	PROJECT NO. C 535-1-72	SHEET NO. 646	
STATE TEXAS	DIST. SAT.	COUNTY QUADALUPE	
CONTRACT 0535	SECTION 01	SHEET 072	HIGHWAY NO. IH 10

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.

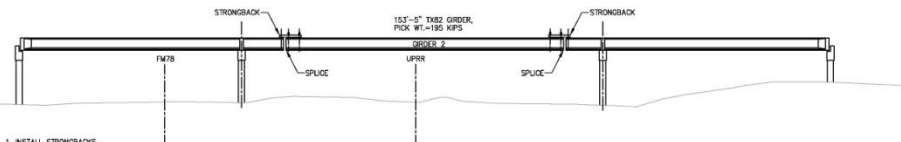
Spliced Precast Bulb Tee Girder Bridges

Construction Sequencing

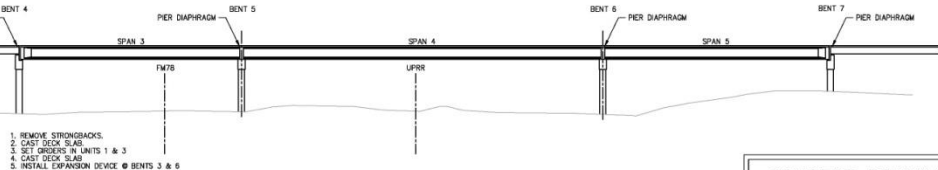
End Girders Set on Piers, Drop In Girders Set on Erection Corbels
No Shoring Required



STAGE 1 ERECTION

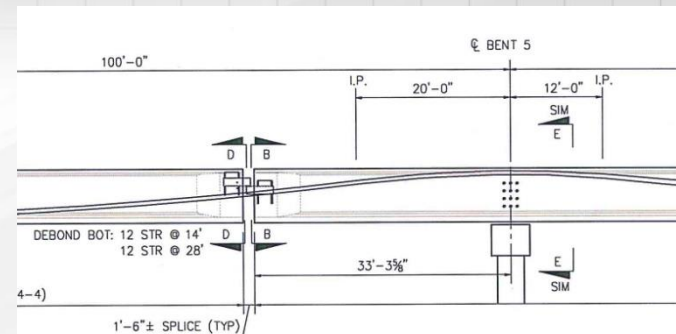


STAGE 2 ERECTION

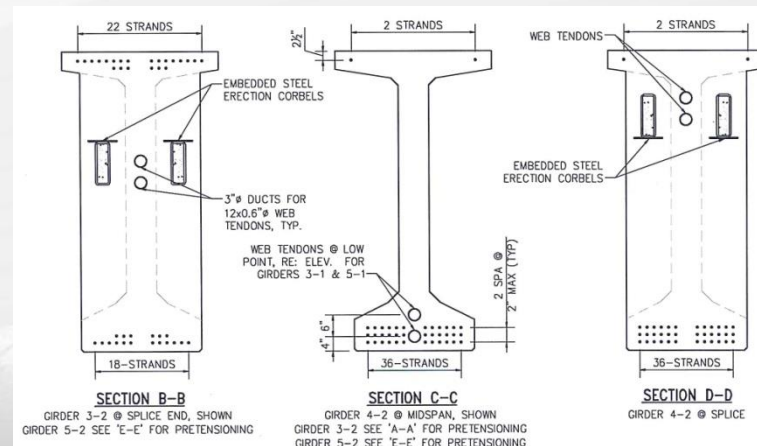


COMPLETED STRUCTURE

CONCEPT DRAWING
NOT FOR CONSTRUCTION



Erection Corbels Details at Splices



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.

