CONCRETE SPLICED GIRDERS IN TEXAS

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What is a “Concrete Spliced Girder”?
What is a “Concrete Spliced Girder”? 

What it is **NOT** : Continuous For Live Load
What is a “Concrete Spliced Girder”? 

Hybrid of 2 existing structure types

- Prestressed Beam  
  – Span Lengths 50’ to 150’

- Segmental  
  – Span Lengths > 300’
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Similarities to Prestressed Beam

- Precast Sections
- Prestressed (strands or tendons)
- Similar shapes
- Similar deck construction (PCP and CIP top)
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Differences to Prestressed Beam

- Post Tensioning Tendons in the web
- Continuous over multiple spans
- Both flanges (top and bottom) experience tension and compression
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Similarities to Segmental

- Precast Sections
- Continuity Tendons
- Continuous over multiple spans
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Differences to Segmental

- Longer Precast Sections
- Fewer Precast Sections
- Includes multiple girder lines (structural redundancy)
- Replaceable deck
What is a “Concrete Spliced Girder”? 

- 2 or more precast concrete beam sections
- Cast in place splices
- Post tensioned with full length continuity tendons
- Final Condition → Fully Continuous Concrete Girder
What is a “Concrete Spliced Girder”? 
What is a “Concrete Spliced Girder”? 

- Precast Sections
What is a “Concrete Spliced Girder”?

- Precast Sections
- Cast in Place Splices
What is a “Concrete Spliced Girder”?

- Precast Sections
- Cast in Place Splices
- Continuity Tendons
APPLICABILITY AND ADVANTAGES:

- Provide an option for spans in the 150’ to 300’ range
- Provide an alternative to steel
- Straight or horizontally curved alignments
- Fast
- Uses (combines) current construction techniques
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TYPICAL SECTIONS:
TYPICAL SECTIONS:

I-Section

U-Section
I-SECTION: Uses

- Max Span (Main Span) Length → 300’ to 325’ (Haunched)
I-SECTION: Uses

- Max Span (Main Span) Length $\rightarrow$ 300’ to 325’ (Haunched)

- Max Span (Main Span) Length $\rightarrow$ 225’ to 275’ (Constant Depth)
I-SECTION: Uses

- Horizontally Straight Alignments
I-SECTION: Uses

- Horizontally Straight Alignments
- Skewed or Normal Bents
  - Limit skew angle if possible. Same issues with skew as with any other superstructure type
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- Phased Construction
I-SECTION: Uses

- Horizontally Straight Alignments
- Skewed or Normal Bents
  - Limit skew angle if possible. Same issues with skew as with any other superstructure type
- Phased Construction
- Useful on projects that do not allow for shore towers in the main span
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I-SECTION: Construction Process

- Step 1: Set Back Span Sections
I-SECTION: Construction Process

- Step 1: Set Back Span Sections
- Step 2: Set Pier Sections
I-SECTION: Construction Process

- Step 1: Set Back Span Sections
- Step 2: Set Pier Sections
- Step 3: Cast Anchorage Blocks, Splices, and Diaphragms.
I-SECTION: Construction Process

- Step 1: Set Back Span Sections
- Step 2: Set Pier Sections
- Step 3: Cast Anchorage Blocks, Splices, and Diaphragms.
- Step 4: Set Drop In Span Section
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I-SECTION: Drop In Span Section
I-SECTION: Drop In Span Section

- **Strong Back**
  - Advantage: Simple
  - Disadvantage: Additional Weight
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I-SECTION: Drop In Span Section

- **Hanger System**
  - Advantage: No Additional Weight
  - Disadvantage: Complicates Details, Larger Moment Arm
I-SECTION: Drop In Span Section

From a DESIGN STANDPOINT ➔

Preference is to specify a Strong Back
I-SECTION: Drop In Span Section

From a DESIGN STANDPOINT→
Preference is to specify a Strong Back
– Allow contractor to develop details to incorporate a hanger system if he/she chooses.
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I-SECTION: Construction Process

- Step 1: Set Back Span Sections
- Step 2: Set Pier Sections
- Step 3: Cast Anchorage Blocks, Splices, and Diaphragms.
- Step 4: Set Drop In Span Section
I-SECTION: Construction Process

- Step 1: Set Back Span Sections
- Step 2: Set Pier Sections
- Step 3: Cast Anchorage Blocks, Splices, and Diaphragms.
- Step 4: Set Drop In Span Section
- Step 5: Cast 2nd Splices and Stress Continuity Tendons
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I-SECTION: Construction Process

- Step 1: Set Back Span Sections
- Step 2: Set Pier Sections
- Step 3: Cast Anchorage Blocks, Splices, and Diaphragms.
- Step 4: Set Drop In Span Section
- Step 5: Cast 2\textsuperscript{nd} Splices and Stress Continuity Tendons
- Step 6: Place Precast Concrete Panels (PCP) and Cast Deck
I-SECTION: Construction Process

- Step 1: Set Back Span Sections
- Step 2: Set Pier Sections
- Step 3: Cast Anchorage Blocks, Splices, and Diaphragms.
- Step 4: Set Drop In Span Section
- Step 5: Cast 2\textsuperscript{nd} Splices and Stress Continuity Tendons
- Step 6: Place Precast Concrete Panels (PCP) and Cast Deck

Place PCP’s across entire unit prior to casting deck. Helps to reduce deck stresses due to staged pouring.
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I-SECTION (Constant Depth)
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I-SECTION (Constant Depth)

- 10” Web
I-SECTION (Constant Depth)

- 10” Web
- 4” Top Flange (Depth)
I-SECTION (Constant Depth)

- 10” Web
- 4” Top Flange (Depth)
- 60” Top Flange (Width)
I-SECTION (Constant Depth)

- 10” Web
- 4” Top Flange (Depth)
- 60” Top Flange (Width)
- 40” Bottom Flange (Width)
CONCRETE SPLICED GIRDERS IN TEXAS

I-SECTION (Constant Depth)

- 10” Web
- 4” Top Flange (Depth)
- 60” Top Flange (Width)
- 40” Bottom Flange (Width)
- 80 Pretensioning Strands Available
  - Debond as needed
CONCRETE SPLICED GIRDERS IN TEXAS

I-SECTION (Constant Depth)

- 10” Web
- 4” Top Flange (Depth)
- 60” Top Flange (Width)
- 40” Bottom Flange (Width)
- 80 Pretensioning Strands Available
  - Debond as needed
- 4 Continuity Ducts
  - 19 ~ 0.6 Strand Tendons
I-SECTION (Constant Depth)

- 10” Web
- 4” Top Flange (Depth)
- 60” Top Flange (Width)
- 40” Bottom Flange (Width)
- 80 Pretensioning Strands Available
  - Debond as needed
- 4 Continuity Ducts
  - 19 ~ 0.6 Strand Tendons
- Depth → Varies
  - 7 Ft, 8 Ft, 9 Ft
I-SECTION (Constant Depth)

- Section weight between 1,500 lbs/ft → 1,850 lbs/ft

- Segment Length = 140 ’
  - Segment weight 105 Tons - 130 Tons
I-SECTION (Constant Depth)

- Section weight between 1,500 lbs/ft → 1,850 lbs/ft

- Segment Length = 140 ‘
  - Segment weight 105 Tons - 130 Tons

Max Span Length is the result of the shipping, lifting, shore tower availability, site conditions.
I-SECTION (Haunched)

- Dimensions are same as Constant Depth
I-SECTION (Haunched)

- Dimensions are same as Constant Depth
- Overall Height varies linearly
  - Max height is 16’
I-SECTION (Haunched)

- Dimensions are same as Constant Depth
- Overall Height varies linearly
  - Max height is 16’
- Bottom Flange Thickness varies
I-SECTION (Haunched)

- Dimensions are same as Constant Depth
- Overall Height varies linearly
  - Max height is 16’
- Bottom Flange Thickness varies
- Max Segment Length is 90’ to 120’
  (weight governs)
I-SECTION (Splice)
I-SECTION (Splice)

Uniform Cross Section
I-SECTION (Splice)

Uniform Cross Section

Disadvantages:

- More detailed form work
I-SECTION (Splice)

Uniform Cross Section

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- More detailed form work
- Small tolerance for duct misalignment
I-SECTION (Splice)

Uniform Cross Section

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- More detailed form work
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- Less clearance for plastic duct couplers
I-SECTION (Splice)

Uniform Cross Section

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- Less clearance for plastic duct couplers
- Potential for poor consolidation in bottom flange
I-SECTION (Splice)

Uniform Cross Section

Disadvantages:

- More detailed form work
- Small tolerance for duct misalignment
- Less clearance for plastic duct couplers
- Potential for poor consolidation in bottom flange
- Using a “stinger” is difficult, could easily damage ducts
I-SECTION (Splice)

Uniform Cross Section

Advantages:
I-SECTION (Splice)

Uniform Cross Section

Advantages:
- Smooth appearance
I-SECTION (Splice)

Tapered Web Width
I-SECTION (Splice)

Tapered Web Width

Advantages:

- Simple form work
- More room for alignment errors
- “Stinger” can be used (with care)
- More room for plastic couplers
I-SECTION (Splice)
Tapered Web Width
Advantages:

- Simple form work
- More room for alignment errors
- “Stinger” can be used (with care)
- More room for plastic couplers
- Higher probability of a quality splice
I-SECTION (Splice)

Tapered Web Width

Disadvantages:

- Increased lifting weight on precast section
- More detailed forming in the precast yard
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I-SECTION (Splice)

Tapered Web Width

Disadvantages:

- Increased lifting weight on precast section
- More detailed forming in the precast yard
- Produces a visible “knuckle”
U-SECTION: Uses

- Max Span (Main Span) Length → 265’ to 280’
U-SECTION: Uses

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- Can be used on Horizontally Curved Alignments
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- Larger girder spacing (>20’) resulting in fewer girder lines
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- Can be used on Horizontally Curved Alignments
- Larger girder spacing (>20’) resulting in fewer girder lines
- Require (typically) shore towers in the main span
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U-SECTION: Uses

- Max Span (Main Span) Length → 265’ to 280’

- Can be used on Horizontally Curved Alignments

- Larger girder spacing (>20’) resulting in fewer girder lines

- Require (typically) shore towers in the main span

- May require additional construction steps, compared to I-Section
U-SECTION: Construction Process ➔ Potential Additional Steps
U-SECTION: Construction Process ➔ Potential Additional Steps

- Additional Post Tensioning Stages
  - Splices located away from inflection points (due to shorter precast lengths) ➔ Additional Bottom Tendons
  - Constant section depth, requires post tensioning above piers ➔ Additional Top Tendons
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U-SECTION: Construction Process ➔ Potential Additional Steps

- Cast a Lid Slab prior to stressing Continuity Tendons
  - Required when used on horizontal alignment
  - Creates a “closed box”, which can handle the torsion induced by the curvature
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U-SECTION: Construction Process ➔ Potential Additional Steps

- Requires an Internal Diaphragm
  - Diaphragm is constructed with an access hole for future (potentially) internal inspections
U-SECTION (Typical)
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U-SECTION (Typical)

- 10” Web
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U-SECTION (Typical)

- 10” Web
- 8 Continuity Tendons
U-SECTION (Typical)

- 10” Web
- 8 Continuity Tendons
- Bottom Tendons
  (could be pretension strands)
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U-SECTION (Typical)

- 10” Web
- 8 Continuity Tendons
- Bottom Tendons (could be pretension strands)
- 6’, 7’ and 8’ depths
U-SECTION (Typical)

- Section weight between 2,100 lbs/ft → 2,800 lbs/ft

- Segment Length = 90‘
  - Segment weight 95 Tons - 130 Tons
U-SECTION (Splice)
U-SECTION (Splice)

- Increased Web Width
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U-SECTION (Splice)

- Increased Web Width
- Increased Bottom Flange Thickness
U-SECTION (Splice)

- Increased Web Width
- Increased Bottom Flange Thickness
- Continuous Top Flange
U-SECTION (Splice)

- Increased Web Width
- Increased Bottom Flange Thickness
- Continuous Top Flange
- Shear Keys in Webs
RESEARCH

- 0-6651, “Continuous Prestressed Concrete Girder Bridges”, TTI
- 0-6652, “Spliced Texas Girder Bridges”, CTR
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RESEARCH

- 0-6651, “Continuous Prestressed Concrete Girder Bridges”, TTI

  - Synthesis study of industry practice, casting, transportation and construction
  - Analysis of the “modified” Tx70 and U54 girders for a range of main span lengths
  - Practical limits for the girders
  - Failure mechanisms for splices at various moment/shear combinations
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RESEARCH

- 0-6652, “Spliced Texas Girder Bridges”, CTR
  - Comparison of steel vs plastic duct on shear capacity
  - Shear capacity of the cast in place splice with the presence of the plastic couplers
ENGINEERING SOFTWARE

– Stage construction, removal/addition of supports, composite properties, pretensioning/post tensioning modeling, time dependent effects (ADAPT, RMBRIDGE, MIDAS, etc)