Steel Bridge Fabrication
A Virtual Shop Tour

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Outline

• Plate Girder Design
• Building a Girder Bridge
  – How we do it know
  – How we want to do it in the future
Modular Design
Crane and Wrenches Required for Assembly
No Post Tensioning Required
Plate Girder
3 plates: 2 flanges plus a web
Strong and Ductile
Plate Girder Design

• No List of Properties Like a Rolled Beam
• Designer Starts with a Clean Sheet of Paper
  – Develop Custom Designed Section
  – Typically Deeper and Thinner Webs Than Rolled Beam
  – Deeper Sections - Stronger and Stiffer
  – Choice of Steel Strengths
  – Not Symmetric, Composite Design-Deck Used as Compression Flange
Girder Dimension Requirements
Positive Moment

• **Top Compression Flange**
  – Non Composite Construction and Deck Casting Controls Design
  – Limit States
    • Lateral Torsional Buckling (flange lateral stiffness)
    • Yielding or Local Buckling of Flange (b/2t_f)

• **Web**
  – Shear at Pier
  – Web Bend Buckling (2Dc /tw)

• **Bottom Flange- Yielding**
Typical Girder Proportions

- Span/Depth = 25-30
- $D / t_w \leq 120$, $2D_c / t_w \leq 137$
- Compression Flange
  - $\frac{1}{4} > b_f / D > \frac{1}{6}$
  - $b_f / 2t_f \leq 12 < 9.2$ for 50 ksi
  - $A_{f\;\text{top}} \sim 2/3 \; A_{f\;\text{bottom}}$
- Transverse Stiffeners only as Required

Span = 200 ft.

D = 6.7-8 ft.

$t_w = 7/8$ in.

$b_f = 24$ in.

$t_f = 1.25$ in.
Optimal Fabrication Capacities

• Standard
  Up to 120” Girders depths with parallel Flanges
  Up to 144” Haunched Girders

• Conditional
  Up to 168” with State permission for Girder lay down during shipment
Building a Girder
Raw Material

Longest Plate
80 feet
Mill Lead Times

- A572 gr. 50 & A588 = 4 to 8 weeks
- HPS 70W = 4 to 10 weeks
- Rolled beams = 3 to 8 weeks
Raw Material
Flange Plates Spliced
Weld Preparation
Multi Pass Submerged Arc Welding
Turn Over Plate
Back Gouge Weld Root and Weld Back Side
Slabbing of Welds:
2 Welds for 5 Flanges

1. Weld Flange Plates
2. Strip out Flanges on Cutting Bed
Cutting and Drilling
North Carolina Shop
16.75 ft. x 165 ft. bed

2-48 HP Drill Heads
12 tool Changer station

Plasma Automated Contour Bevel Cutting System

6-Oxy-Fuel Torch Stations
48 horsepower Drill Heads
3 second holes
Assemble the Plates to Form Girder
Camber Cut Into Web
Welding the Flange to the Web

Weld Both Sides at Once

Welding Head and Preheat Torches
Stiffener Dart Welding
Tub (Box) Girders Hand Assembled

Flanges and Connection Plates Welded to Web

Cross Frames Used to Control Box Geometry
In Process Inspection
Heat Curved to Match Road Geometry
Girder Lay Down to Fit Field Splices
Flange Splice
Web Splice

Too Many Bolts!
Match Drill Flanges and Webs Using Splice Plate for Template

1. Fabricate Splice Plates
2. Lay Down Girders
3. Clamp Plates to Girders
4. Match Drill
Completed Girder Ready for Paint

Field Splice
92 bolts in each web
32 bolts each flange
Total 312 bolts
936 holes
Tub Girder Ready For Shipping

Field Splice
36 each top flange
80 bolts in each web
85 bolts bottom flange
634 bolts
1,902 holes
The Future

- Drill Holes in the Flat
- Automated NC Equipment Can Cut and Drill Plates in One Operation
- Result is Accurate Location of Holes on Plate Elements
- Weld Plates Together to Form Girders
- Accurately Measure Girders to Determine As Built Geometry
- Drill Splice Plates to Provide Desired Girder Alignment
The Savings

• Reduced Material Handling-Drilling and Cutting in One Operation
• Speed- Hole Drilling About 10 times faster (3 seconds a hole)
• No Girder Lay Down Required (Girders can be fabricated in separate shops)
Equipment and Capabilities Required

• Accurate and Fast Cutting and Drilling Operation
• Accurate Measurement of Fabricated Girders
Laser Measurement of Girders

• Scanners- Virginia Pooled Fund Study
  – TPF-5(226) Instrumentation to Aid in Steel Bridge Fabrication
  – Paul Fuchs and Bill Wright Investigators

• Develop a 3 Dimensional Laser Scanner System to Measure Large Girder Sections
  – 150 foot long pieces
  – Accuracy of 0.01 in. or better
  – Output Geometry of Girder and Location of Splice Holes
Measure Girder Fabricated From Drilled Plates
Tenn DOT Bridge Job

830 ft
Measurements in Shop
Virtual Assembly Software
QA/QC: Web Panel Measurements
Integrated System

• Full 3 Dimensional Model of Bridge
  – Detailing for Camber and Weld Shrinkage Must be Considered
  – Drill flanges and webs in the flat on cutting table.

• Three Dimensional Measurement System
  – Bonus: Computerized checking of dimensions by comparing measurements with solid model

• Use Girder Measurements and Model Dimensions to Detail Splice Plates

• Splice Plates Drilled on NC Equipment
Good Design of Simple Bridge
A New Day Another Bridge