Bridge Welding

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Welded Bridge Elements

Greenfield Bridge
Field Welding

- Excellent flexibility
- Nice aesthetics
- NB: welding takes time
- Skilled welder availability
Three Keys to Successful Welded Bridges

- **Strength and fatigue**: proper design for weld strength and fatigue performance (AASHTO LRFD)
- **Quality**: achieve proper weld quality when making welds
  - Mechanical properties
  - Soundness
- **Constructability**: improve constructability for better designs
  - Cost-effective details
  - Access
  - Clear communication of intent

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**Welding**

molten electrode

molten base metal
Electric Spark

Electric Arc
Arc Welding

- Base metal
- Electrode (by classification)
- Shielding (gas or flux)
- Heat input - amps, volts, & travel speed
- Arc length (stick out)
- Polarity
- Weld type (CJP, PJP, Fillet)
- Joints (when CJP or PJP)
- Position

Welding Procedures

Figure 7. Illustration. The arc welding circuit with manual electrode.
Mechanical Properties & Soundness: Proper AWS Code

- Use the right code for your application
- Check for your material

Base metals in D1.5

1.2.2 Approved Base Metals. Unless otherwise specified, base metals to be welded under this code shall meet the requirements of the latest edition of AASHTO M 270/M 270 (ASTM A709/A709M) for Grade 250 [36], 345 [50] (Type 1, 2, or 3), 345S [50S], 345W [50W], HPS 345W (HPS 50W), HPS 485W (HPS 70W), or HPS 690W (HPS 100W), as shown on the plans or described in the specifications. All Grade 345 [50] steel that is to be welded shall be Type 1, 2, or 3. Other steels may be approved by the Engineer. Thickness limitations shall not apply to bearing components.

2015 edition

Planned for 2025
- 50CR
- Tubular materials

2020 edition
Noted Features of the Bridge Code

- Bridge materials and associated electrodes
- Tolerances for typical bridges members
  - Includes plate girders and rolled beams
  - Does not address orthotropic decks or folded beams
- Non-destructive examination for bridges welds
  - RT, UT, and PAUT for groove welds
  - MT for fillet welds
- Preheat, interpass requirements and limits (hydrogen controls)
- Standard CJP and PJP joints (not needed for fillet welds)
- Special rules welding fracture critical members
  - Adding SRMs and IRMs in 2025

Non-Destructive Evaluation

- Magnetic particle testing (MT)
- Ultrasonic Testing (UT)
- Radiographic Testing (RT)
Phased Array UT (PAUT)

Weld Constructability - Weld Type

<table>
<thead>
<tr>
<th></th>
<th>Fillet</th>
<th>PJP</th>
<th>CJP</th>
</tr>
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<tbody>
<tr>
<td>Prep surface</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bevel</td>
<td>5</td>
<td>5</td>
<td></td>
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<tr>
<td>Fit</td>
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<td>2</td>
<td>2</td>
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<tr>
<td>Tack</td>
<td>1</td>
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<tr>
<td>Preheat</td>
<td>2</td>
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<td>2</td>
</tr>
<tr>
<td>Weld</td>
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<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Backgouge</td>
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<td></td>
<td></td>
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<tr>
<td>Back grind</td>
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</tr>
<tr>
<td>Weld</td>
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<td>8</td>
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<tr>
<td>NDE</td>
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<td>Total</td>
<td>11</td>
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<tr>
<td>Rough effort factor</td>
<td>x2</td>
<td></td>
<td>X10</td>
</tr>
</tbody>
</table>
Weld Constructability - Access

Height + 3”

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Weld Constructability

Orient thickness transitions “out” of the web

Generally, use thickness transitions instead of width transitions

Align transitions

PREFERRED
Flange Thickness Transitions

AVOID
Flange Width Transitions

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Weld Constructability – PJP versus Fillet Weld

Weld types
• CJs v PJPs v fillet welds
• Target single pass fillet welds
• Consider PJPs and PJP/fillet combinations

Weld Constructability – Bearing Stiffeners

Bearing stiffeners
• Avoid CJP
  • Use finish-to-bear (aka mill-to-bear) with fillet welds
• Avoid multiple bearings stiffeners
  • Use partial-depth jacking stiffeners
• Use bearing stiffeners as connection plates

Use!!!
Weld Constructability – Skewed Joints

- Maximum fillet weld 60 degrees
- Then go to PJP or bent plate

FC Design Practice

Use sketches
Do address attachments
Do not designate welds

Designations
Do use grade and zone
Example: ASTM A709 grade 50W zone 2
Don’t use requirements
Example: “25 ft. lbs. at 40 degrees”
Example: “Service temp 0 F to -30 F”
Intersecting Welds

- Phantom Issue!
- Intersecting (or touching) welds are not inherently a problem – rather constraint induced fracture (CIF)
- Misperception arose from the Hoan Bridge Problem

Resources
Summary

- Welding gives steel tremendous versatility for bridges
- Usually we’re talking about arc welding
- D1.5 is the code of choice for steel bridges
  - Use of D1.5 helps ensure weld quality for typical bridge materials
  - Go to plan B if using other materials
- Achieve the best cost and schedule through constructable designs – fillet welds, access, flange splice arrangement, skewed elements
- Use sketches for FC members; designate materials and attachments but not welds
- Don’t be afraid of
  - Touching welds or
  - Field welding
- There are plenty of good resources available to help you
There is always a solution in welded steel
- Dr. Duane Miller