

Thank you for joining our live webinar today.

We will begin shortly.
Please standby. Thank you.

Need Help?
Call ReadyTalk Support:
800.843.9166

**AISC**
Night School



Welded Connections
A Primer for Engineers



**Smarter.
Stronger.
Steel.**

**AISC**
Night School

Audio Options

Today's audio will be broadcast through the internet.

Alternatively, to hear the audio through the phone, dial:

(866)-519-2796
Passcode: 254072



**Smarter.
Stronger.
Steel.**



Today's live webinar will begin shortly. Please stand by.

As a reminder, all lines have been muted. Please type any questions or comments through the chat feature on the left portion of your screen.

Today's audio will be broadcast through the internet.
Alternatively, to hear the audio through the phone, dial:

(866)-519-2796
Passcode: 254072



AIA Credit

AISC is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES). Credit(s) earned on completion of this program will be reported to AIA/CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This program is registered with AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.





Copyright Materials

This presentation is protected by US and International Copyright laws. Reproduction, distribution, display and use of the presentation without written permission of AISC is prohibited.

© The American Institute of Steel Construction 2019

The information presented herein is based on recognized engineering principles and is for general information only. While it is believed to be accurate, this information should not be applied to any specific application without competent professional examination and verification by a licensed professional engineer. Anyone making use of this information assumes all liability arising from such use.



Course Description

21.7 Special Welding Applications
December 3, 2019

This session covers atypical welding applications for buildings. The live webinar presents practical, straightforward solutions to challenging situations including: welding of steel headed stud anchors, welding on coated steels, welding AESS, welding on existing structures, welding heavy sections, welding under high restraint, field welding, heat shrinking, cold temperature applications and more.





Learning Objectives

- Describe tolerance issues that may affect welded connections in AESS structures.
- Identify welded HSS connections where member configurations could prevent proper welding, inspection or assembly.
- List considerations for welded connections on rolled heavy shapes.
- List consideration for welded connections in cold temperature applications



Smarter.
Stronger.
Steel.



Night School 21 Course Schedule

- 10/8/2019 1. Introduction and Weld Processes
10/15/2019 2. Principles of Welded Connections
10/29/2019 3. Welded Connection Details
11/5/2019 4. Metallurgy and Cracking
11/19/2019 5. Fatigue of Welded Connections
11/26/2019 6. Seismic Welding Issues
12/3/2019 7. Special Welding Applications
12/10/2019 8. Problems and Fixes



Smarter.
Stronger.
Steel.

Night School 21 Welded Connections -- A Primer for Engineers

Session 7: Special Welding Applications
December 3, 2019



Duane K. Miller, PE, ScD
Manager of Engineering Services and Welding
Design Consultant



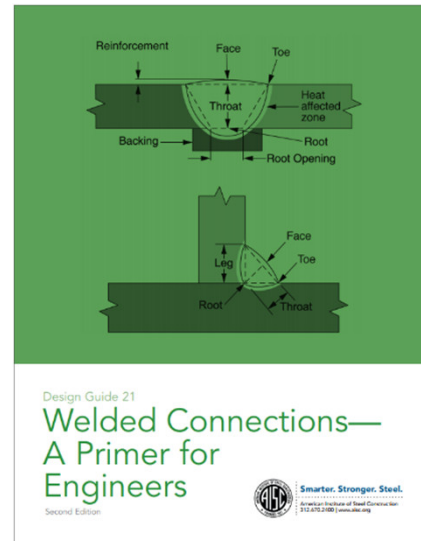
Smarter.
Stronger.
Steel.

SPECIAL WELDING APPLICATIONS



AISC Design Guide 21, 2nd Edition

Welded Connections—
A Primer for Engineers



11

SPECIAL WELDING APPLICATIONS

Chapter 14 Special Welding Applications

- 14.1 Welding of Steel Headed Stud Anchors
- 14.2 Welding on Galvanized Steels
- 14.3 Welding on Primed and Painted Steel
- 14.4 Welding on Heavy Shapes
- 14.5 Welding on Highly Restrained Members
- 14.6 Welding HSS



12

SPECIAL WELDING APPLICATIONS



- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.10 Welds and Mechanical Fasteners
- 14.11 Welding on Members to be Hot-Dip Galvanized
- 14.12 Cold Temperature Applications
- 14.13 Deck Welding



13

SPECIAL WELDING APPLICATIONS



- 14.14 Welding on In-Place Embed Plates
- 14.15 Heat Shrinking
- 14.16 Buttering



14

SPECIAL WELDING APPLICATIONS

Today's Webinar



- ➔ 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering



15



16



17



18

SPECIAL WELDING APPLICATIONS

W14x730

22 in

5 in

3 in

18 in

“Jumbo Shapes”

Welded Connections—
A Primer for
Engineers

19

AISC 360-16 SPECIFICATION

Commentary A3

1c. Rolled Heavy Shapes

The web-to-flange intersection and the web center of heavy hot-rolled shapes, as well as the interior portions of heavy plates, may contain a more coarse grain structure and/or lower notch toughness material than other areas of these products.

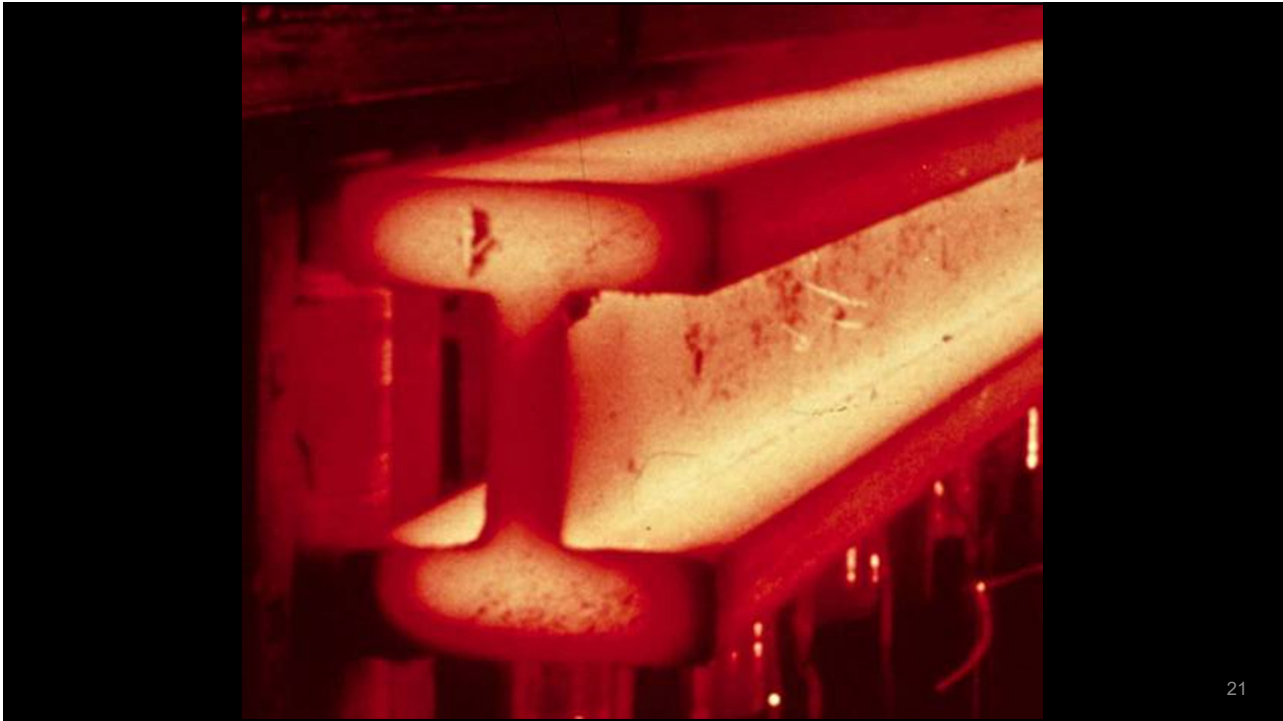
Segregation

Reduced Rolling

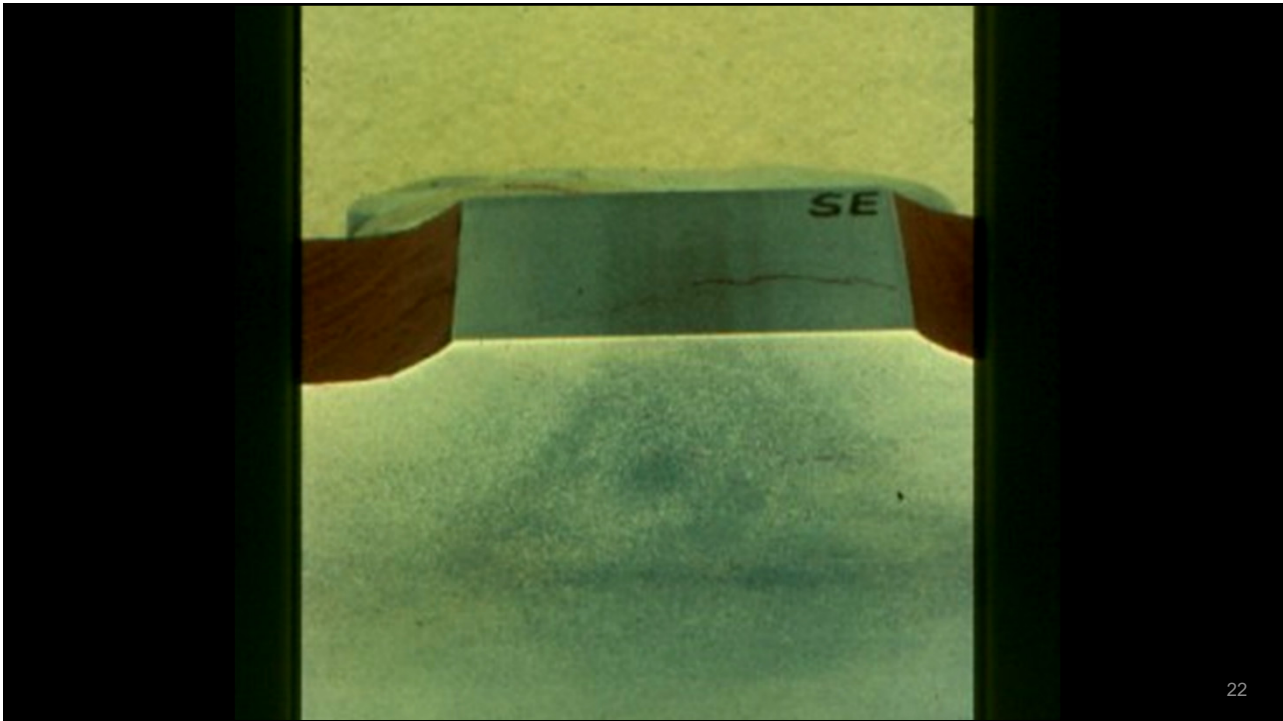
Slower Cooling

Specification
for Structural Steel Buildings

20



21



22

AISC 360-16 Specification for Structural Steel Buildings



Commentary A3

1c. Rolled Heavy Shapes

This characteristic is not detrimental to suitability for compression members or for non-welded members. However, when heavy cross sections are joined by splices or connections using complete-joint-penetration groove welds that extend through the coarser and/or low notch-tough interior portions, tensile strains induced by welding may result in cracking.



23

AISC 360-16 Specification for Structural Steel Buildings



Commentary A3

1a. ASTM Designations

Roller Steel is anisotropic, especially insofar as ductility is concerned; therefore, weld contraction strain in the region of highly restrained welded connections may exceed the strength of the material if special attention is not given to material selection, details, workmanship and inspection.

Material

Details

Workmanship

Inspection



24

AISC 360-16 Specification for Structural Steel Buildings


CHAPTER A
GENERAL PROVISIONS

Material

A3. MATERIAL

1c. Rolled Heavy Shapes

ASTM A6/A6M hot-rolled shapes with a flange thickness exceeding 2 in. (50 mm) are considered to be rolled heavy shapes. Rolled heavy shapes used as members subject to primary (computed) tensile forces due to tension or flexure and spliced or connected using complete-joint-penetration groove welds that fuse through the thickness of the flange or the flange and the web, shall be specified as follows. The structural design documents shall require that such shapes be supplied with Charpy V-notch (CVN) impact test results in



25

AISC 360-16 Specification for Structural Steel Buildings


CHAPTER A
GENERAL PROVISIONS

Material

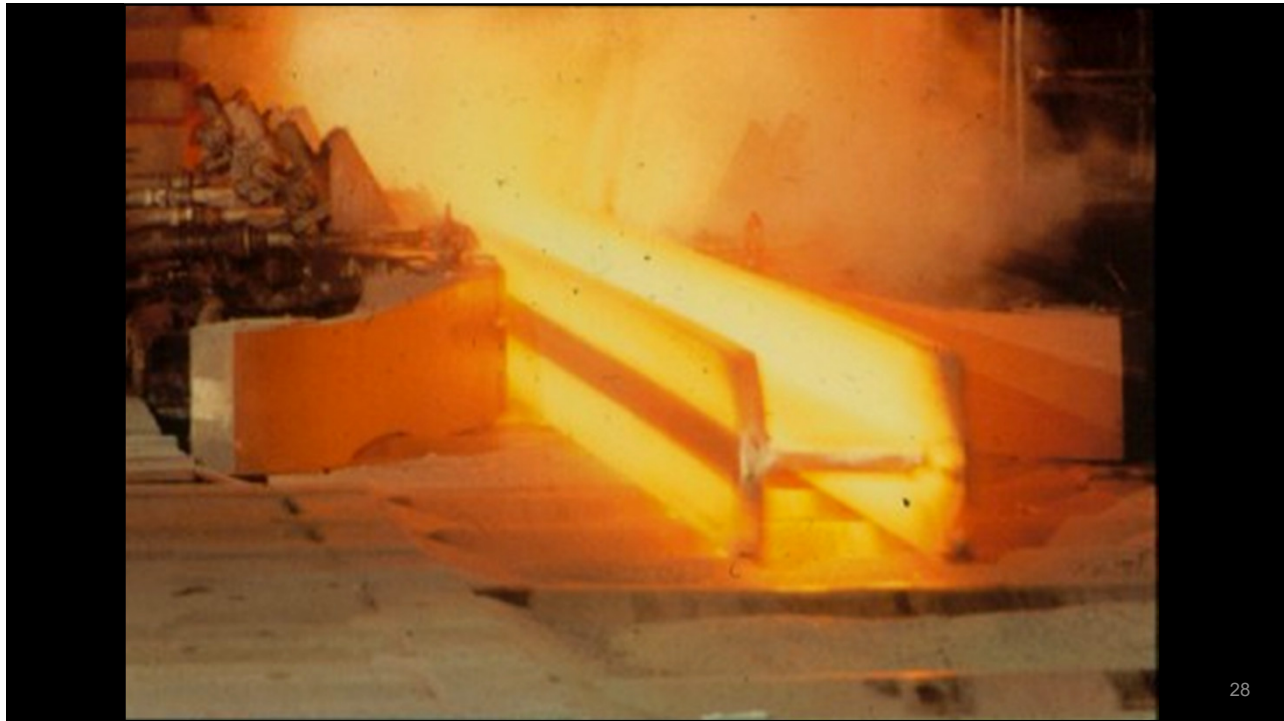
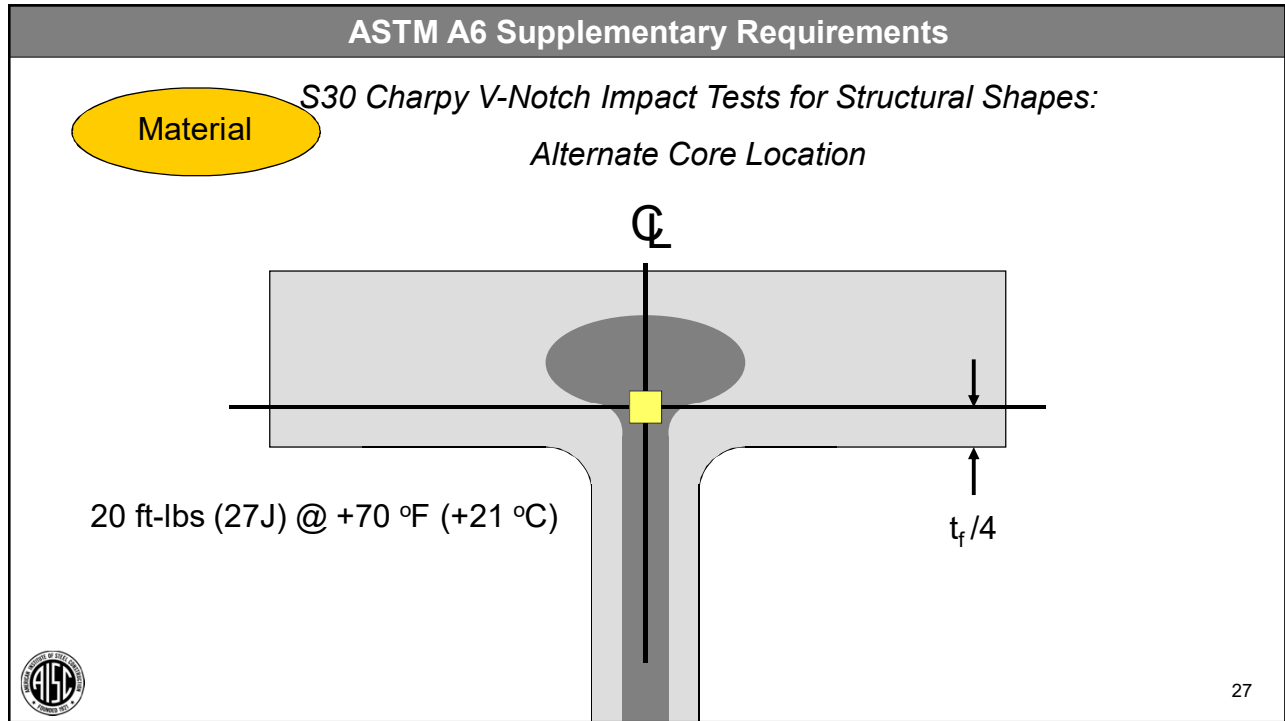
A3. MATERIAL

1c. Rolled Heavy Shapes (cont'd)

The structural design documents shall require that such shapes be supplied with Charpy V-notch (CVN) impact test results in accordance with ASTM A6/A6M, Supplementary Requirement S30, Charpy V-Notch Impact Test for Structural Shapes—Alternate Core Location. The impact test shall meet a minimum average value of 20 ft-lb (27 J) absorbed energy at a maximum temperature of +70°F (+21°C).



26



AISC 360-16 Specification for Structural Steel Buildings

CHAPTER A
GENERAL PROVISIONS

Material

A3 MATERIAL

1d. Built-Up Heavy Shapes

Built-up cross sections consisting of plates with a thickness exceeding 2 in. (50 mm) are considered built-up heavy shapes. Built-up heavy shapes used as members subject to primary (computed) tensile forces due to tension or flexure and spliced or connected to other members using complete-joint-penetration groove welds that fuse through the thickness of the plates, shall be specified as follows. The structural design documents shall require that the steel be supplied with Charpy V-notch impact test results in accordance with ASTM A6/A6M,

29

AISC 360-16 Specification for Structural Steel Buildings

CHAPTER A
GENERAL PROVISIONS

Material

A3 MATERIAL

1d. Built-Up Heavy Shapes (cont'd)


The structural design documents shall require that the steel be supplied with Charpy V-notch impact test results in accordance with ASTM A6/A6M, Supplementary Requirement S5, Charpy V-Notch Impact Test. The impact test shall be conducted in accordance with ASTM A673/A673M, Frequency P, and shall meet a minimum average value of 20 ft-lb (27 J) absorbed energy at a maximum temperature of +70°F (+21°C).

30

ASTM A6 Supplementary Requirements

S5 Charpy V-Notch Impact Test

Material



$t \geq 2 \text{ in}$

20 ft-lbs (27J) @ +70 °F (+21 °C)

For built-up cross sections


31

AISC 360-16 Specification for Structural Steel Buildings

CHAPTER J

DESIGN OF CONNECTIONS

Material



J2. 6. Filler Metal Requirements


Filler metal with a specified minimum Charpy V-notch toughness of 20 ft-lb (27 J) at 40°F (4°C) or lower shall be used in the following joints:

(a) CJP groove welded T- and corner joints with steel backing left in place, subject to tension normal to the effective area, unless the joints are designed using the nominal strength and resistance factor or safety factor, as applicable, for a PJP groove weld

(b) CJP groove welded splices subject to tension normal to the effective area in heavy sections, as defined in Sections A3.1c and A3.1d

32


AISC 360-16 Specification for Structural Steel Buildings


33


Material

J2.6 Filler Metal Requirements

20 ft-lbs (27J) @ +40 °F (+4 °C)




AISC 360-16 Specification for Structural Steel Buildings

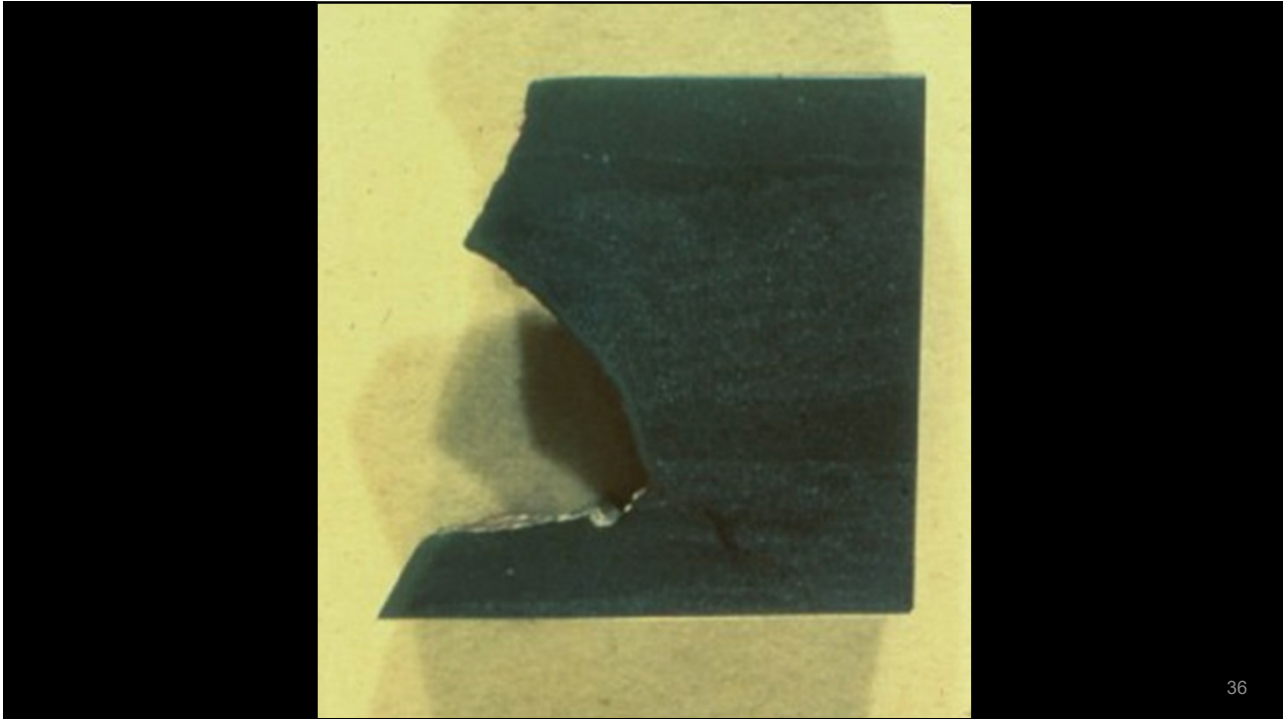
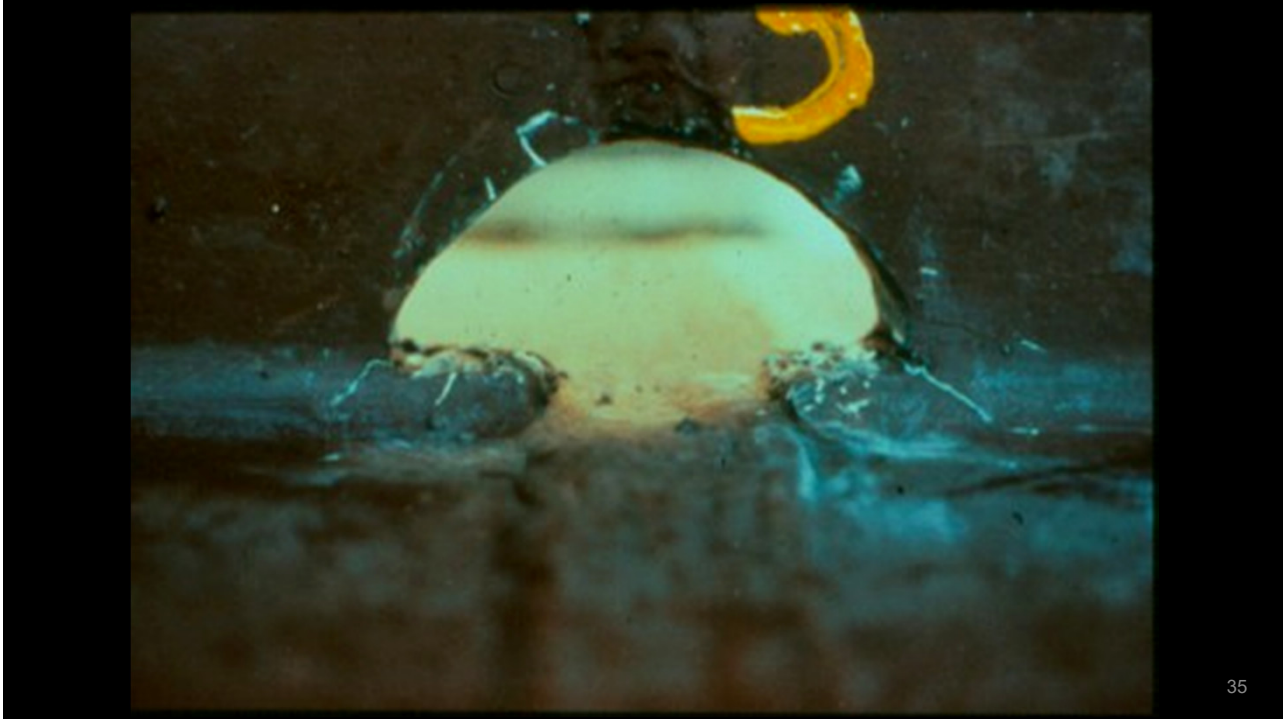

34

Commentary A3

1c. Rolled Heavy Shapes

To minimize the potential for fracture, the notch toughness requirements of Section A3.1c must be used in conjunction with good design and fabrication procedures. Specific requirements are given in Sections J1.5, J1.6, J2.6 and J2.7.





AISC 360-16 Specification for Structural Steel Buildings



Details

CHAPTER J
DESIGN OF CONNECTIONS

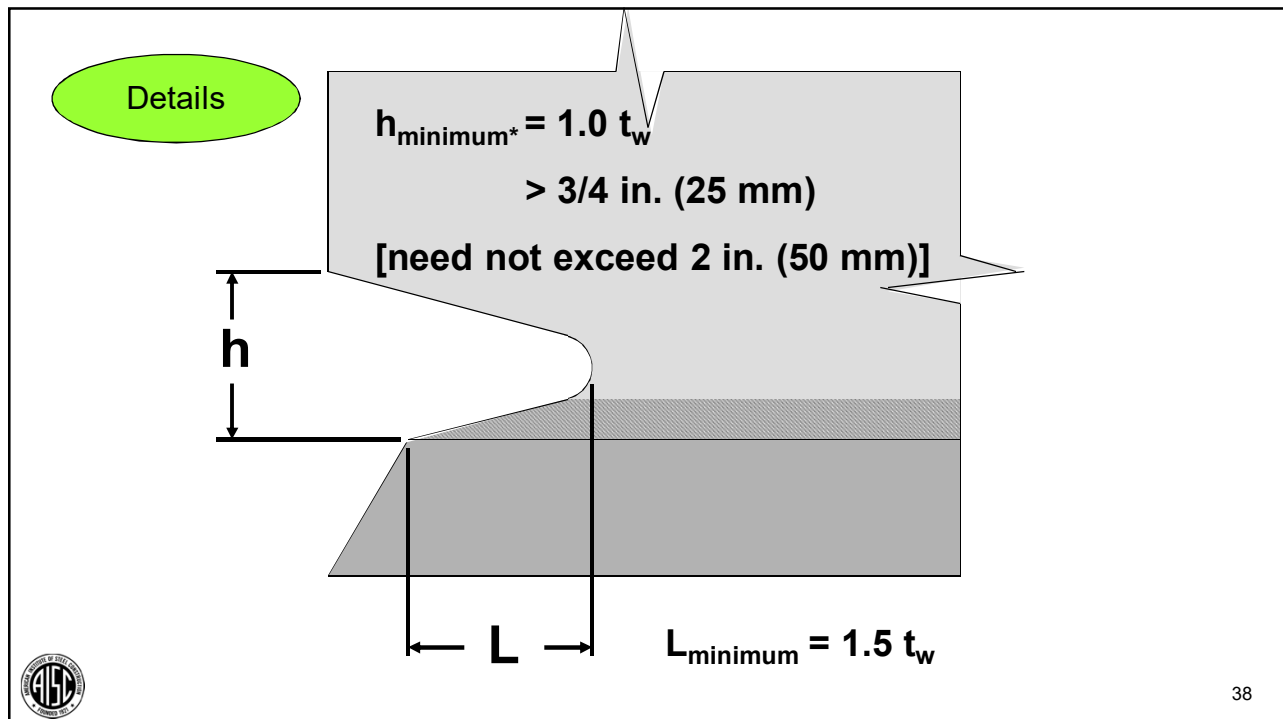
J1.6. Weld Access Holes

Weld access holes shall meet the following requirements:

(a) All weld access holes required to facilitate welding operations shall be detailed to provide room for weld backing as needed.

(b) The access hole shall have a length from the toe of the weld preparation not less than 1-1/2 times the thickness of the material in which the hole is made, nor less than 1-1/2 in. (38 mm).

(c) The access hole shall have a height not less than the thickness of the material with the access hole, nor less than 3/4 in. (19 mm), nor does it need to...³⁷





39

AISC 360-16 Specification for Structural Steel Buildings



Workmanship

CHAPTER M

FABRICATION AND ERECTION


M2.2. Thermal Cutting

For beam copes and weld access holes in which the curved part of the access hole is thermally cut in ASTM A6/A6M hot-rolled shapes with a flange thickness exceeding 2 in. (50 mm) and welded built-up shapes with material thickness greater than 2 in. (50 mm), a preheat temperature of not less than 150°F (66°C) shall be applied prior to thermal cutting. The thermally cut surface of access holes in ASTM A6/A6M hot-rolled shapes with a flange thickness exceeding 2 in. (50 mm) and built-up shapes with a material thickness greater than 2 in. (50 mm) shall be ground.



40

AWS D1.1:2015 STRUCTURAL WELDING CODE



**Table 3.3
Prequalified Minimum Preheat and Interpass Temperature (see 3.5)**

Steel Specification	Welding Process	Thickness of Thickest Part at Point of Welding		Minimum Preheat and Interpass Temperature	
		in	mm	°F	°C
ASTM A36 Grade B	SMAW with other than low-hydrogen electrodes	1/8 to 3/4 incl.	3 to 20 incl.	32 ^a	0 ^a
ASTM A572 Grade 65					
ASTM A572 Grade 50					
ASTM A709 Grade 50					
ASTM A1008 SS Grade 30					
ASTM A1011 SS Grade 30 Type 1					
ASTM A1011 SS Grade 33					
ASTM A1011 SS Grade 36 Type 1					
ASTM A1011 SS Grade 40					
ASTM A1011 SS Grade 45					
ASTM A1011 SS Grade 50					
ASTM A1011 SS Grade 55					
ASTM A1018 SS Grade 30					
ASTM A1018 SS Grade 33					
ASTM A1018 SS Grade 36					
ASTM A1018 SS Grade 40					
API 5L Grade B	SMAW with low-hydrogen electrodes, SAW, GMAW, FCAW	1/8 to 3/4 incl.	3 to 20 incl.	32 ^a	0 ^a
ASTM A36 Grade B					
ASTM A572 Grade B					
ASTM A106 Grade B					
ASTM A131 Grades A, B, CS, D, DS, E					
ASTM A131 Grades A, B, CS, D, DS, E, AH 32 & 36, DH 32 & 36, EH 32 & 36					
ASTM A139 Grade B					
ASTM A381 Grade Y35					
ASTM A441 Grade B					
ASTM A500 Grade A					
ASTM A500 Grade B					
ASTM A500 Grade C					
ASTM A501 Grades A and B					
ASTM A516 Grades 55 & 60					
ASTM A516 Grades 65 & 70					
ASTM A524 Grades 1 & 11					
ASTM A529 Grades 50 & 55					

(Continued)

Table 3.3


Prequalified Minimum Preheat/Interpass Temperatures


C
a
t
e
g
o
r
y

A


B

B
(Cont'd)





AWS D1.1:2015 STRUCTURAL WELDING CODE





Steel Specification	Welding Process	Thickness of Thickest Part at Point of Welding		Minimum Preheat and Interpass Temperature	
		in	mm	°F	°C
ASTM A808 (≥ 3/16 [2.0 mm])	SMAW with low-hydrogen electrodes, SAW, GMAW, FCAW	1/8 to 3/4 incl.	3 to 20 incl.	32 ^a	0 ^a
ASTM A913 ^b Grade 50					
ASTM A992					
ASTM A1008 HSLAS Grade 45 Class 1					
ASTM A1008 HSLAS Grade 45 Class 2					
ASTM A1008 HSLAS Grade 50 Class 1					
ASTM A1008 HSLAS Grade 50 Class 2					
ASTM A1008 HSLAS Grade 55 Class 1					
ASTM A1008 HSLAS Grade 55 Class 2					
ASTM A1008 HSLAS-F Grade 50					
ASTM A1011 HSLAS Grade 45 Class 1					
ASTM A1011 HSLAS Grade 45 Class 2					
ASTM A1011 HSLAS Grade 50 Class 1					
ASTM A1011 HSLAS Grade 50 Class 2					
ASTM A1011 HSLAS Grade 55 Class 1					
ASTM A1011 HSLAS Grade 55 Class 2					
ASTM A1011 HSLAS-F Grade 50					
ASTM A1018 HSLAS Grade 45 Class 1					
ASTM A1018 HSLAS Grade 45 Class 2					
ASTM A1018 HSLAS Grade 50 Class 1					
ASTM A1018 HSLAS Grade 50 Class 2					
ASTM A1018 HSLAS Grade 55 Class 1					
ASTM A1018 HSLAS Grade 55 Class 2					

Table 3.3

Prequalified Minimum Preheat/Interpass Temperatures

B
(Cont'd)







AISC 360-16 Specification for Structural Steel Buildings

Inspection

Commentary J1

J1.5. Splices in Heavy Sections

Previous editions of this Specification required magnetic particle or dye-penetrant inspection of thermally cut weld access holes for splices in heavy sections. This requirement was deliberately removed as anecdotal evidence suggested this inspection was not necessary because cracks from thermal cutting rarely occurred when the other Specification requirements were met. The previously prescribed magnetic particle testing or penetrant testing was replaced with a requirement for visual inspection of weld access holes after welding (see Table N5.4-3).





43

SPECIAL WELDING APPLICATIONS

Welding Heavy Sections: Summary

- Material notch toughness requirements (≥ 2 in [50 mm])
- Weld access hole geometry
- Preheat for thermal cutting, grinding
- MT and PT no longer required, but good visual needed
- Preheat for welding
- Follow other “good practices” for welding on highly restrained members

Material **Details** **Workmanship** **Inspection**



44

SPECIAL WELDING APPLICATIONS

Today's Webinar

- 14.4 Welding on Heavy Shapes
- ➔ 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering



45



SPECIAL WELDING APPLICATIONS

14.6 Welding HSS

- ➔ • Connections and HSS member size
- Overall configuration
- Cutting and preparing HSS



46


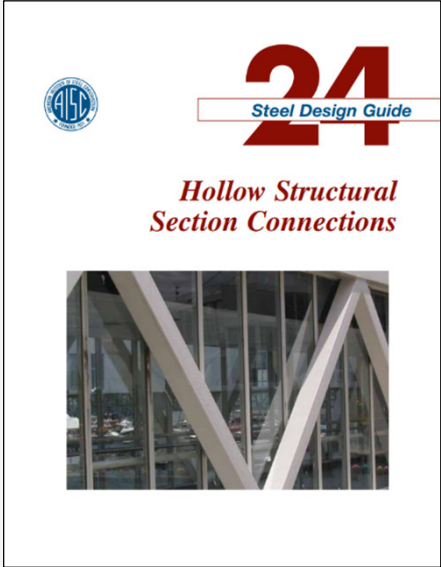


Design Guide 24

Hollow Structural Section Connections

by


Packer, Sherman, Lecce



47


Design Guide 24 Hollow Structural Section Connections

Chapter 1
Introduction



“Connections usually have been the challenging aspect for the designer of structures that involve HSS....Note that, in many cases, the local strength of the HSS at the connection is an integral part—and perhaps a limitation--of the design.”

HSS member size may need to be increased to accommodate connection design.



48

Design Guide 24 Hollow Structural Section Connections



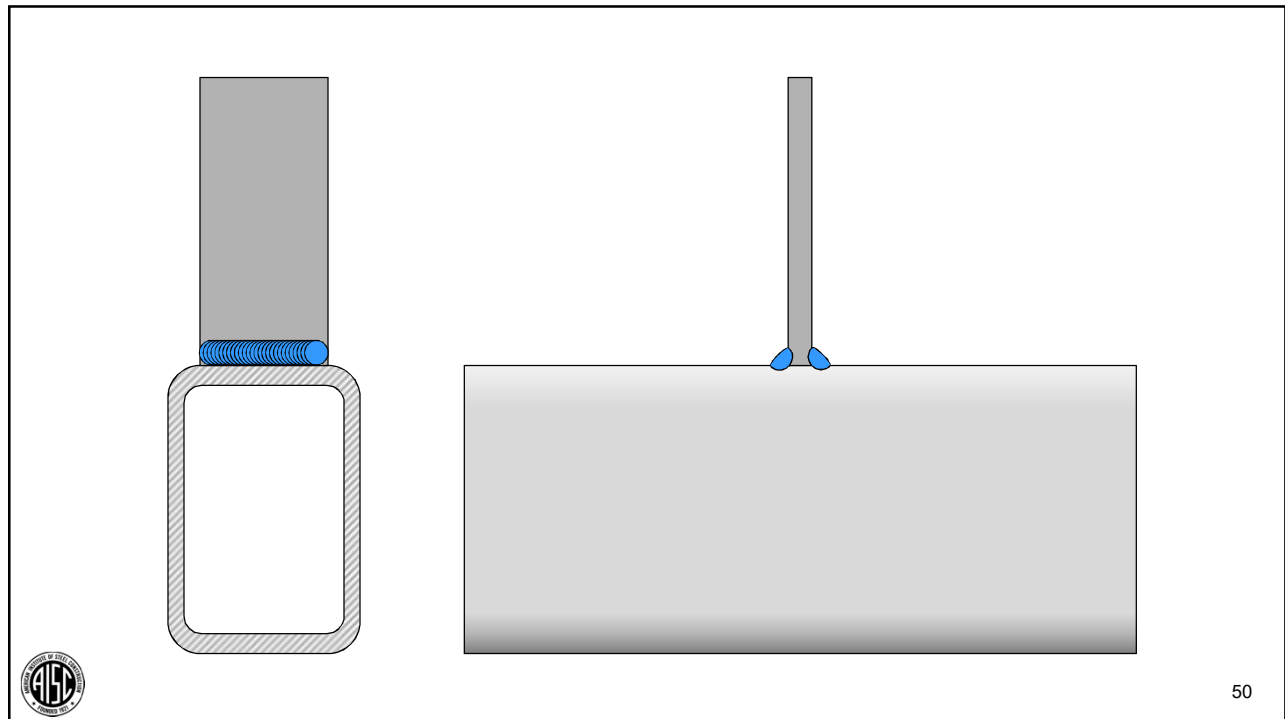
Chapter 2 Welding

2.4 EFFECTIVE WELD LENGTH

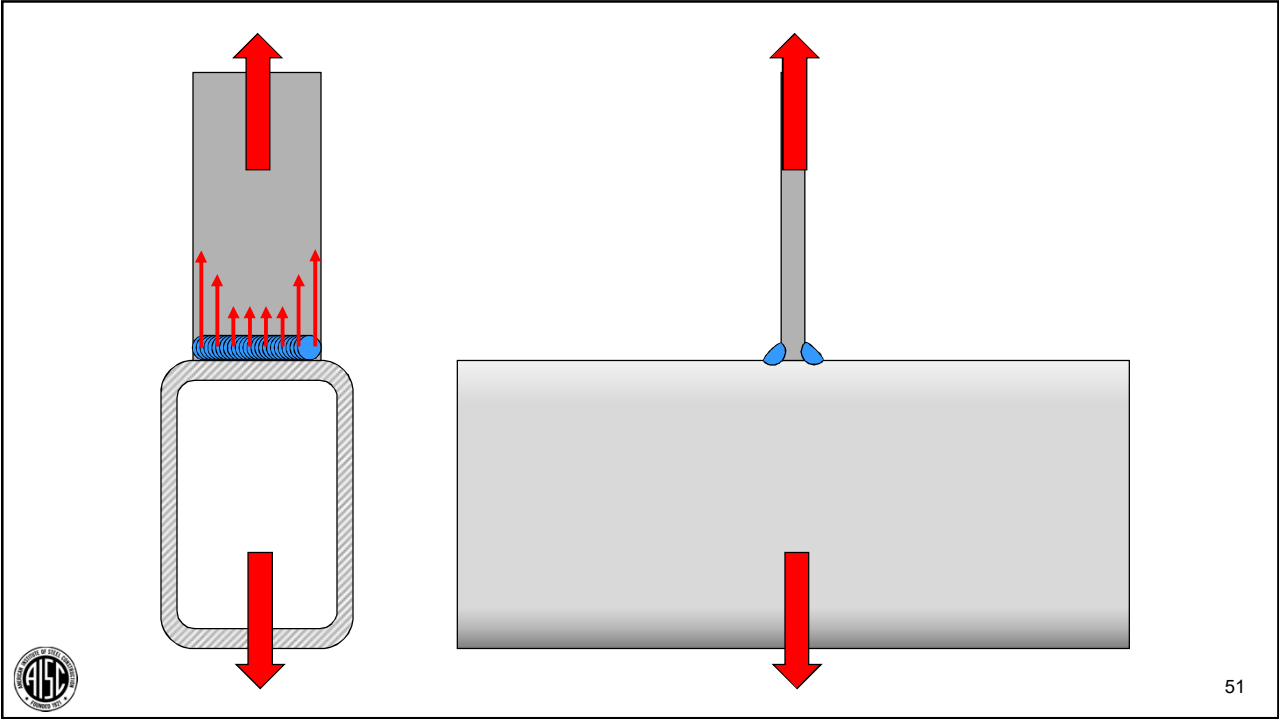
Due to the variation in flexural stiffness of the wall across the width of a rectangular HSS, a force transmitted through a weld is often not uniformly distributed. This can be accounted for in design using an effective weld length approach. This reduced effective length applies both to the weld and to the force in the connected element.

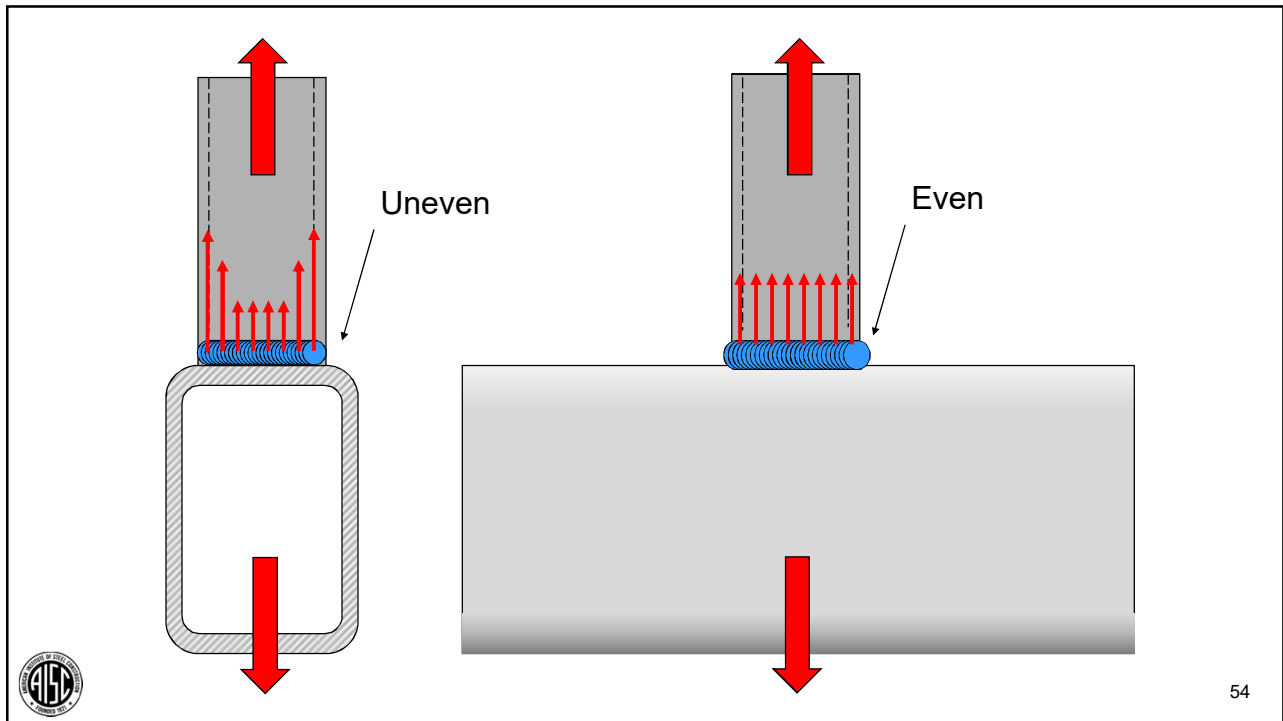
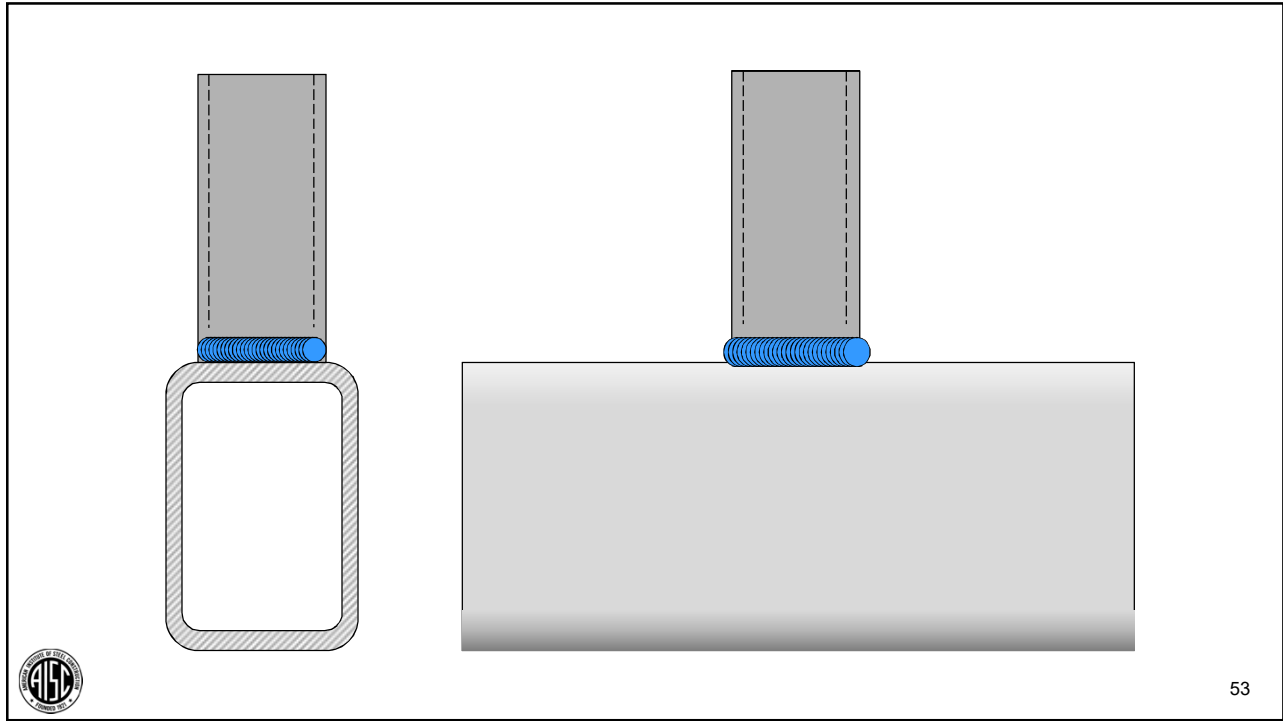


49



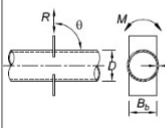
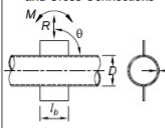
50





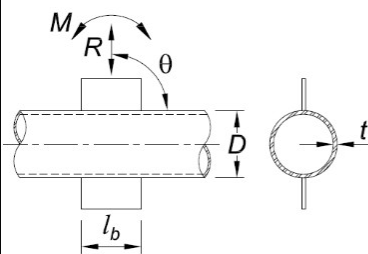
AISC 360:16 Specification for Structural Steel Buildings

TABLE K2.1
Available Strength of Plate-to-Round HSS Connections

TABLE K2.1 Available Strengths of Plate-to-Round HSS Connections		
Connection Type	Connection Available Strength	Plate Bending
Transverse Plate T- and Cross-Connections 	Limit State: HSS Local Yielding	
	Plate Axial Load	In-Plane
	$R_n \sin \theta = F_y t^2 \left(\frac{5.5}{1 - 0.81 \frac{B_p}{D}} \right) Q_f$ (K2-1a)	–
$\phi = 0.90$ (LRFD) $\Omega = 1.67$ (ASD)		
Longitudinal Plate T-, Y- and Cross-Connections 	Limit State: HSS Plastification	
	Plate Axial Load	In-Plane
	$R_n \sin \theta = 5.5 F_y t^2 \left(1 + 0.25 \frac{l_b}{D} \right) Q_f$ (K2-2a)	$M_n = 0.8 l_b R_n$ (K2-2b)
$\phi = 0.90$ (LRFD) $\Omega = 1.67$ (ASD)		
Functions $Q_f = 1$ for HSS (connecting surface) in tension $= 1.0 - 0.3U$ for HSS (connecting surface) in compression (K2-3)		
$U = \frac{P_{co} + M_{co}}{F_c A_c + F_c S}$ (K2-4)		
where P_{co} and M_{co} are determined on the side of the joint that has the lower compression stress. P_{co} and M_{co} refer to required strengths in the HSS: $P_{co} = P_u$ for LRFD, and P_u for ASD; $M_{co} = M_u$ for LRFD, and M_u for ASD.		



AISC 360:16 Specification for Structural Steel Buildings

Longitudinal Plate T-, Y- and Cross-Connections 	Limit State: HSS Plastification		
	Plate Axial Load	In-Plane	Out-of-Plane
$R_n \sin \theta = 5.5 F_y t^2 \left(1 + 0.25 \frac{l_b}{D} \right) Q_f$ (K2-2a)	$M_n = 0.8 l_b R_n$ (K2-2b)	–	
$\phi = 0.90$ (LRFD) $\Omega = 1.67$ (ASD)			



AISC 360:16 Specification for Structural Steel Buildings

Specification
for Structural Steel Buildings

TABLE K5.1
Effective Weld Properties for
Connection to Rectangular HSS

Connection Type	Weld Properties
<p>Transverse Plate T- and Cross-Connections under Plate Axial Load</p>	<p>Effective Weld Properties</p> $l_e = 2B_e \quad (K5-4)$ <p>where l_e = total effective weld length for welds on both sides of the transverse plate</p>
<p>T, Y, and Cross-Connections under Branch Axial Load or Bending</p> <p style="font-size: 8px;">Not present for T- or Y-connection</p> <p style="font-size: 8px;">Section A-A: Effective weld</p>	<p>Effective Weld Properties</p> $l_e = \frac{2H_b}{\sin \theta} + 2B_b \quad (K5-5)$ $S_w = \frac{t_b}{3} \left(\frac{H_b}{\sin \theta} \right)^2 + L_b B_b \left(\frac{H_b}{\sin \theta} \right) \quad (K5-6)$ $S_{wp} = t_b \left(\frac{H_b}{\sin \theta} \right) B_b + \frac{1}{3} \left(\frac{H_b}{\sin \theta} \right)^3 \left(\frac{L_b}{B_b} \right) \left(\frac{B_b - B_b}{B_b} \right)^2 \quad (K5-7)$ <p>When $\beta > 0.85$ or $\theta > 60^\circ$, $B_b/2$ shall not exceed $B_b/4$.</p>
<p>Gapped K-Connections under Branch Axial Load</p> <p style="font-size: 8px;">4th side effective when $\theta \leq 50^\circ$</p> <p style="font-size: 8px;">Section A-A: Effective weld for $\theta \geq 60^\circ$</p>	<p>Effective Weld Properties</p> <p>When $\theta \leq 50^\circ$:</p> $l_e = \frac{2(H_b - 1.2g)}{\sin \theta} + 2(B_b - 1.2g) \quad (K5-8)$ <p>When $\theta \geq 60^\circ$:</p> $l_e = \frac{2(H_b - 1.2g)}{\sin \theta} + B_b - 1.2g \quad (K5-9)$ <p>When $50^\circ < \theta < 60^\circ$, linear interpolation shall be used to determine l_e.</p>

57

AISC 360:16 Specification for Structural Steel Buildings

Specification
for Structural Steel Buildings

TABLE K5.1
Effective Weld Properties for
Connections to Rectangular HSS

Connection Type	Weld Properties
<p>Transverse Plate T- and Cross-Connections under Plate Axial Load</p>	<p style="border: 2px solid red; padding: 5px; display: inline-block;">Effective Weld Properties</p>
	$l_e = 2B_e \quad (K5-4)$ <p>where l_e = total effective weld length for welds on both sides of the transverse plate</p>

58

SPECIAL WELDING APPLICATIONS

14.6 Welding HSS

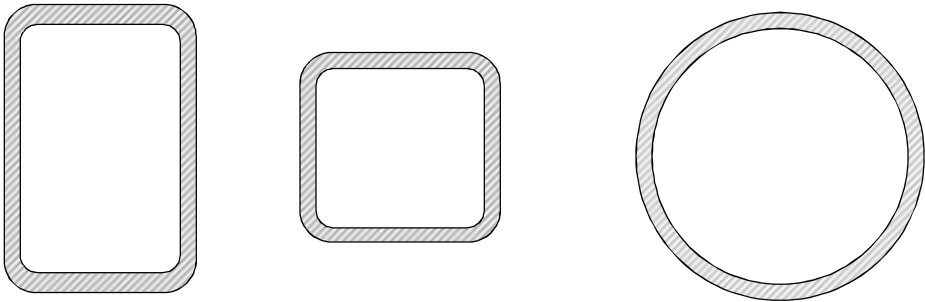
- Connections and HSS member size
- ➔ • Overall configuration
- Cutting and preparing HSS





59

SPECIAL WELDING APPLICATIONS

Rectangular **Round**



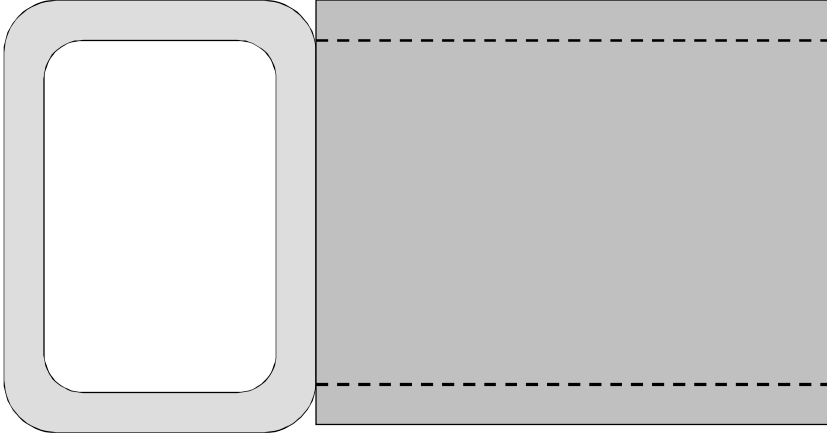
Rectangular is nearly always
easier to fabricate





60

SPECIAL WELDING APPLICATIONS

Matched Connection

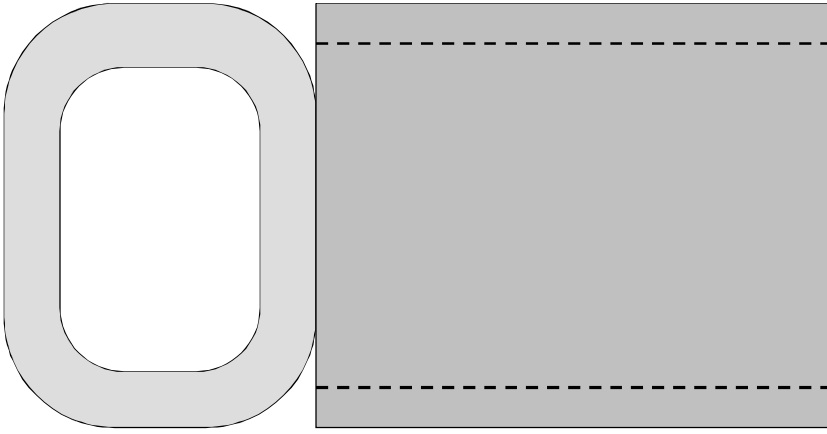








61

SPECIAL WELDING APPLICATIONS

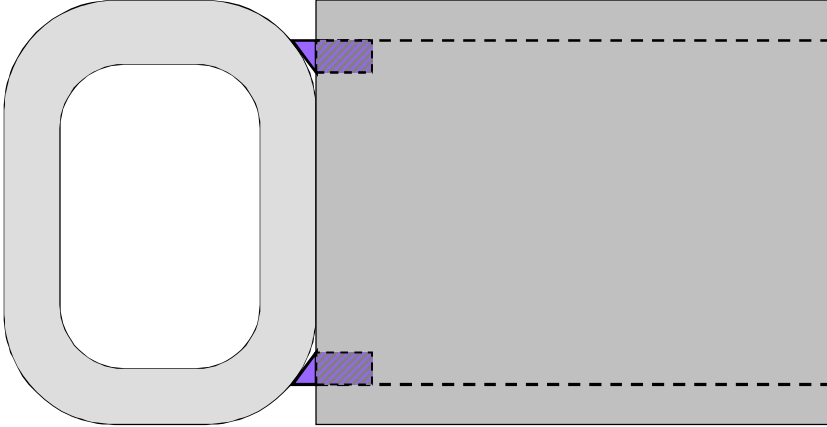








62

SPECIAL WELDING APPLICATIONS

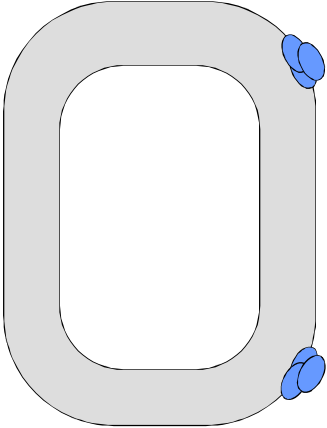


The diagram shows a cross-section of a column-to-beam connection. The column is on the left, and the beam is on the right. A groove weld is shown between the column flange and the beam web. The weld is a partial penetration groove weld, indicated by the hatched area and the dashed line representing the root of the groove. The weld is shown in two locations: one at the top and one at the bottom of the column flange.

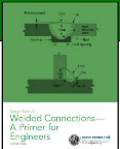



63

SPECIAL WELDING APPLICATIONS

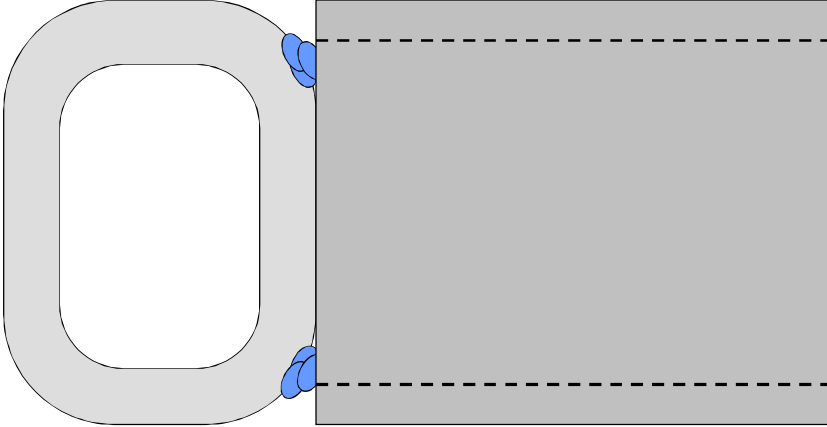


The diagram shows a cross-section of a column-to-beam connection. The column is on the left, and the beam is on the right. A groove weld is shown between the column flange and the beam web. The weld is a full penetration groove weld, indicated by the blue hatched area and the dashed line representing the root of the groove. The weld is shown in two locations: one at the top and one at the bottom of the column flange.





64

SPECIAL WELDING APPLICATIONS




The diagram shows a channel section on the left and a rectangular plate on the right. Two blue welds are shown at the top and bottom corners of the channel's web, connecting it to the plate. Dashed lines on the plate indicate the weld locations.





65

SPECIAL WELDING APPLICATIONS

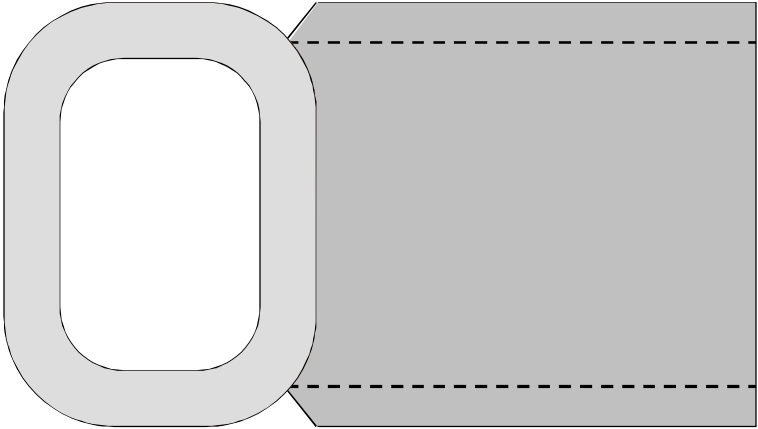


The diagram shows a channel section on the left and a rectangular plate on the right. The top and bottom edges of the channel's web are curved to match the top and bottom edges of the plate. Dashed lines on the plate indicate the weld locations.





66

SPECIAL WELDING APPLICATIONS

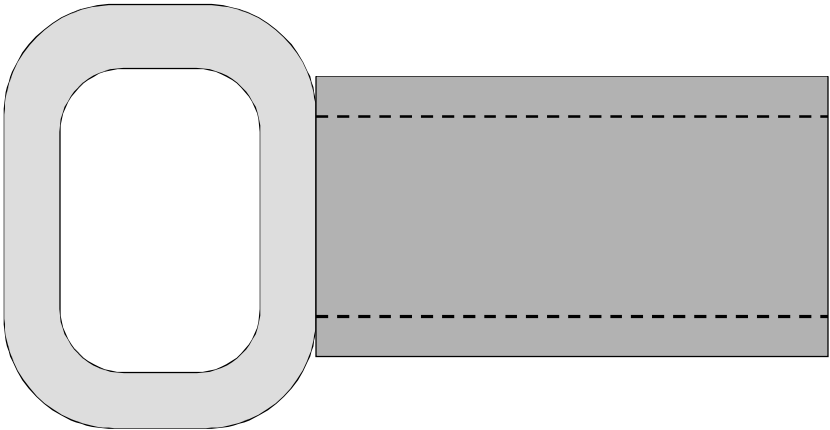


67

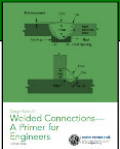



SPECIAL WELDING APPLICATIONS

Stepped Connection



68



SPECIAL WELDING APPLICATIONS



Welded Connections—
A Primer for
Engineers


14.6 Welding HSS

- Connections and HSS member size
- ➔ • Overall configuration
- Cutting and preparing HSS




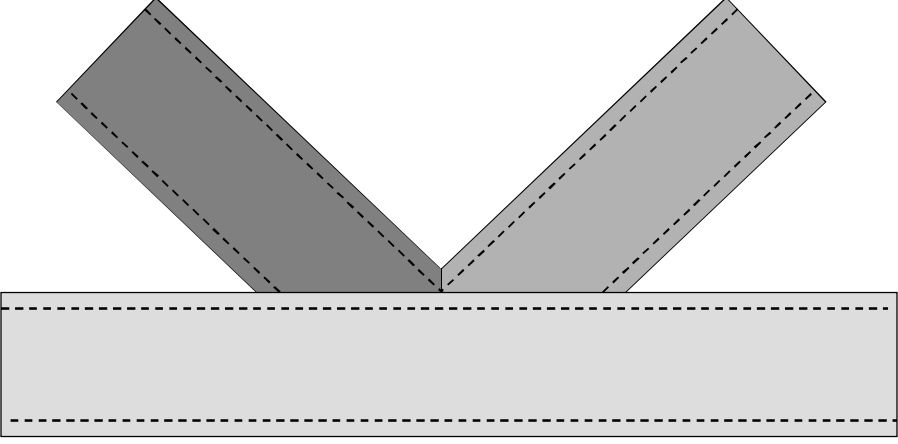
69

SPECIAL WELDING APPLICATIONS



Welded Connections—
A Primer for
Engineers

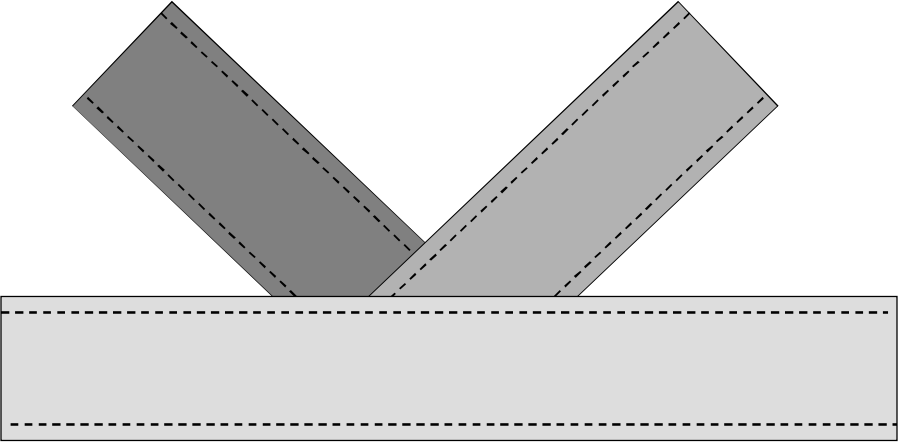
Overlapped




70

SPECIAL WELDING APPLICATIONS

Overlapped



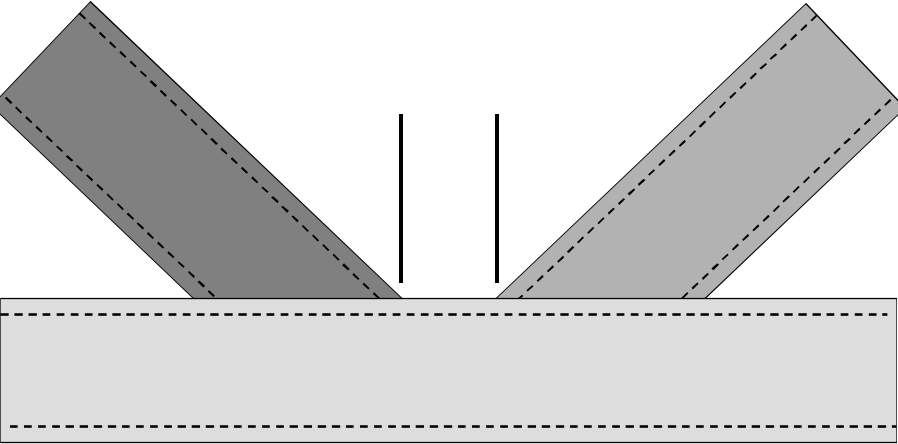
Welded Connections—
A Primer for
Engineers



71


SPECIAL WELDING APPLICATIONS

Gapped




Preferred

Welded Connections—
A Primer for
Engineers



72

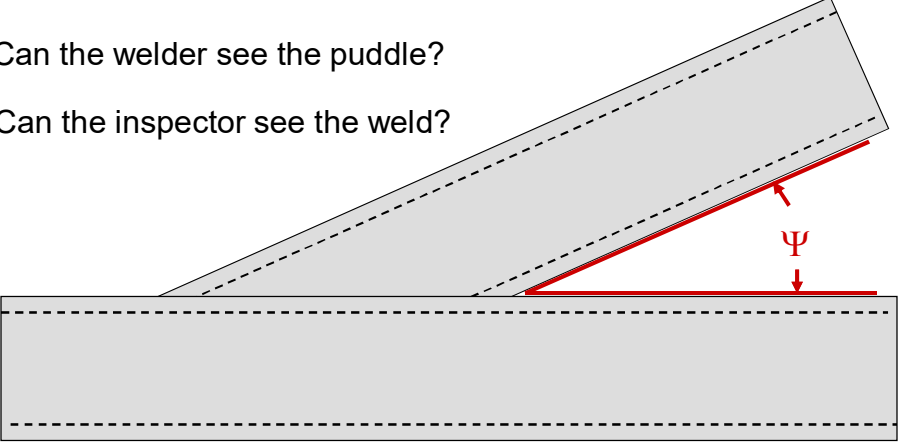
SPECIAL WELDING APPLICATIONS




Welded Connections—
A Primer for
Engineers

Provide Access for Welding and Inspection

- Can the welder see the puddle?
- Can the inspector see the weld?

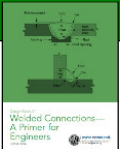


$\Psi = 30^\circ$ minimum



73


SPECIAL WELDING APPLICATIONS



Welded Connections—
A Primer for
Engineers

14.6 Welding HSS




- Connections and HSS member size
- Overall configuration
- ➔ • Cutting and preparing HSS



74

SPECIAL WELDING APPLICATIONS



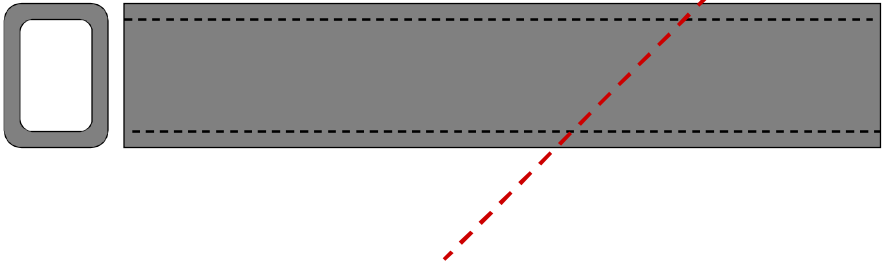
Box HSS



75

SPECIAL WELDING APPLICATIONS


Box HSS





76

SPECIAL WELDING APPLICATIONS

Box HSS



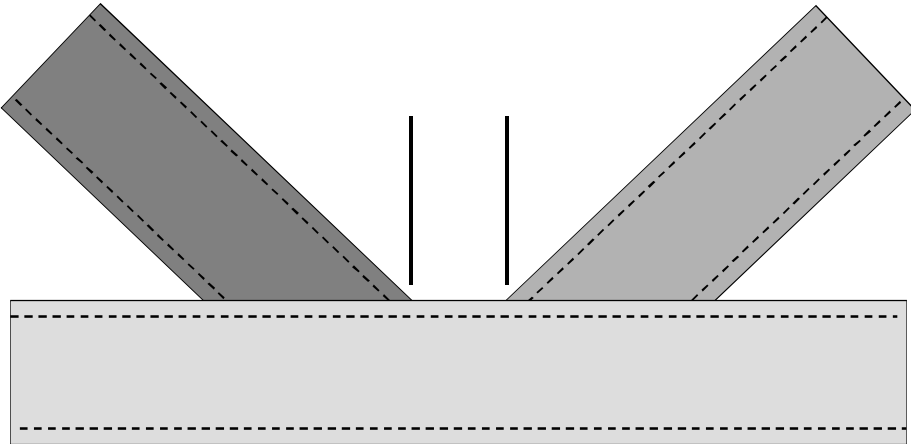
The diagram illustrates a cross-section of a Box HSS (Hollow Structural Section). It consists of a rectangular section on the left and a tapered section on the right. Dashed lines indicate the weld lines where the plates meet. The tapered section is shown with a diagonal cut on its right side.





77

SPECIAL WELDING APPLICATIONS

Gapped



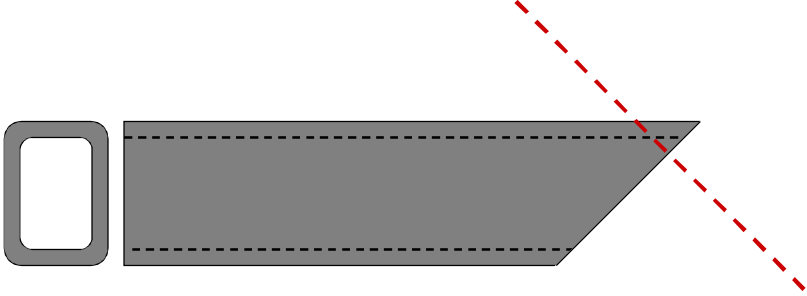
The diagram illustrates a gapped welded connection. It shows two angled plates meeting a horizontal plate. The angled plates are positioned such that there is a gap between them and the horizontal plate. Dashed lines indicate the weld lines. Two vertical lines are drawn between the angled plates, indicating the gap.





78

SPECIAL WELDING APPLICATIONS

Box HSS




The diagram shows a cross-section of a Box HSS member. On the left is a rectangular hollow section. To its right is a solid gray section representing a top flange. This flange has a dashed line along its top and bottom edges, indicating it is a thin-walled section. A red dashed line is drawn diagonally across the top right corner of the flange, representing a cut through the top flange.



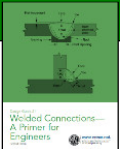

79

SPECIAL WELDING APPLICATIONS

Box HSS



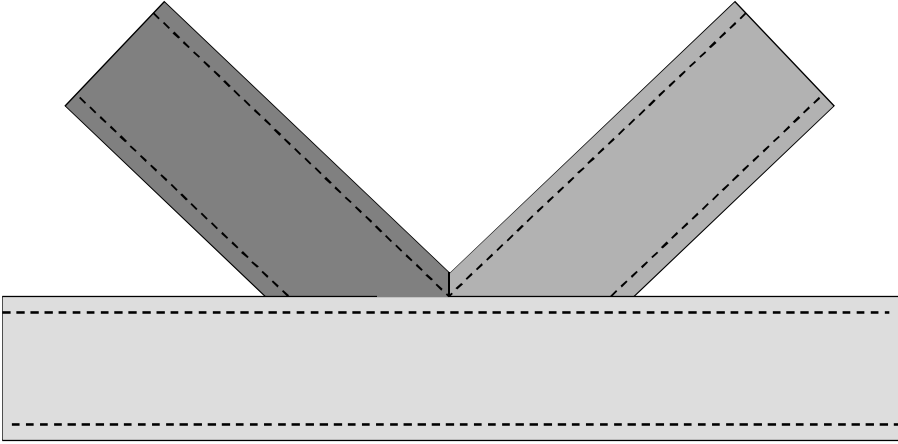
The diagram shows a cross-section of a Box HSS member. On the left is a rectangular hollow section. To its right is a solid gray section representing a top flange. This flange has a dashed line along its top and bottom edges, indicating it is a thin-walled section. The right end of the flange is shaped like an arrowhead pointing to the right.





80

SPECIAL WELDING APPLICATIONS

Overlapped










81

SPECIAL WELDING APPLICATIONS

Round HSS



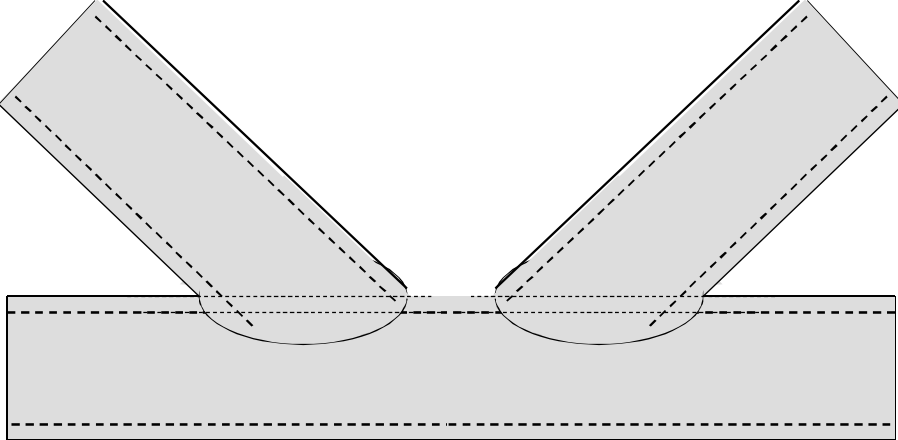






82

SPECIAL WELDING APPLICATIONS

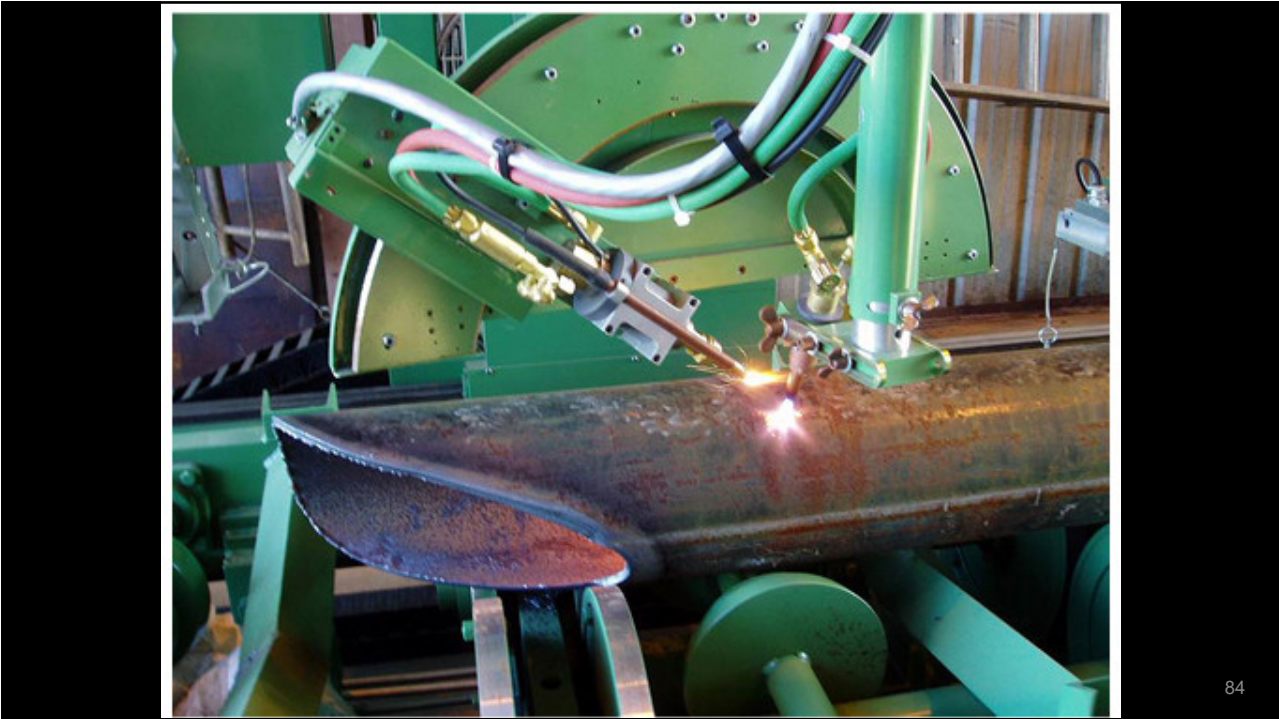
Round HSS



The diagram illustrates a welded connection for Round HSS. It shows a horizontal base plate with a dashed line indicating a weld line. Two angled plates are attached to the top surface of the base plate. Each angled plate has a dashed line indicating a weld line. The welds are shown as semi-circular shapes at the junctions. The entire diagram is enclosed in a black border.

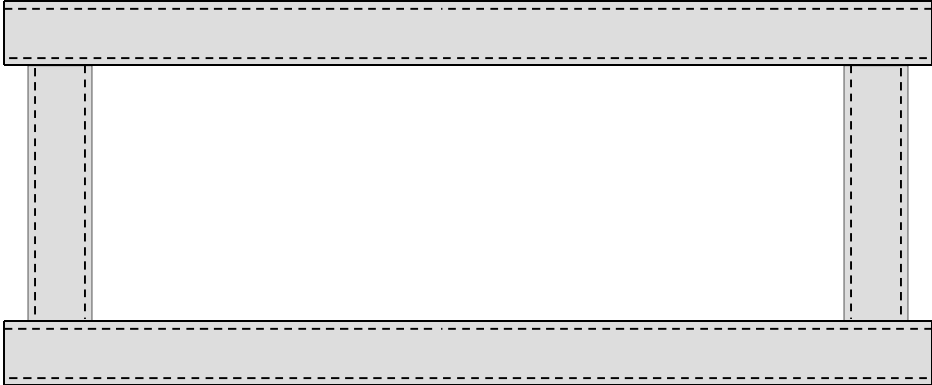


83





SPECIAL WELDING APPLICATIONS

Box HSS



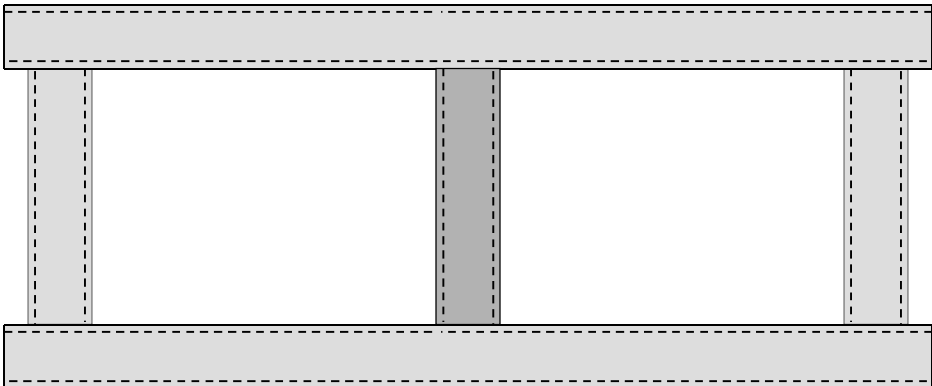
The diagram shows a cross-section of a Box HSS (Hollow Structural Section) with two vertical stiffeners. The stiffeners are positioned symmetrically on either side of the vertical centerline. Dashed lines indicate the weld lines connecting the stiffeners to the top and bottom flanges of the box section.





85

SPECIAL WELDING APPLICATIONS

Box HSS



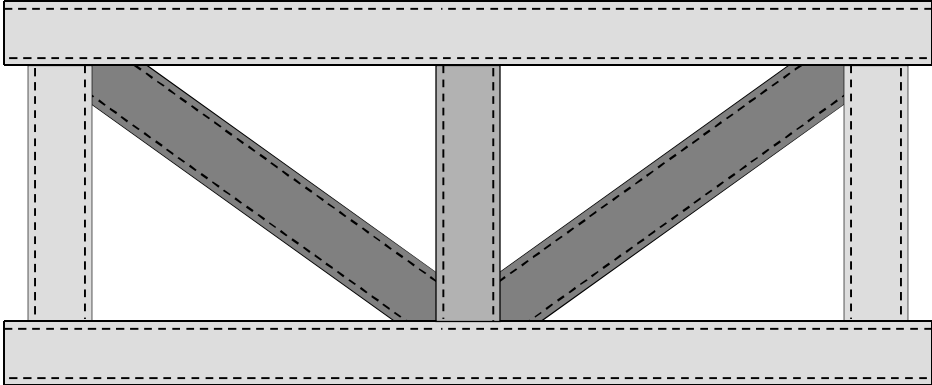
The diagram shows a cross-section of a Box HSS with three vertical stiffeners. The stiffeners are positioned symmetrically, with one in the center and two on either side. Dashed lines indicate the weld lines connecting the stiffeners to the top and bottom flanges of the box section.

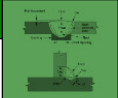



86

SPECIAL WELDING APPLICATIONS

Box HSS



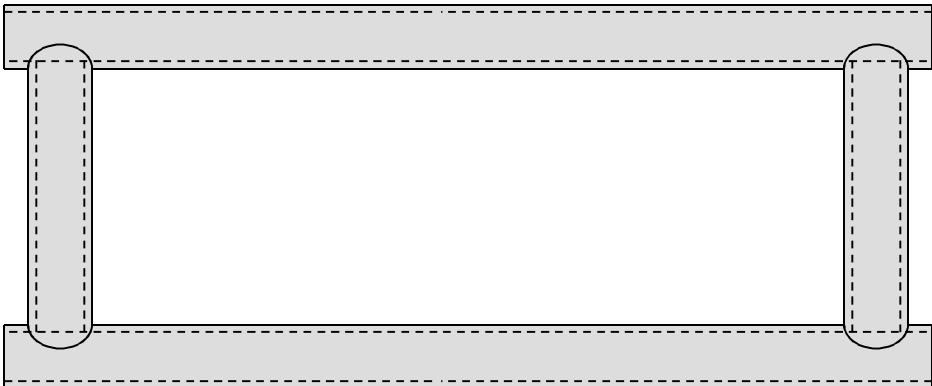

Welded Connections—
A Primer for
Engineers

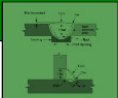



87

SPECIAL WELDING APPLICATIONS

Round HSS




Welded Connections—
A Primer for
Engineers





88

SPECIAL WELDING APPLICATIONS

Round HSS

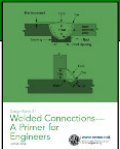

Cannot insert this member



89

SPECIAL WELDING APPLICATIONS

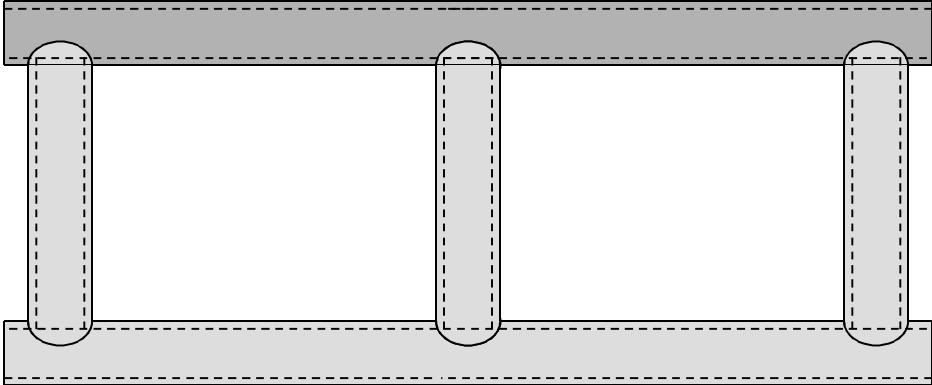
Round HSS





90

SPECIAL WELDING APPLICATIONS

Round HSS



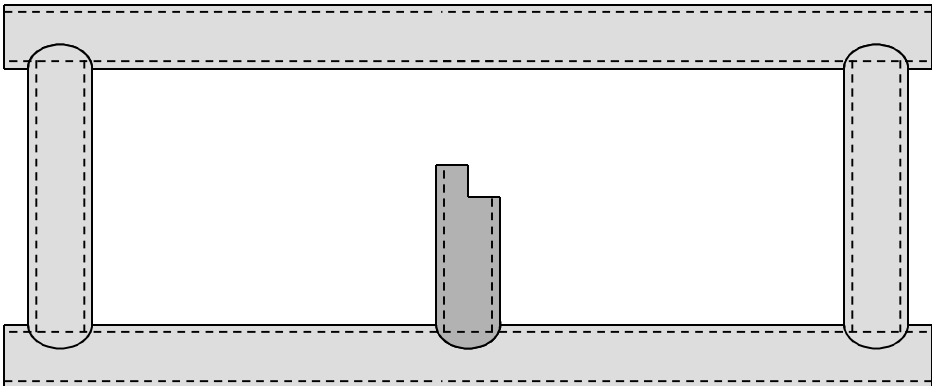
The diagram illustrates a welded connection for Round HSS. It features a top horizontal member and a bottom horizontal member, both shown with dashed lines to indicate they are behind the vertical members. Three vertical members are connected to both the top and bottom horizontal members. Each vertical member has a rounded top and bottom end, and is connected to the horizontal members via a fillet weld. The entire assembly is shown in a perspective view.





91

SPECIAL WELDING APPLICATIONS

Round HSS



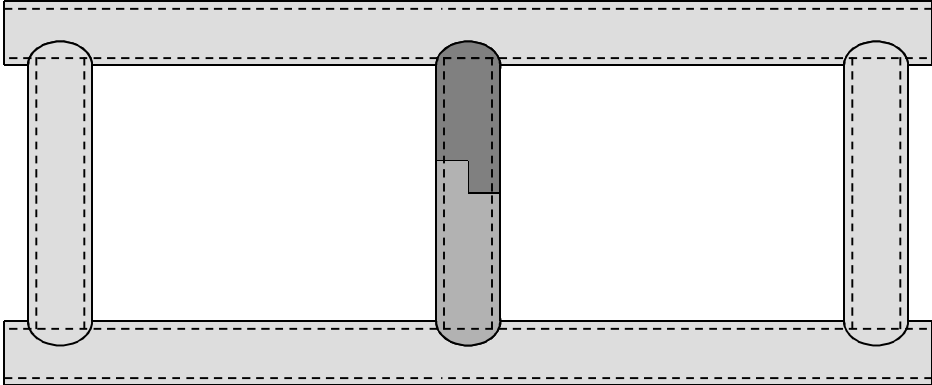
The diagram illustrates a welded connection for Round HSS. It features a top horizontal member and a bottom horizontal member, both shown with dashed lines to indicate they are behind the vertical members. Two vertical members are connected to both the top and bottom horizontal members. Each vertical member has a rounded top and bottom end, and is connected to the horizontal members via a fillet weld. A third vertical member is attached to the bottom horizontal member, extending downwards. This third member has a flat top and bottom end and is connected to the horizontal member via a fillet weld. The entire assembly is shown in a perspective view.



92


SPECIAL WELDING APPLICATIONS

Round HSS



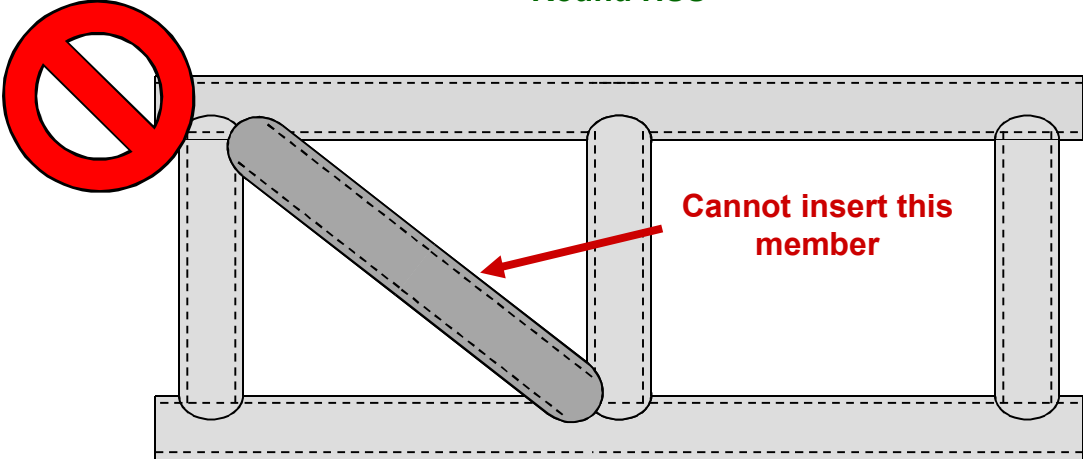
93

Welded Connections—
A Primer for
Engineers



SPECIAL WELDING APPLICATIONS


Round HSS



Cannot insert this member

94

Welded Connections—
A Primer for
Engineers



AWS D1.1:2015 STRUCTURAL WELDING CODE



9. Tubular Structures

9.1 General

This Clause supplements Clauses 1–8. The specific requirements of Clause 9 apply only to tubular connections. For design purposes this clause shall be used with the applicable requirements of Clause 2, Part A. All provisions of Clause 9 apply to static applications and cyclic applications, with the exception of the fatigue provisions of 9.2.7, which are unique to cyclic applications.

This clause is divided into parts, as follows:

- Part A — Design of Tubular Connections
- Part B — Prequalification of Welding Procedure Specifications (WPSs)
- Part C — Welding Procedure Specification (WPS) Qualification
- Part D — Performance Qualification
- Part E — Fabrication

9.2.3 Tubular Section Limitations. Limitations on diameter/thickness for circular sections, and largest flat width/thickness ratio for box sections, beyond which local buckling or other local failure modes shall be considered, shall be in conformance with the governing design code. Limits of applicability for the criteria given in 9.6 shall be observed as follows:

- (1) Circular tubes: $D/t < 3300/F_y$ [for F_y in ksi], $22\ 800/F_y$ (for F_y in MPa)
- (2) Box section gap connections: $D/t \leq 210/\sqrt{F_y}$ [for F_y in ksi], $550/\sqrt{F_y}$ (for F_y in MPa) but not more than 35
- (3) Box section overlap connections: $D/t \leq 190/\sqrt{F_y}$ [for F_y in ksi], $500/\sqrt{F_y}$ (for F_y in MPa)

9.2.4 Welds Stresses. The allowable stresses in welds shall not exceed those given in Table 9.2, or as allowed

SPECIAL WELDING APPLICATIONS



Welding HSS: Summary

- Welds are usually unevenly stressed
- Connection details may control member sizes
- Round vs square/rectangular: box tubes usually easier
- Cutting and assembly
- Access for welding and inspection
- May also have AESS concerns



SPECIAL WELDING APPLICATIONS

Today's Webinar



- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- ➔ 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering



97



98



99



100





SPECIAL WELDING APPLICATIONS

Welding AESS

- ➔ Defining “pretty”
 - Use of Mock-ups
 - Technical issues
 - Note requirements on drawings



AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges

AISC 303-16

Code of Standard Practice for Steel Buildings and Bridges

Section 10.

Architecturally Exposed Structural Steel

TABLE 10.1
AESS Category Matrix

Category	AESS C	AESS 4	AESS 3	AESS 2	AESS 1	SSS
Id	Custom Elements	Showcase Elements	Feature Elements in close view	Feature Elements not in close view	Basic Elements	Standard Structural Steel
1.1		*	*	*	*	
1.2		*	*	*	*	
1.3		*	*	*	*	
1.4		*	*	*	*	
1.5		*	*	*	*	
2.1		*	*	optional		
2.2		*	*	*		
2.3		*	*	*		
2.4		*	*	*		
3.1		*	*			
3.2		*	*			
3.3		*	*			
3.4		*	*			
3.5		*	*			
3.6		optional	optional			
4.1		*				
4.2		*				
4.3		*				
4.4		*				
C.1						
C.2						
C.3						
C.4						
C.5						

User Note:
 1.1 Prior to blast cleaning, grease and oil are removed by solvent cleaning to meet SSPC-SP1.
 1.2 Rough surfaces are deburred and ground smooth. Sharp edges resulting from flame cutting, grinding and especially shearing are softened.
 1.3 Intermittent welds are made continuous, either with additional welding, caulking or body filler. For exercises and/or

105

AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges

TABLE 10.1
AESS Category Matrix

Category	AESS C	AESS 4	AESS 3	AESS 2	AESS 1	SSS
Id	Custom Elements	Showcase Elements	Feature Elements in close view	Feature Elements not in close view	Basic Elements	Standard Structural Steel
1.1		*	*	*	*	
1.2		*	*	*	*	
1.3		*	*	*	*	
1.4		*	*	*	*	
1.5		*	*	*	*	
2.1		*	*	optional		
2.2		*	*	*		
2.3		*	*	*		
2.4		*	*	*		
3.1		*	*			
3.2		*	*			
3.3		*	*			
3.4		*	*			
3.5		*	*			
3.6		optional	optional			
4.1		*				
4.2		*				
4.3		*				
4.4		*				
C.1						
C.2						
C.3						
C.4						
C.5						

106

© Copyright 2019
American Institute of Steel Construction

53

AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges

Code of Standard Practice for Steel Buildings and Bridges

**TABLE 10.1
AESS Category Matrix**

Category		AESS C	AESS 4	AESS 3	AESS 2	AESS 1	SSS
Id	Characteristics	Custom Elements	Showcase Elements	Feature Elements in close view	Feature Elements not in close view	Basic Elements	Standard Structural Steel
1.1	Surface preparation to SSPC-SP 6		•	•	•	•	
1.2	Sharp edges ground smooth		•	•	•	•	
1.3	Continuous weld appearance		•	•	•	•	
1.4	Standard structural bolts		•	•	•	•	
1.5	Weld spatters removed		•	•	•	•	
2.1	Visual samples		•	•	optional		
2.2	One-half standard fabrication tolerances		•	•	•		
2.3	Fabrication marks not apparent		•	•	•		
2.4	Welds uniform and smooth		•	•	•		

107

AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges

Code of Standard Practice for Steel Buildings and Bridges

**TABLE 10.1
AESS Category Matrix**

Category		AESS C	AESS 4	AESS 3	AESS 2	AESS 1	SSS
Id	Characteristics	Custom Elements	Showcase Elements	Feature Elements in close view	Feature Elements not in close view	Basic Elements	Standard Structural Steel
1.1	Surface preparation to SSPC-SP 6		•	•	•	•	
1.2	Sharp edges ground smooth		•	•	•	•	
1.3	Continuous weld appearance		•	•	•	•	
1.4	Standard structural bolts		•	•	•	•	
1.5	Weld spatters removed		•	•	•	•	
2.1	Visual samples		•	•	optional		
2.2	One-half standard fabrication tolerances		•	•	•		
2.3	Fabrication marks not apparent		•	•	•		
2.4	Welds uniform and smooth		•	•	•		

108

AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges						
	1.1	Surface preparation to SSPC-SP 6		•	•	•
	1.2	Sharp edges ground smooth		•	•	•
→	1.3	Continuous weld appearance		•	•	•
→	1.4	Standard structural bolts		•	•	•
→	1.5	Weld spatters removed		•	•	•
→	2.1	Visual samples		•	•	optional
→	2.2	One-half standard fabrication tolerances		•	•	•
→	2.3	Fabrication marks not apparent		•	•	•
→	2.4	Welds uniform and smooth		•	•	•
→	3.1	Mill marks removed		•	•	
→	3.2	Butt and plug welds ground smooth and filled		•	•	
→	3.3	HSS weld seam oriented for reduced visibility		•	•	
→	3.4	Cross sectional abutting surface aligned		•	•	
→	3.5	Joint gap tolerances minimized		•	•	
→	3.6	All welded connections		optional	optional	
→	4.1	HSS seam not apparent		•		
→	4.2	Welds contoured and blended		•		
→	4.3	Surfaces filed and sanded		•		
→	4.4	Weld show-through minimized		•		

Many welding-related issues

109

SPECIAL WELDING APPLICATIONS

Welding AESS

- Defining “pretty”
- • Use of Mock-ups
- Technical issues
- Note requirements on drawings

110



AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges						
1.1	Surface preparation to SSPC-SP 6		•	•	•	•
1.2	Sharp edges ground smooth		•	•	•	•
1.3	Continuous weld appearance		•	•	•	•
1.4	Standard structural bolts		•	•	•	•
1.5	Weld spatters removed		•	•	•	•
2.1	Visual samples		•	•	optional	
2.2	One-half standard fabrication tolerances		•	•	•	
2.3	Fabrication marks not apparent		•	•	•	
2.4	Welds uniform and smooth		•	•	•	
3.1	Mill marks removed		•	•		
3.2	Butt and plug welds ground smooth and filled		•	•		
3.3	HSS weld seam oriented for reduced visibility		•	•		
3.4	Cross sectional abutting surface aligned		•	•		
3.5	Joint gap tolerances minimized		•	•		
3.6	All welded connections		optional	optional		
4.1	HSS seam not apparent		•			
4.2	Welds contoured and blended		•			
4.3	Surfaces filed and sanded		•			
4.4	Weld show-through minimized		•			

Mock-ups

111

AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges

SECTION 10. ARCHITECTURALLY EXPOSED STRUCTURAL STEEL

10.1.2. **A mock-up shall be required for AESS 3, 4 and C.** If a mock-up is to be used in other *AESS* categories, it shall be specified in the *contract documents*. When required, the nature and extent of the mock-up shall be specified in the *contract documents*. Alternatively, when a mock-up is not practical, the first piece of an element or *connection* can be used to determine acceptability.

112



AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges

SECTION 10. ARCHITECTURALLY EXPOSED STRUCTURAL STEEL

Commentary:

Generally, a mock-up is produced and approved in the shop and subsequently placed in the field. The acceptability of the mock-up can be affected by many factors, including distance of view, lighting and finishing. The expectations for the location and conditions of the mock-up at time of approval should be defined in the *contract documents*.

Suggestion: View mock-up at the same distance as the viewer will be from the final welded connection in service.



113

SPECIAL WELDING APPLICATIONS

Welding AESS

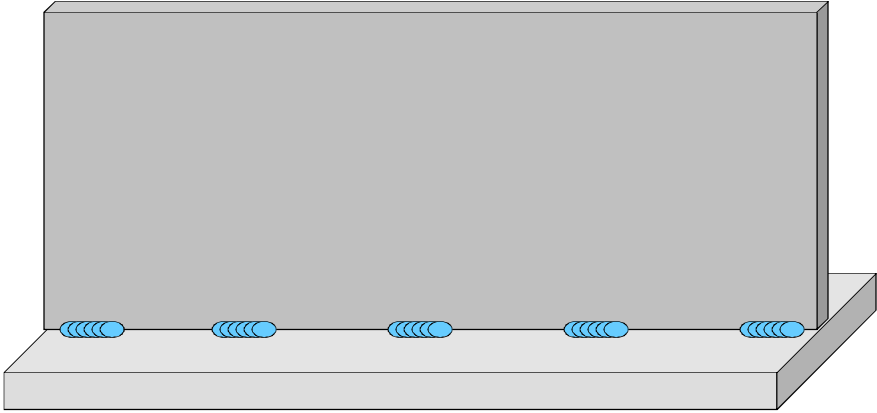
- Defining “pretty”
- Use of Mock-ups
- ➔ • Technical issues
- Note requirements on drawings




114


SPECIAL WELDING APPLICATIONS

Sufficient for strength



The diagram shows a vertical steel plate connected to a horizontal base plate. Five discrete, semi-circular welds are shown along the bottom edge of the vertical plate, representing a non-moment-resisting connection. The welds are spaced evenly across the width of the plate.



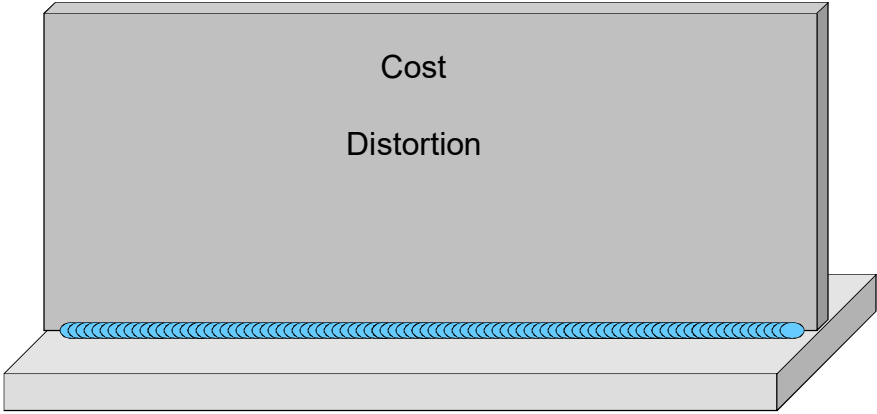


115


SPECIAL WELDING APPLICATIONS


May be required for AESS

Cost
Distortion



The diagram shows a vertical steel plate connected to a horizontal base plate. A single, continuous weld is shown along the entire bottom edge of the vertical plate, representing a moment-resisting connection. The text 'Cost' and 'Distortion' is centered on the vertical plate.



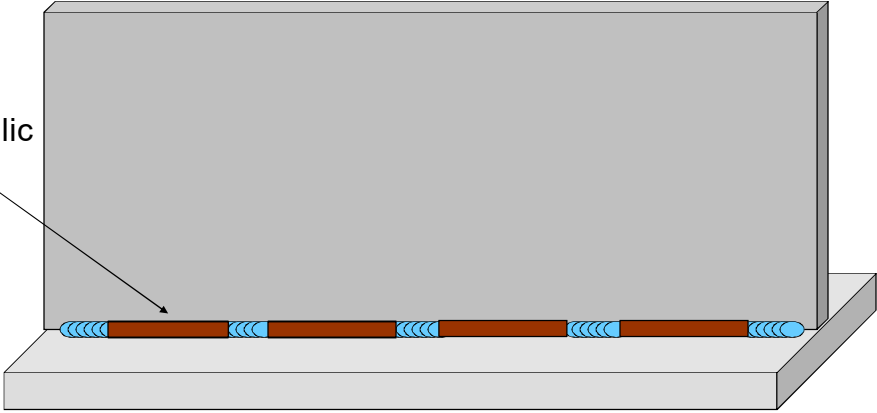


116



SPECIAL WELDING APPLICATIONS

Sufficient for strength

Non-metallic filler



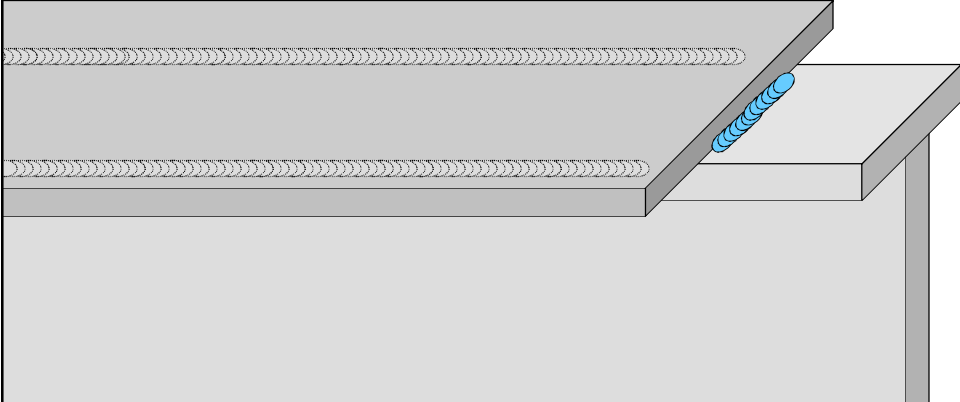
The diagram shows a 3D perspective view of a butt joint between two steel plates. The joint is filled with a non-metallic filler, represented by a brown bar with blue wavy patterns. An arrow points from the text 'Non-metallic filler' to this bar. The plates are shown in a light gray color.





117

SPECIAL WELDING APPLICATIONS

D1.1 code required practice*
*modified in 2015 edition



The diagram shows a 3D perspective view of a lap joint between two steel plates. The joint is filled with a non-metallic filler, represented by a brown bar with blue wavy patterns. The plates are shown in a light gray color.

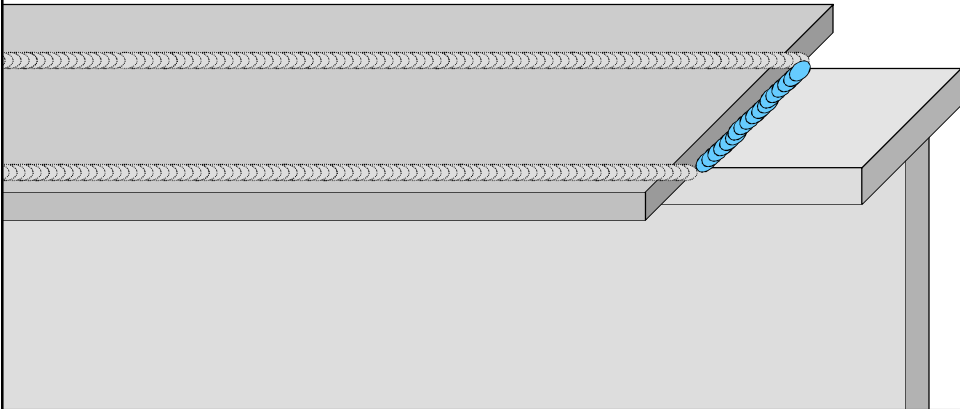


118

SPECIAL WELDING APPLICATIONS

May be AESS specified practice

Workmanship Concerns
Inspection Concerns

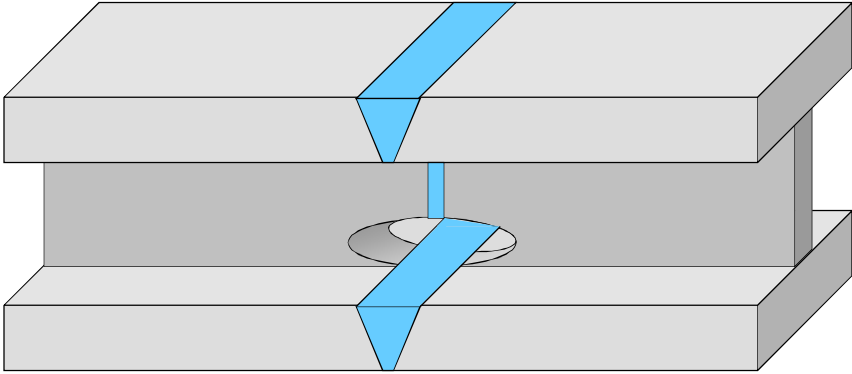


119

The diagram shows a lap joint between two steel plates. A fillet weld is applied to the top surface of the upper plate and the bottom surface of the lower plate. The weld is depicted with a blue, scalloped pattern. The plates are shown in a 3D perspective view.

SPECIAL WELDING APPLICATIONS

Code required practice



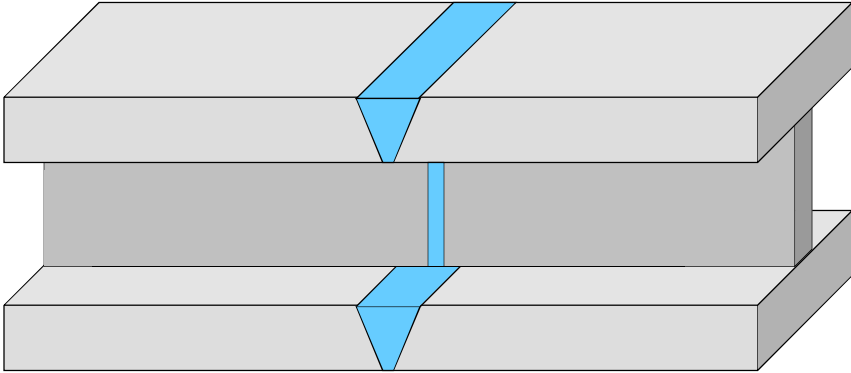
120

The diagram shows a lap joint between two steel plates. A groove weld is applied to the top surface of the upper plate and the bottom surface of the lower plate. The weld is depicted with a blue, V-shaped groove. The plates are shown in a 3D perspective view.





SPECIAL WELDING APPLICATIONS

May be AESS specified practice



How can flange CJP groove weld be made?

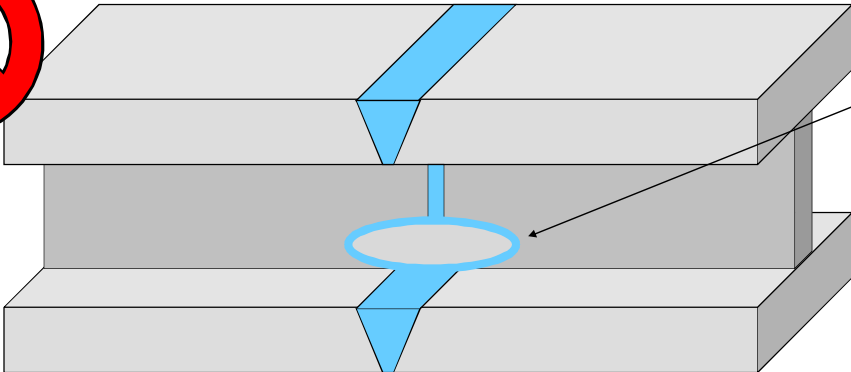


121

Detailed description: This slide features a green header with the text 'SPECIAL WELDING APPLICATIONS'. Below the header, the text 'May be AESS specified practice' is centered. The main content is a 3D perspective diagram of a flange connection. It shows two horizontal plates, one above and one below a vertical web. The top plate has a groove cut into its bottom surface, and the bottom plate has a corresponding groove cut into its top surface. A blue weld bead is shown filling the space between the two plates, connecting the grooves. The question 'How can flange CJP groove weld be made?' is centered below the diagram. In the bottom left corner is the AISC logo, and in the bottom right corner is the number '121'. A small thumbnail of the book cover is in the top right corner.

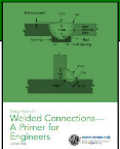

SPECIAL WELDING APPLICATIONS

May be AESS specified practice



Welded insert

Will splice crack when insert is welded?



122

Detailed description: This slide features a green header with the text 'SPECIAL WELDING APPLICATIONS'. Below the header, the text 'May be AESS specified practice' is centered. The main content is a 3D perspective diagram of a flange connection, similar to the one on slide 121. However, a blue oval representing a 'Welded insert' is shown on the top surface of the top plate, directly above the groove. A red prohibition sign (a circle with a diagonal slash) is placed to the left of the diagram. An arrow points from the text 'Welded insert' to the blue oval. Below the diagram is the question 'Will splice crack when insert is welded?'. In the bottom left corner is the AISC logo, and in the bottom right corner is the number '122'. A small thumbnail of the book cover is in the top right corner.

SPECIAL WELDING APPLICATIONS

Distortion

Acceptable to D1.1

123

SPECIAL WELDING APPLICATIONS

Distortion



AESS limit

124

SPECIAL WELDING APPLICATIONS

Weld Throats

throat



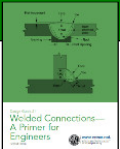

125

SPECIAL WELDING APPLICATIONS

Weld Throats

Project note:
1. Contour and blend all welds.

throat



126



SPECIAL WELDING APPLICATIONS

Welding AESS

- Defining “pretty”
- Use of Mock-ups
- Technical issues
- ➔ • Note requirements on drawings



SPECIAL WELDING APPLICATIONS



Welding AESS: Summary

- Defining “pretty”; use AISC 303 Section 10
- Mock-ups are often critical; view from an appropriate distance
- Define all expectations; some requirement may conflict with code requirements



129

SPECIAL WELDING APPLICATIONS



Today's Webinar

- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- ➔ 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering



130



131



132

SPECIAL WELDING APPLICATIONS



Shop versus Field Welding

- Primarily an issue of cost
- Some environmental issues (cold, wind, rain, etc.)
- Out-of-position welding may be needed
- Easier to control projects in a shop environment



133

SPECIAL WELDING APPLICATIONS



Myths

- You can't get quality welds out-of-position



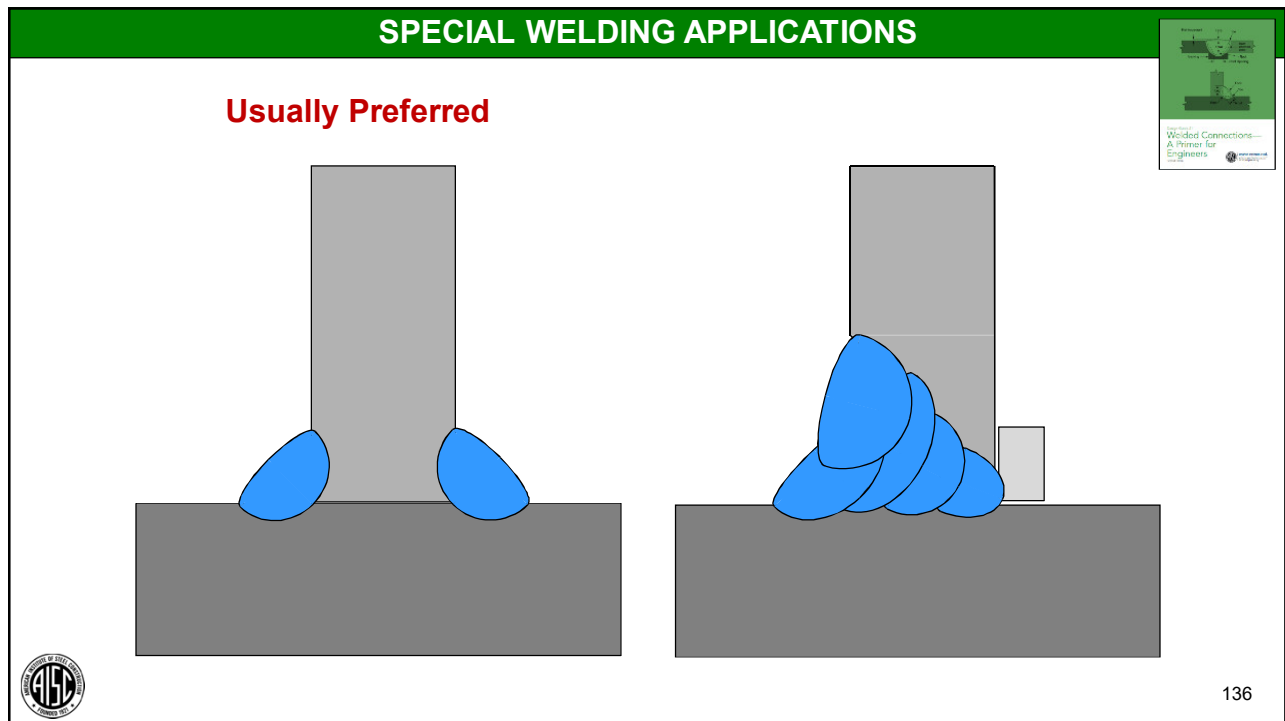
134

AWS D1.1:2015 STRUCTURAL WELDING CODE

Table 4.12
Welding Personnel Performance Essential Variable Changes
Requiring Requalification (see 4.19)

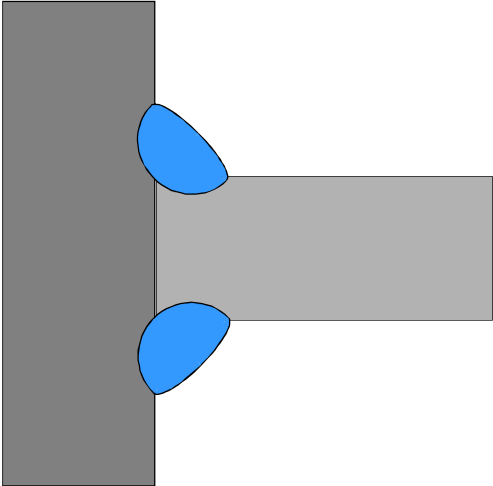
Essential Variable Changes to WPQR Requiring Requalification	Welding Personnel		
	Welders ^b	Welding Operators ^{b, c}	Tack Welders
(1) To a process not qualified (GMAW-S is considered a separate process)	X	X	X
(2) To an SMAW electrode with an F-number (see Table 4.13) higher than the WPQR electrode F-number	X		X
➔ (3) To a position not qualified	X	X	X
(4) To a diameter or thickness not qualified	X	X	
(5) To a vertical welding progression not qualified (uphill or downhill)	X		
(6) The omission of backing (if used in the WPQR test)	X	X	
(7) To multiple electrodes (if a single electrode was used in the WPQR test) but not vice versa		X ^a	

135

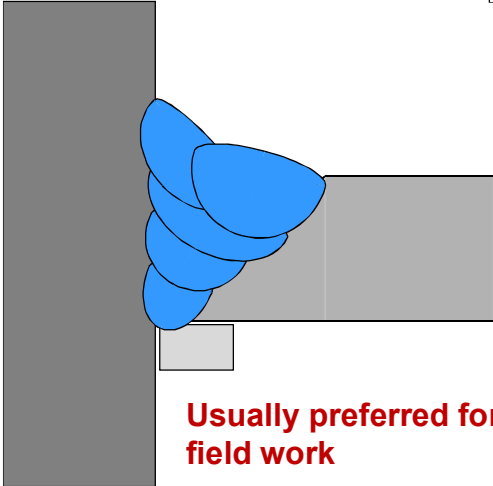


SPECIAL WELDING APPLICATIONS


Requires overhead welding




All flat welding



Usually preferred for field work




137




SPECIAL WELDING APPLICATIONS

Myths

- You can't get quality welds out-of-position
- You can't get quality in the field
- Codes do not apply to field welding



138



AWS D1.1:2015 STRUCTURAL WELDING CODE



5. Fabrication

→ 5.1 Scope

All applicable provisions of this section shall be observed in the fabrication and erection of welded assemblies and structures produced by any process acceptable under this code (see 3.2 and 4.13).

5.2 Base Metal

5.2.1 Specified Base Metal. The contract documents shall designate the specification and classification of base metal to be used. When welding is involved in the structure, approved base metals, listed in Table 3.1 or Table 4.9, should be used wherever possible.



5.3 Welding Consumables and Electrode Requirements

5.3.1 General

5.3.1.1 Certification for Electrodes or Electrode-Flux Combinations. When requested by the Engineer, the Contractor or fabricator shall furnish certification that the electrode or electrode-flux combination conforms to the requirements of the classification.

5.3.1.2 Suitability of Classification. The classification and size of electrode, arc length, voltage, and amperage shall be suited to the thickness of the material, type of groove, welding positions, and other circumstances attending the work. Welding current shall be within the range recommended by the electrode manufacturer.

139

AWS D1.1:2015 STRUCTURAL WELDING CODE



5.1 Scope

All applicable provisions of this section shall be observed in the **fabrication and erection** of welded assemblies and structures produced by any process acceptable under this code (see 3.2 and 4.14).



140

SPECIAL WELDING APPLICATIONS



Myths

- You can't get quality welds out-of-position
- You can't get quality in the field
- Codes do not apply to field welding
- Field welders are not "certified" (qualified)
- WPSs are not used in the field
- There is no audit program for field contractors



141

American Institute of Steel Construction, Inc.


is proud to recognize

ABC Erectors, Inc.

Any City, USA

for successfully meeting the quality certification requirements for

Advanced Certified Steel Erector



Roger E. Ferch





Robbi Marnell

Certification valid through May 2006



142

SPECIAL WELDING APPLICATIONS



Myths

- You can't get quality welds out-of-position
- You can't get quality in the field
- Codes do not apply to field welding
- Field welders are not "certified" (qualified)
- WPSs are not used in the field
- There is no audit program for field contractors
- There are no contractor-supplied inspectors for field work



143

AISC 360-16 Specification for Structural Steel Buildings



CHAPTER N

QUALITY CONTROL AND QUALITY ASSURANCE

N1. GENERAL PROVISIONS

Quality control (QC) as specified in this chapter shall be provided by the **fabricator and erector**. Quality assurance (QA) as specified in this chapter shall be provided by others when required by the authority having jurisdiction (AHJ), applicable building code, purchaser, owner, or engineer of record (EOR). Nondestructive testing (NDT) shall be performed by the agency or firm responsible for quality assurance, except as permitted in accordance with Section N6.



144

AISC 360-16 Specification for Structural Steel Buildings

CHAPTER N

QUALITY CONTROL AND QUALITY ASSURANCE

N2. FABRICATOR AND ERECTOR QUALITY CONTROL PROGRAM

The **fabricator and erector** shall establish, maintain and implement QC procedures to ensure that their work is performed in accordance with this Specification and the construction documents.



145

SPECIAL WELDING APPLICATIONS

Shop vs Field Welding: Summary

- There are some legitimate differences/concerns
- Shop operations generally preferred due to lower costs
- Mature codes control field welding
- Field contractor certification programs exist
- Inspection requirements have been made clearer in Chapter N



146

SPECIAL WELDING APPLICATIONS

Today's Webinar

- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- ➔ 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering



147



SPECIAL WELDING APPLICATIONS

14.9 Welding on Existing Structures

- ➔ • Historic steels
- Welding under load
- Fire
- Cold working / strain aging

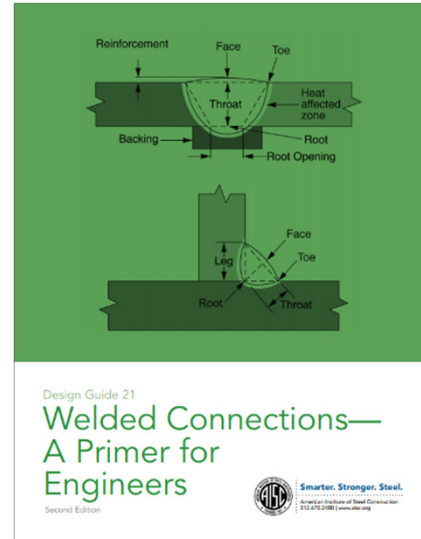


148



AISC Design Guide 21 Chapter 4 Metallurgical Issues

- Historic (obsolete) steels
 - ASTM A9
 - ASTM A7
 - ASTM A373
 - ASTM A242
- Check weldability of steel (especially if riveted)



149

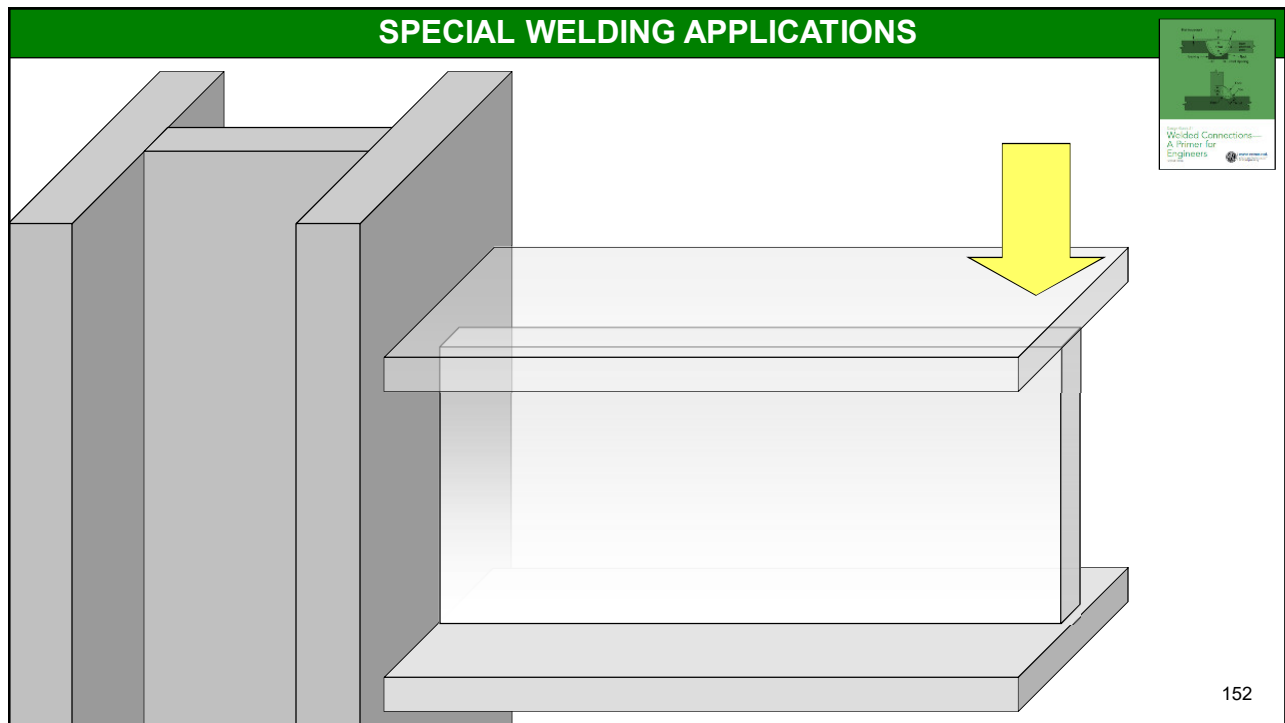
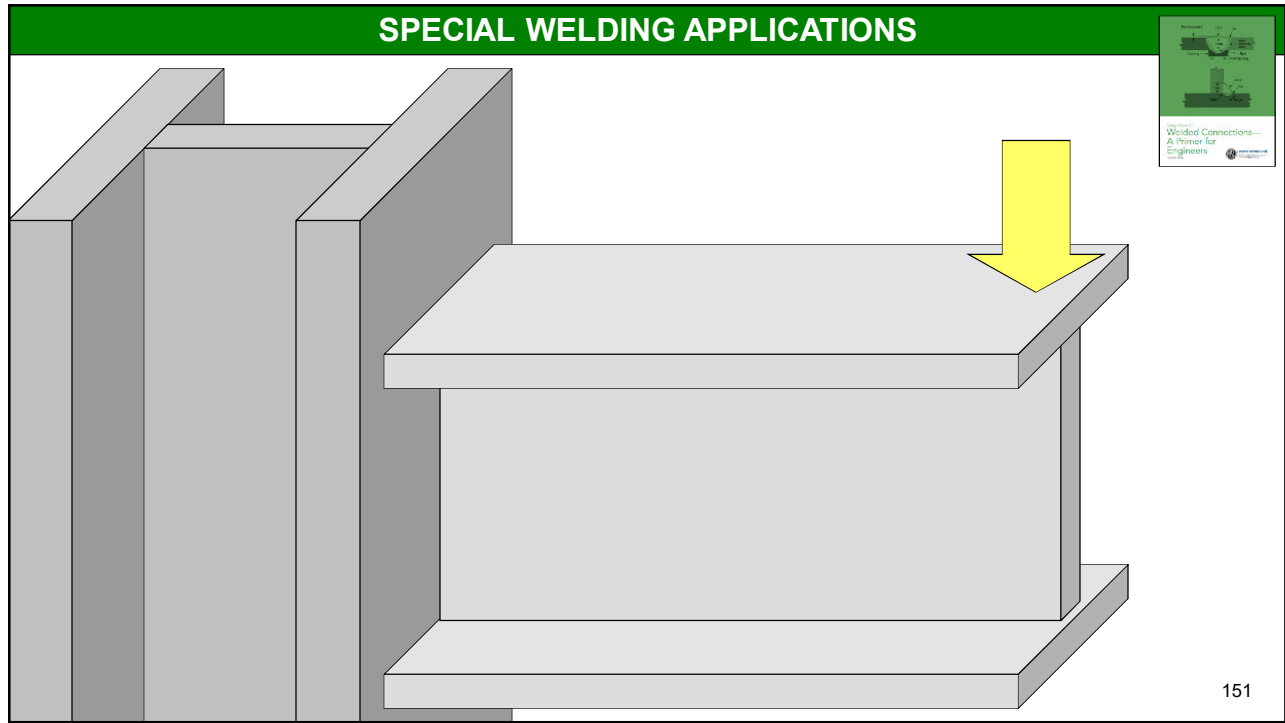
SPECIAL WELDING APPLICATIONS

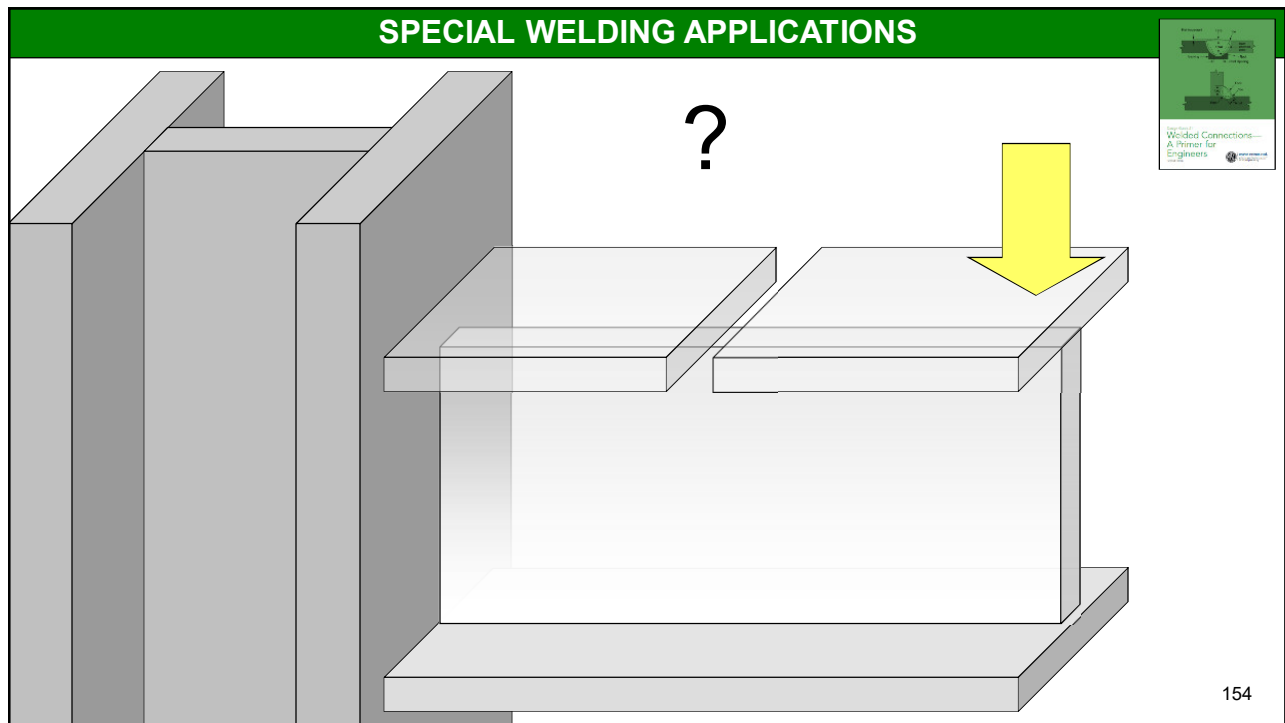
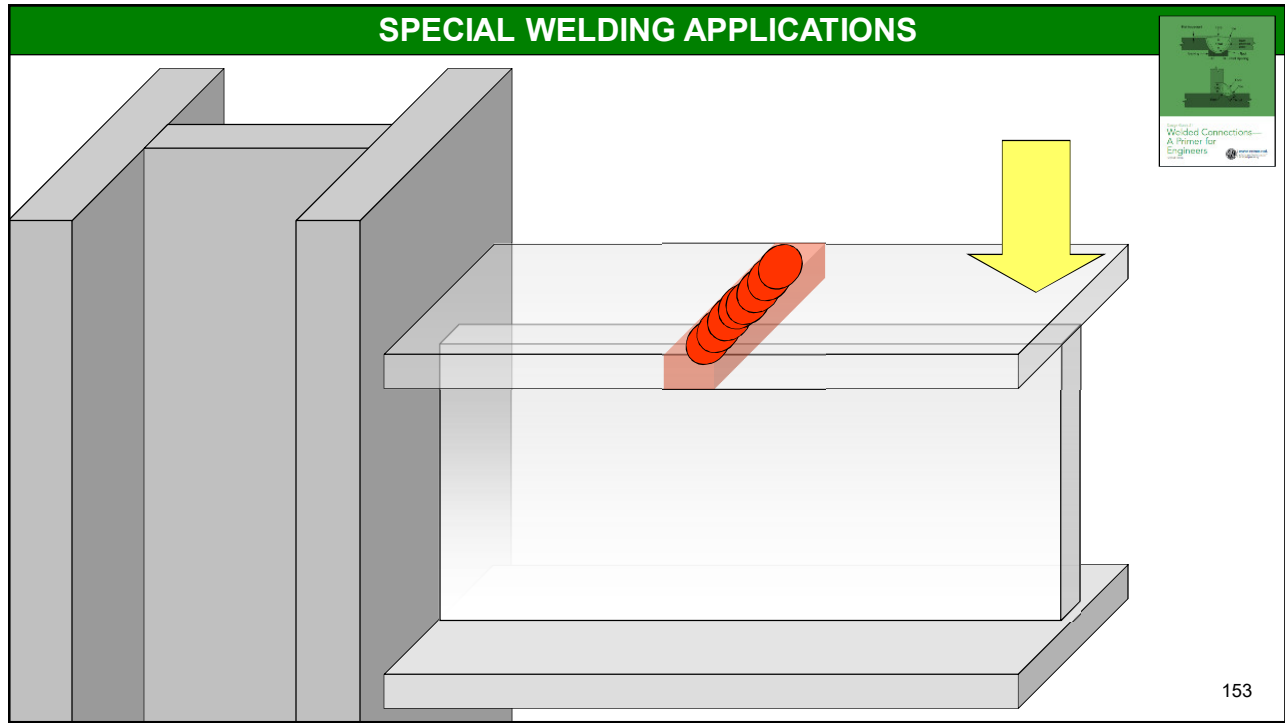
14.9 Welding on Existing Structures

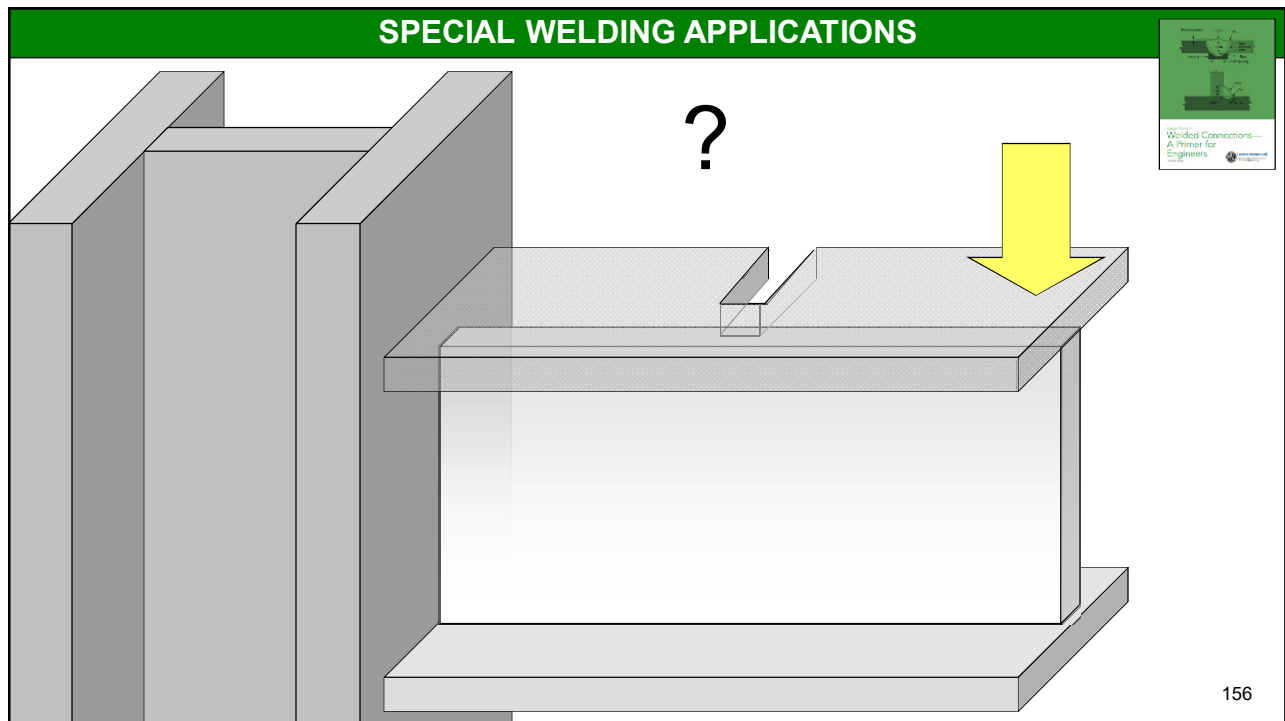
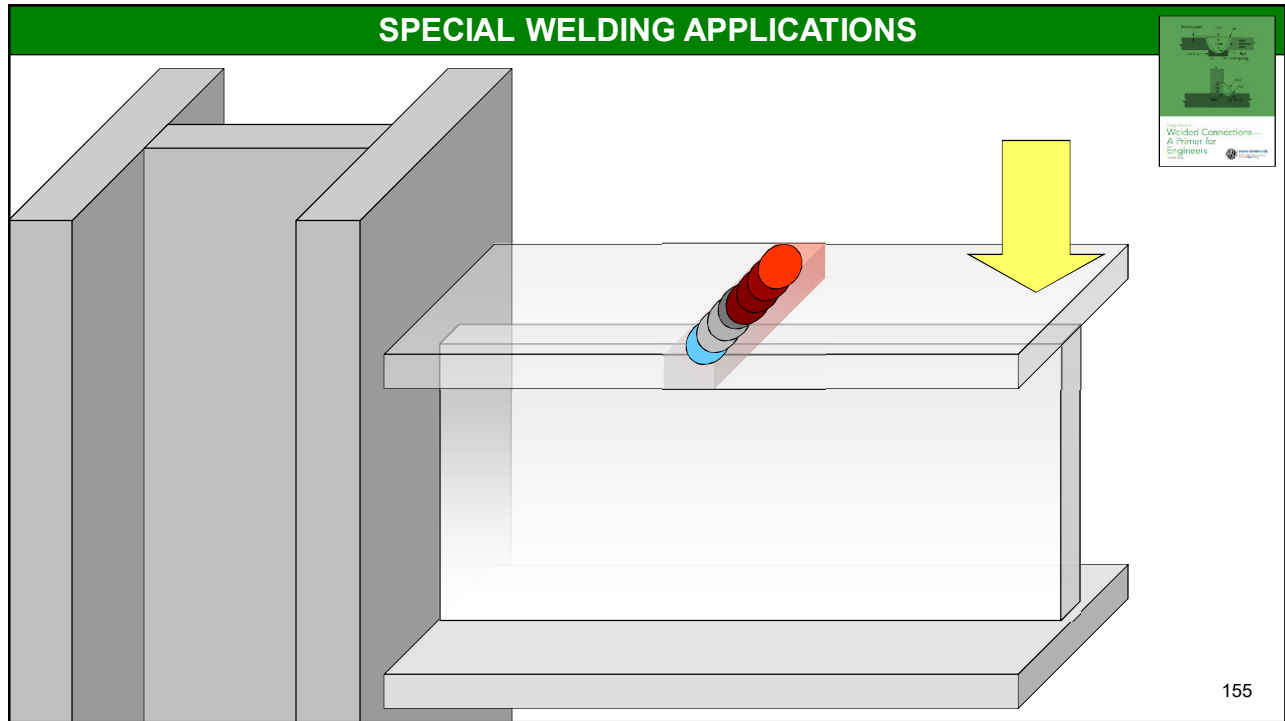
- Historic steels
- ➔ • Welding under load
- Fire
- Cold working / strain aging

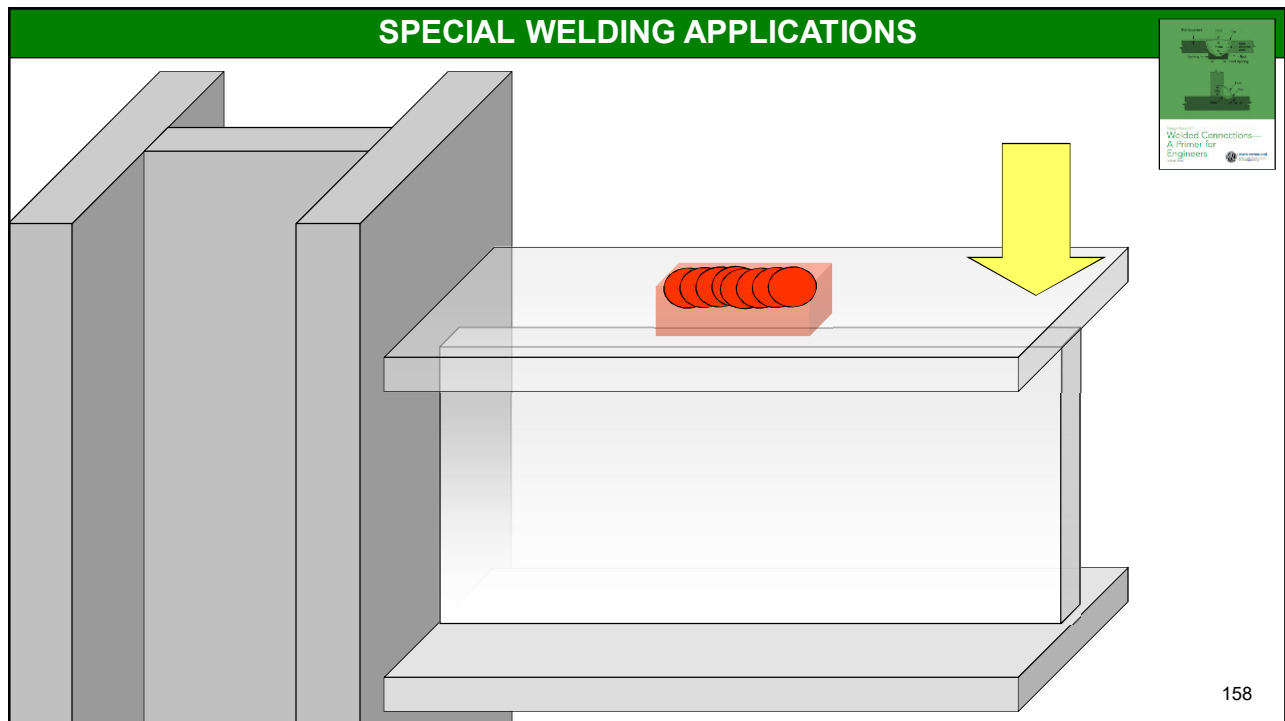
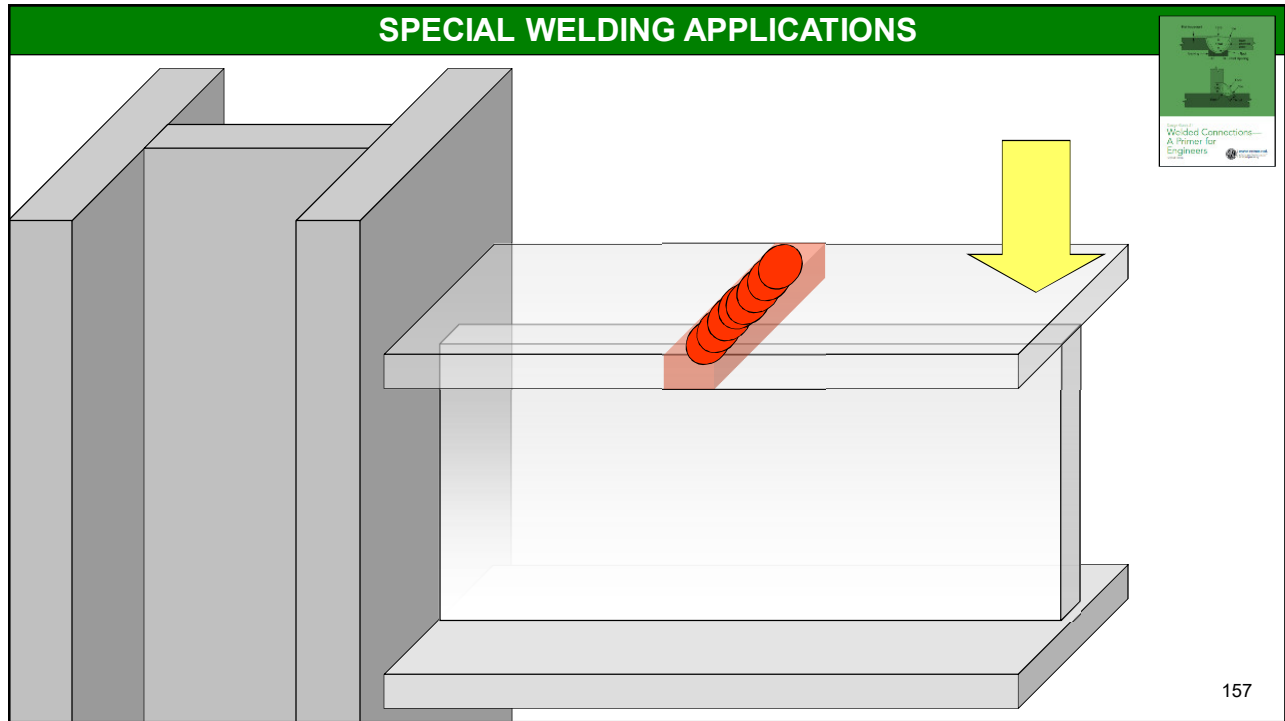


150










SPECIAL WELDING APPLICATIONS

Welded Connections—
A Primer for
Engineers



159


AISC 360-16 Specification for Structural Steel Buildings

**Table A-4.2.1
Properties of Steel at Elevated Temperatures**

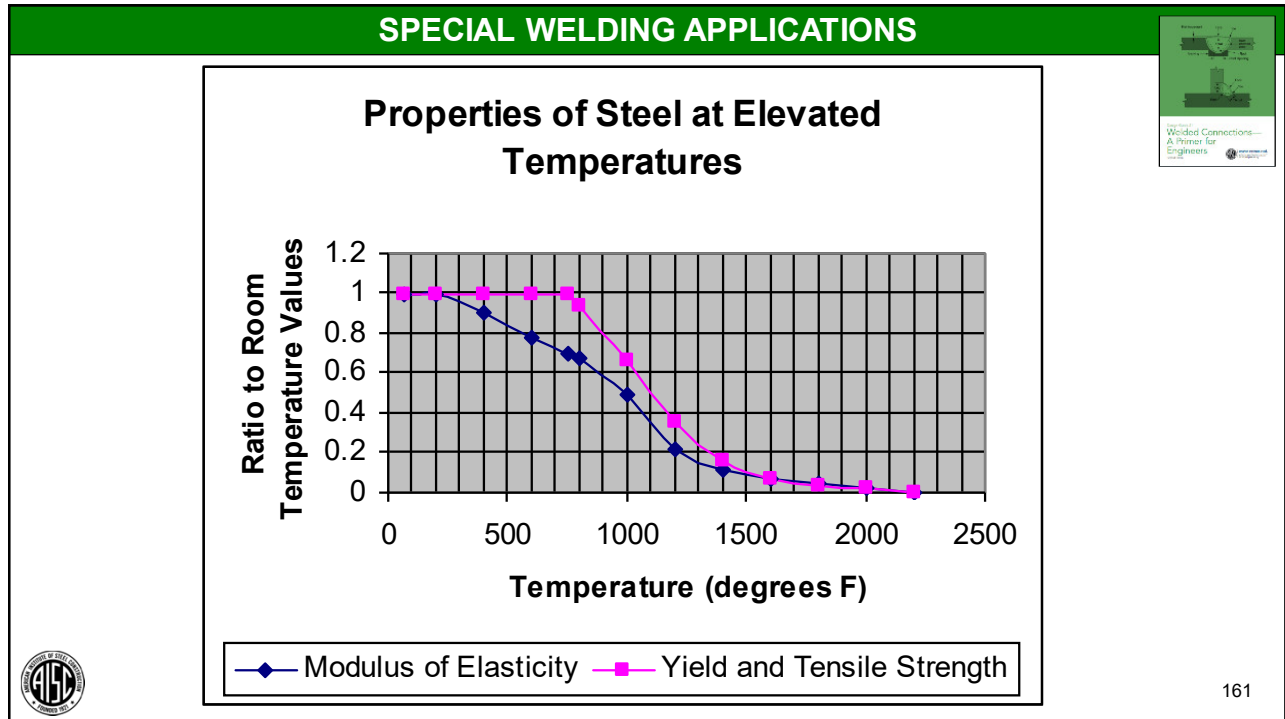
Steel Temperature (°F)[°C]	$k_E = E_m/E$	$k_y = F_{ym}/F_y$	$k_u = F_{um}/F_y$
68 [20]	*	*	*
200 [93]	1.00	*	*
400 [204]	0.90	*	*
600 [316]	0.78	*	*
750 [399]	0.70	1.00	1.00
800 [427]	0.67	0.94	0.94
1000 [538]	0.49	0.66	0.66
1200 [649]	0.22	0.35	0.35
1400 [760]	0.11	0.16	0.16
1600 [871]	0.07	0.07	0.07
1800 [982]	0.05	0.04	0.04
2000 [1093]	0.02	0.02	0.02
2200 [1204]	0.00	0.00	0.00



*Use ambient properties.

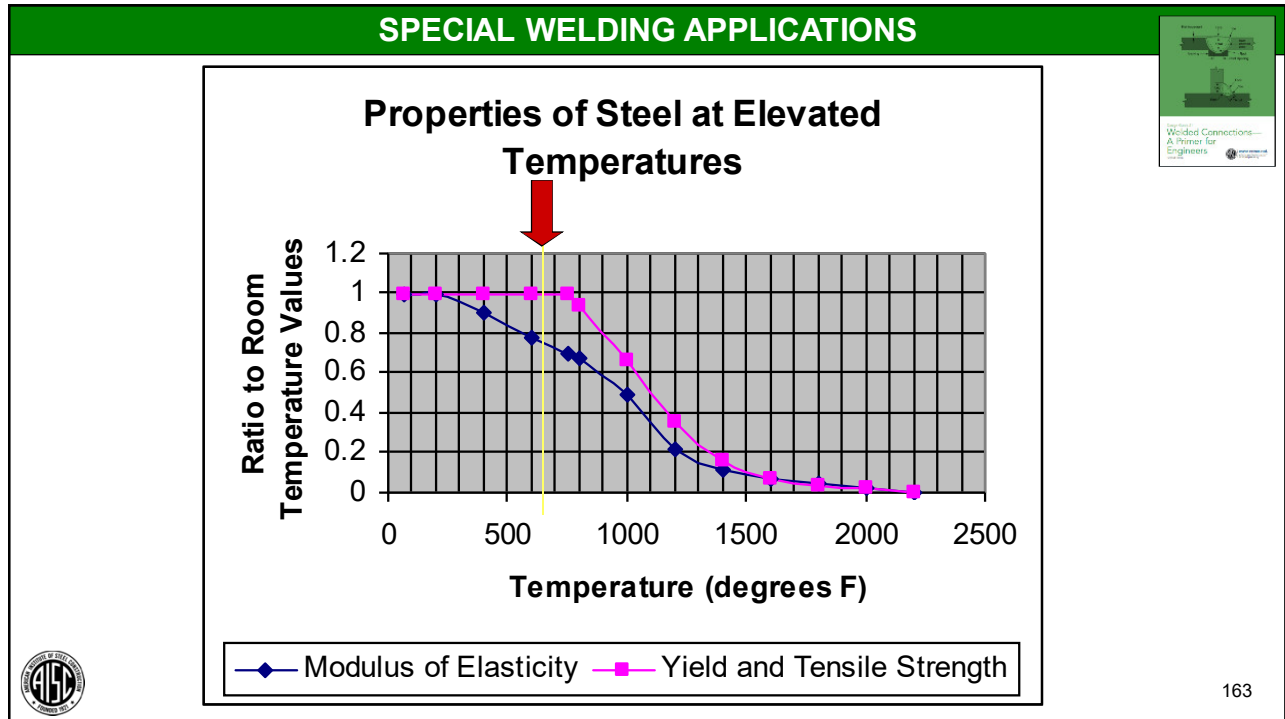
Specification for
Structural Steel
Buildings





160



- ### SPECIAL WELDING APPLICATIONS
- #### Welding on members under load
- The amount of material at temperatures >650 °F is negligible (Blodgett)
 - Only a very small percentage of the cross section experiences reduced properties (Tide)
 - The impact of the weld orientation (longitudinal versus transverse) is typically inconsequential (Ricker)
 - Each situation should be checked
- 
- 
- 162



- ### SPECIAL WELDING APPLICATIONS
- #### 14.9 Welding on Existing Structures
- Historic steels
 - Welding under load
 - ➔ • Fire
 - Cold working / strain aging
- 
- 
- 164

SPECIAL WELDING APPLICATIONS



Welding on Existing Structures

- General precaution: Fire!
 - From combustibles
 - From unintended work circuits
 - Thermal cutting is typically >> problem than welding



165

SPECIAL WELDING APPLICATIONS

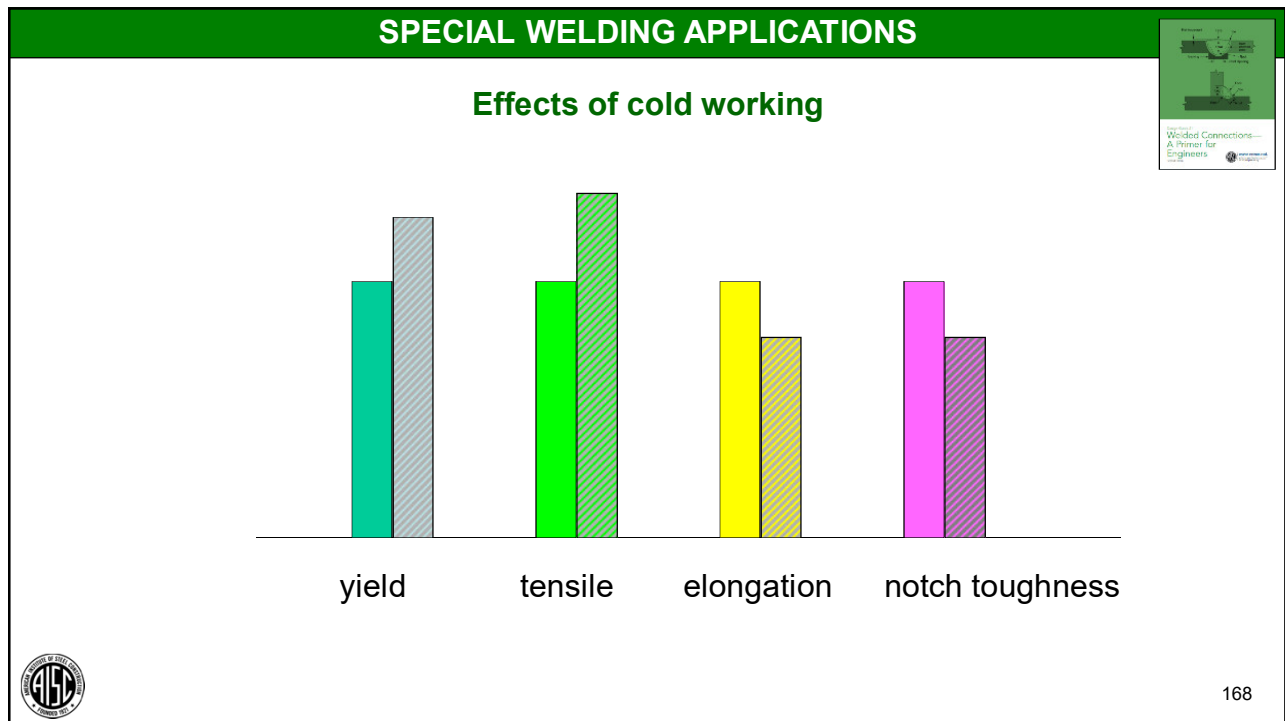
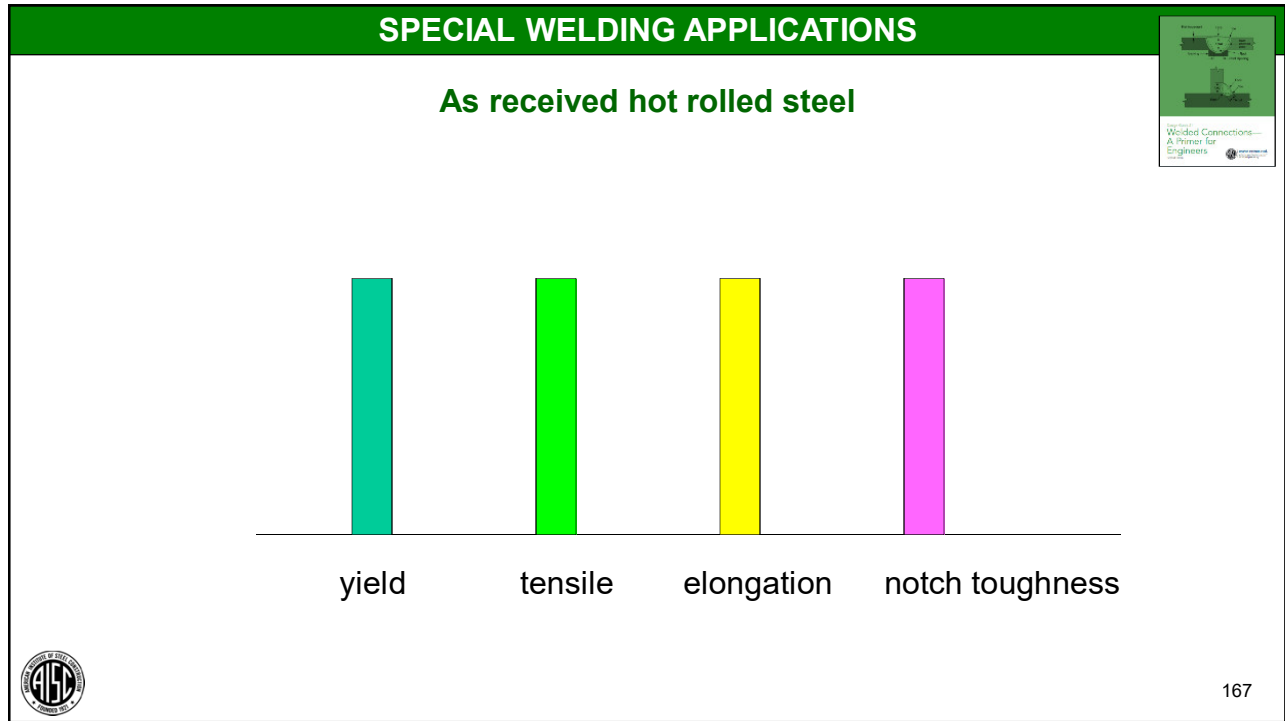


14.9 Welding on Existing Structures

- Historic steels
- Welding under load
- Fire
- ➔ • Cold working / strain aging



166



SPECIAL WELDING APPLICATIONS



Strain Aging

- Occurs when steel is heated to 400-700 °F
- Yield, tensile increase
- Ductility, notch toughness decrease
- Aggravated by presence of “free” nitrogen
- Stress relief helps, but...
 - Typically impractical
 - Depending on alloy, may experience cracking (Cr, Mo, V, B)

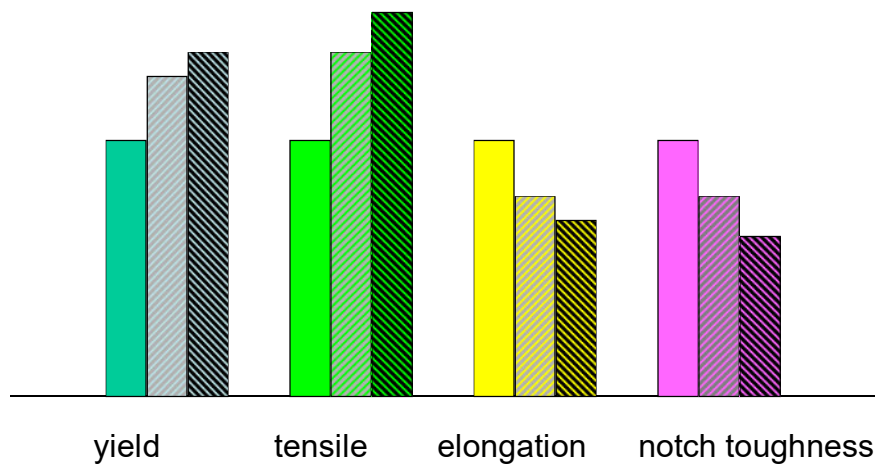


169

SPECIAL WELDING APPLICATIONS



Effects of strain aging



170

SPECIAL WELDING APPLICATIONS



Welding on plastically deformed members

- Reduced notch toughness
 - Make sure material is crack and notch free
- Reduced ductility
 - Minimize practices that increase ductility demand



171

AWS D1.1:2015 STRUCTURAL WELDING CODE



8. Strengthening and Repair of Existing Structures

8.1 General

Strengthening or repairing an existing structure shall consist of modifications to meet design requirements specified by the Engineer. The Engineer shall prepare a comprehensive plan for the work. Such plans shall include, but are not limited to, design, workmanship, inspection, and documentation. Except as modified in this section, all provisions of this code shall apply equally to the strengthening and repairing of existing structures, including heat straightening of distorted members.

8.2 Base Metal

8.2.1 Investigation. Before preparing drawings and specifications for strengthening or repairing existing structures, the types of base metal used in the original

8.3.2 Stress Analysis. An analysis of stresses in the area affected by the strengthening or repair shall be made. Stress levels shall be established for all in-situ dead and live load cases. Consideration shall be made for accumulated damage that members may have sustained in past service.

8.3.3 Fatigue History. Members subject to cyclic loading shall be designed according to the requirements for fatigue stresses. The previous loading history shall be considered in the design. When the loading history is not available, it shall be estimated.

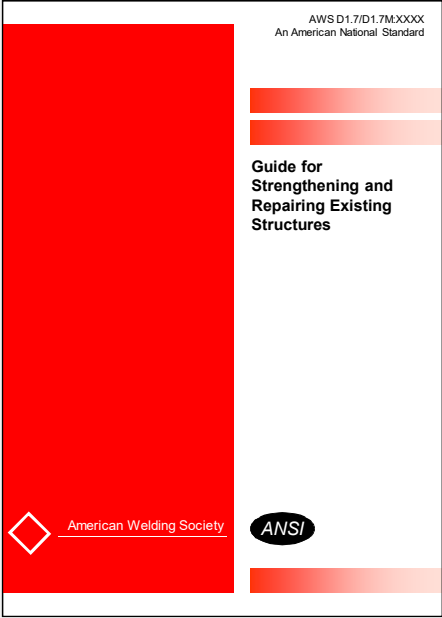
8.3.4 Restoration or Replacement. Determination shall be made whether the repairs should consist of restoring corroded or otherwise damaged parts or of replacing entire members.

8.3.5 Loading During Operations. The Engineer shall



172

AWS D1.7
**Guide for Strengthening and
Repairing Existing Structures**




173

SPECIAL WELDING APPLICATIONS

Welding on Existing Structures: Summary

- May involve historic steel: see DG 21 Chapter 4
- Welding on members under load: Caution
- Fire potential: sparks, resistance heating: Caution
- Welding on cold worked steel: local reduced ductility





174

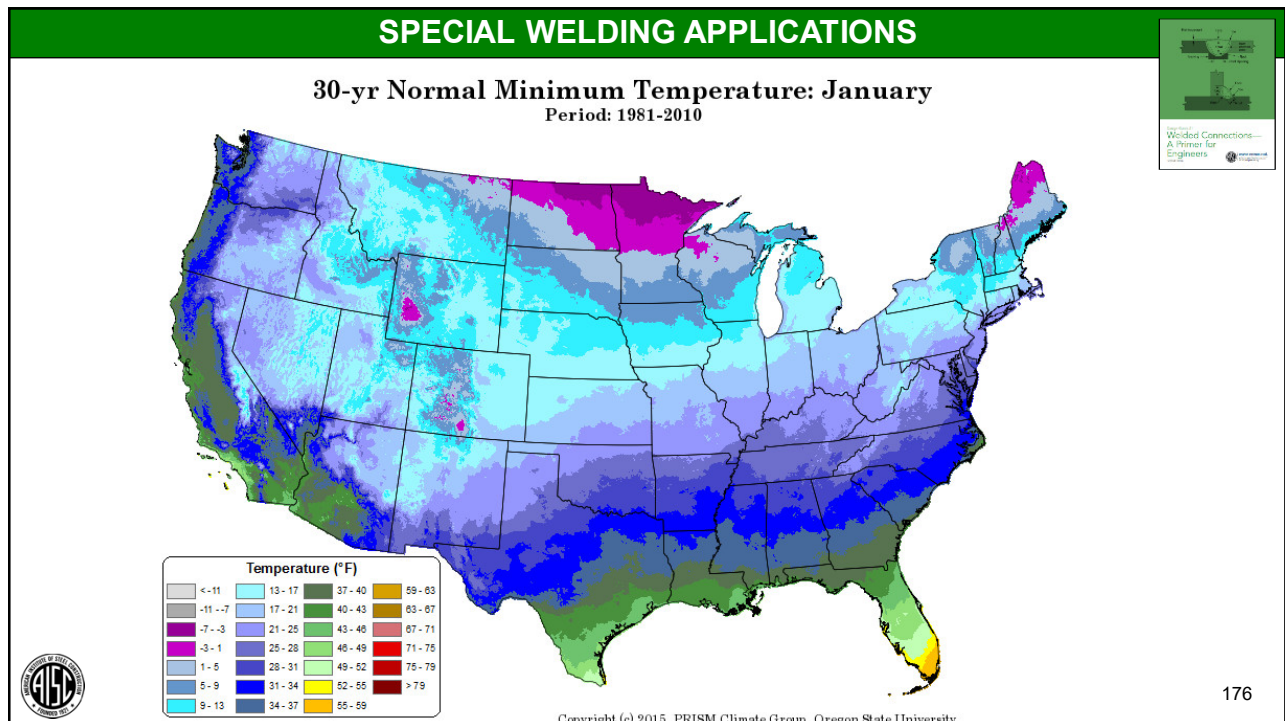
SPECIAL WELDING APPLICATIONS

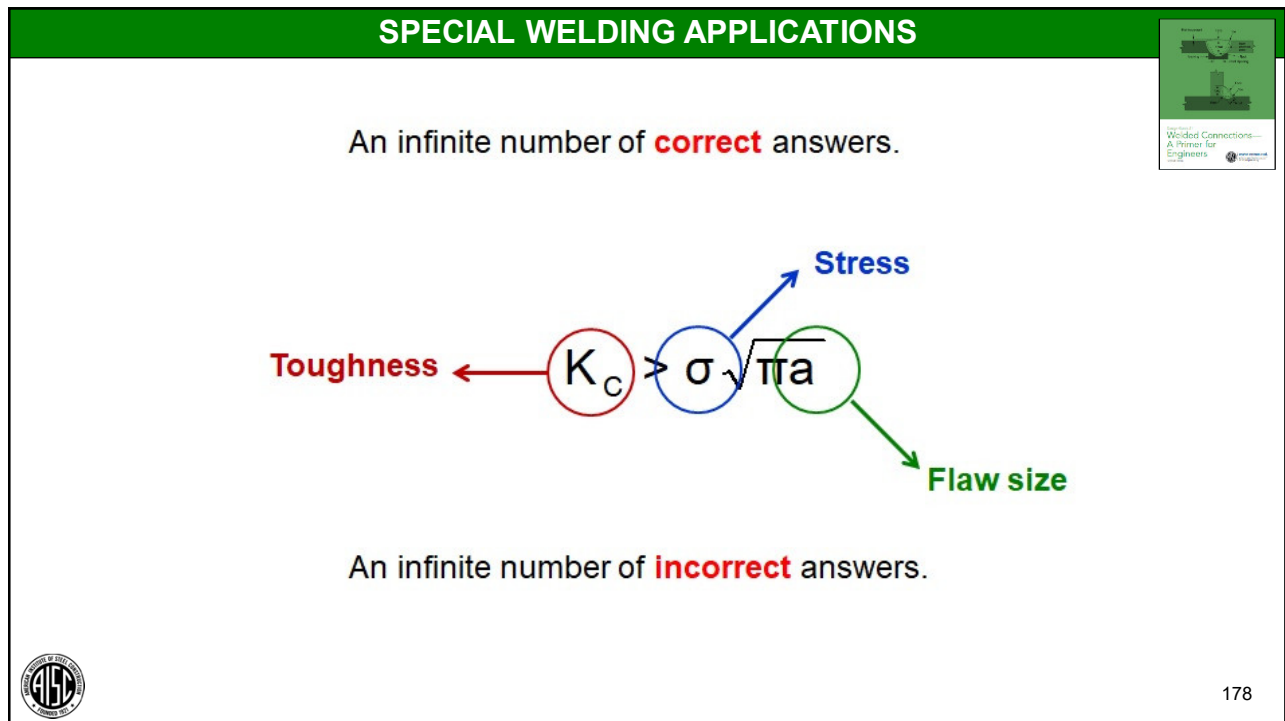
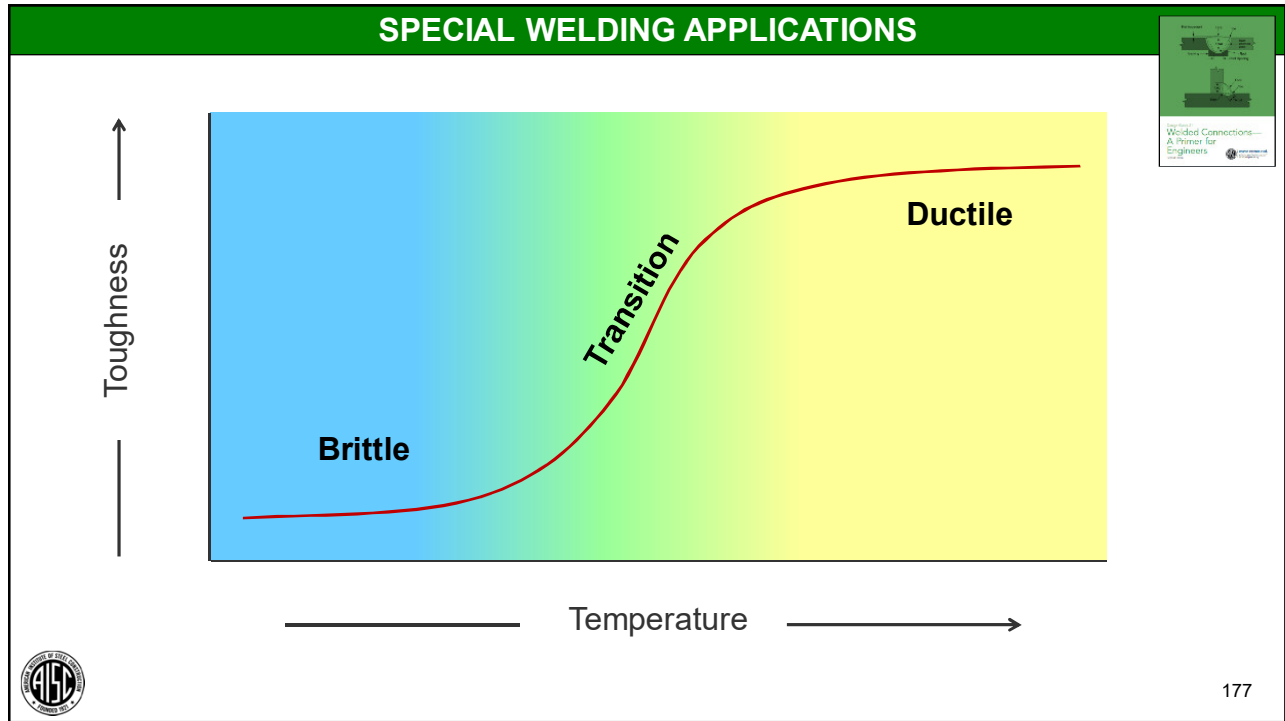
Today's Webinar

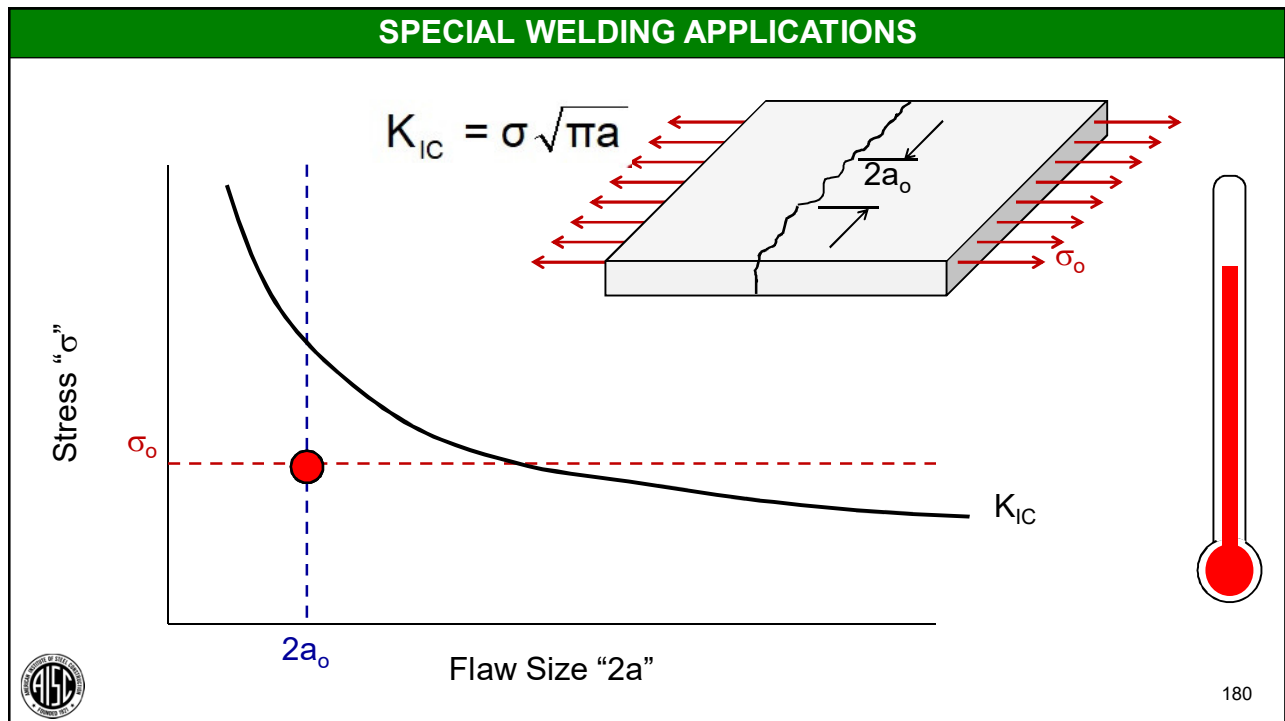
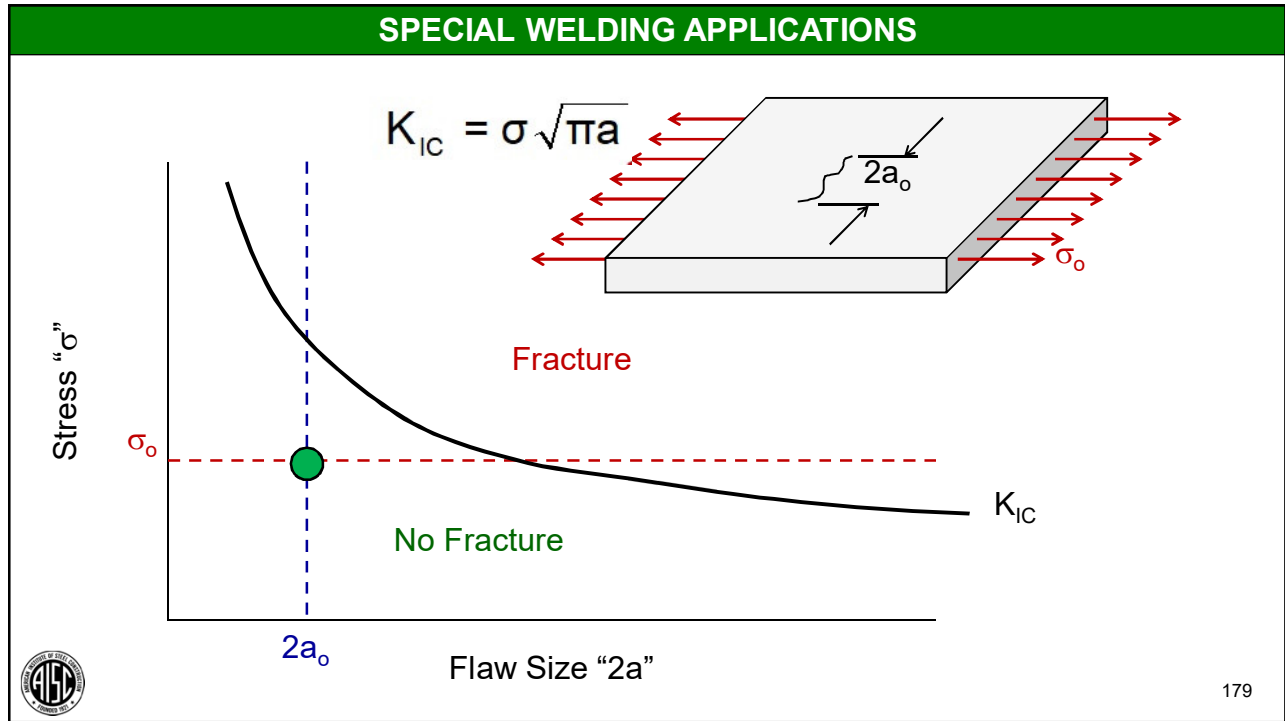
- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- ➔ 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering

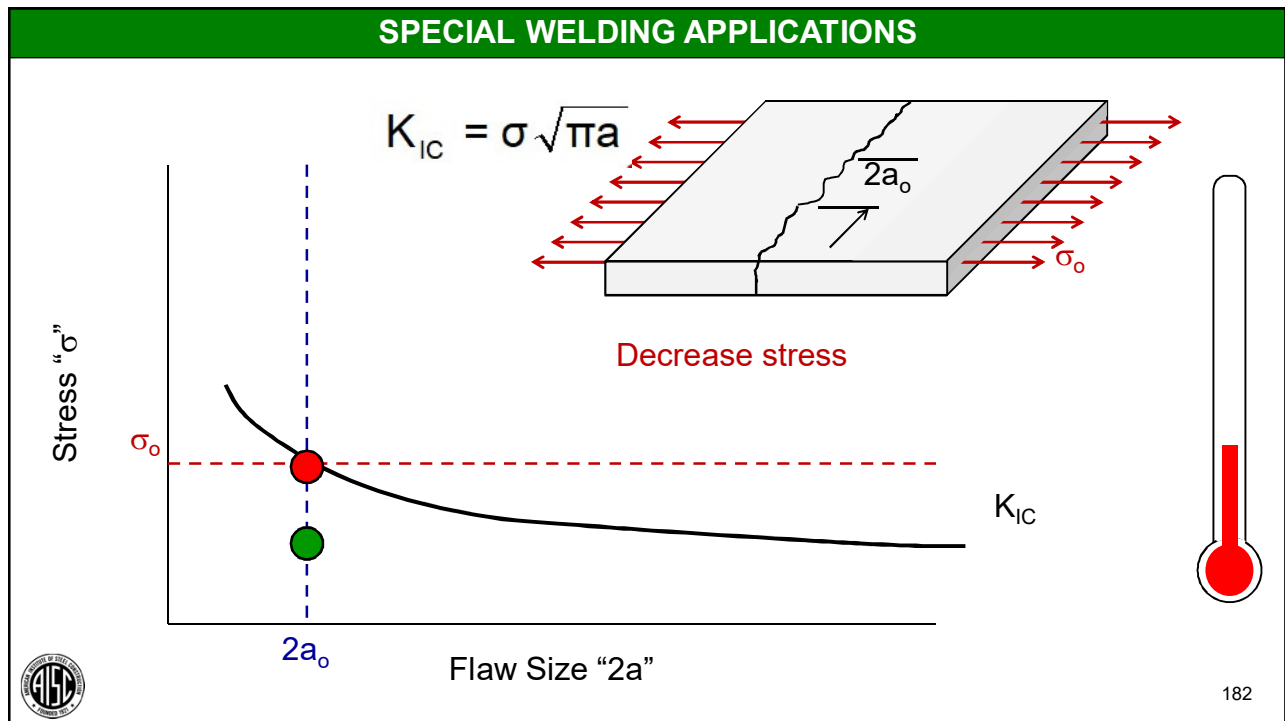
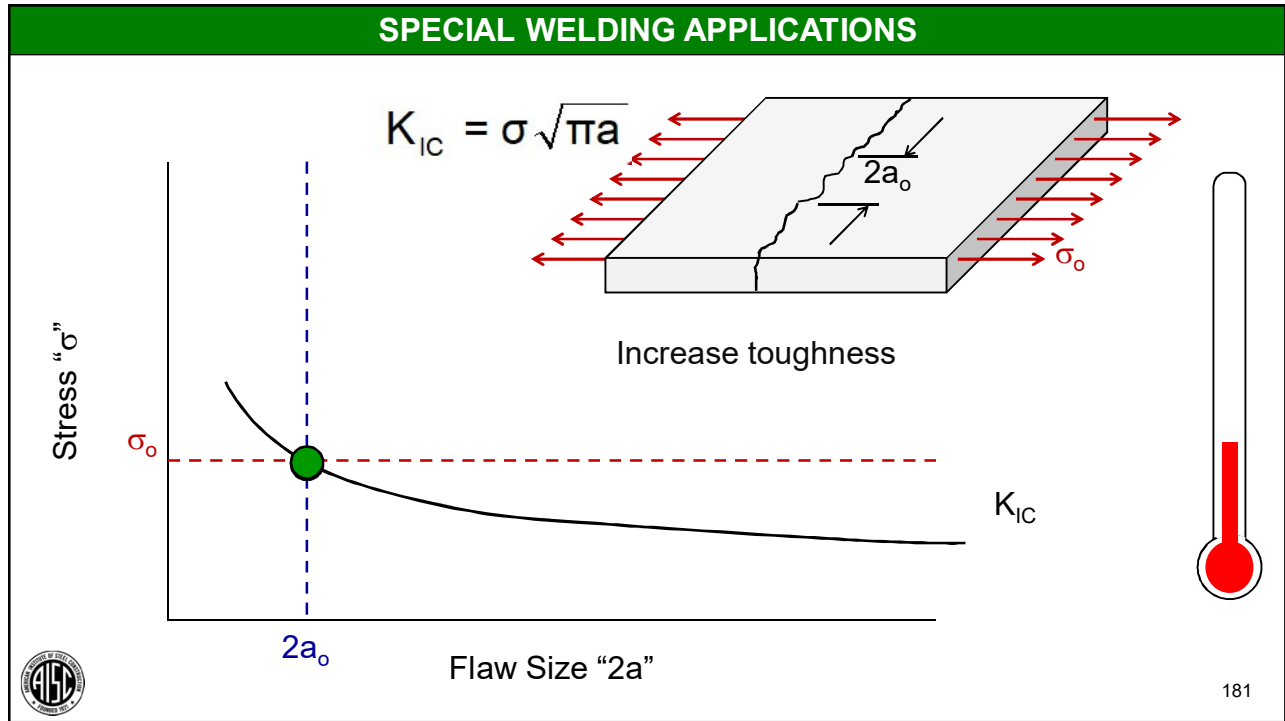


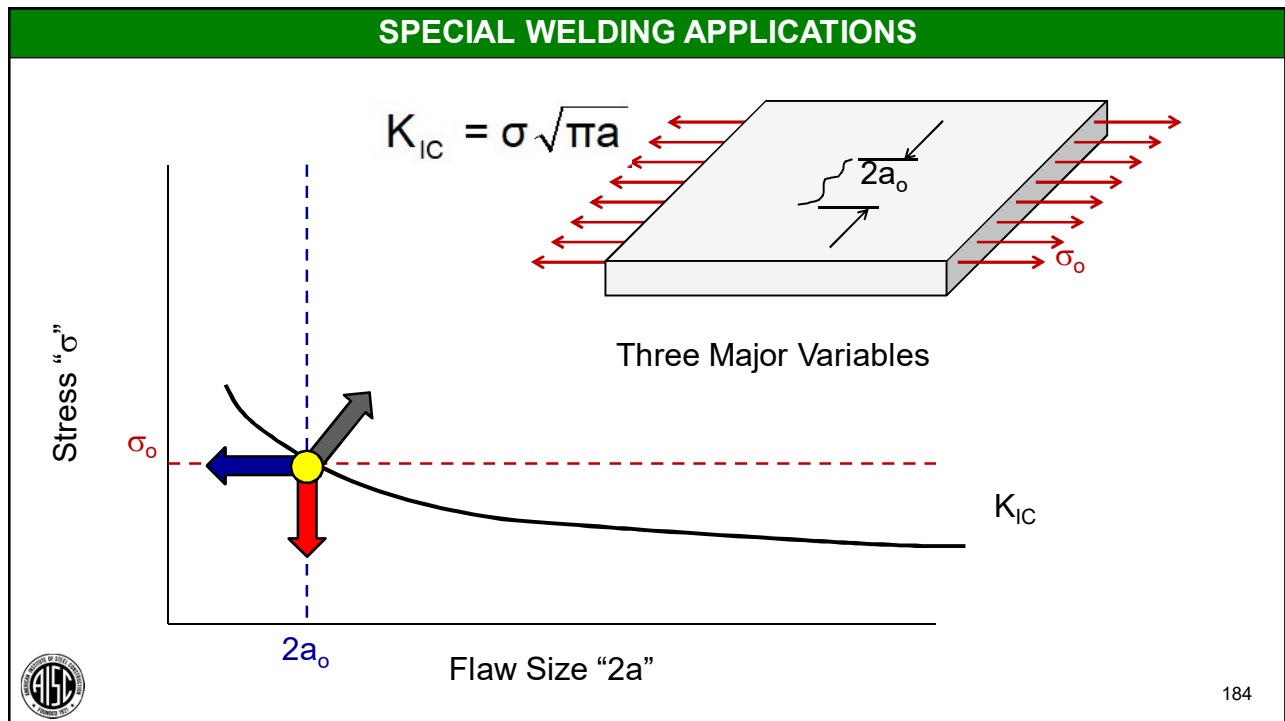
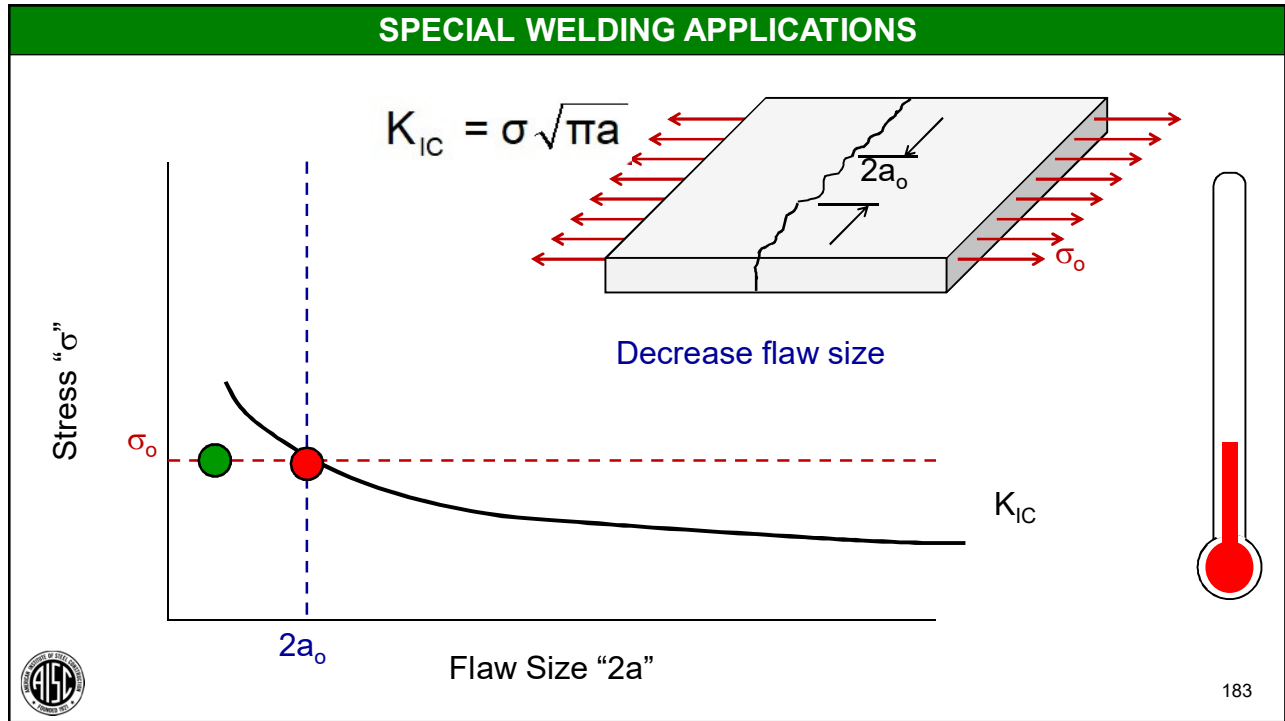
175












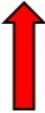
AISC 360-16 Specification for Structural Steel Buildings




Commentary A3. MATERIAL


1a. ASTM Designations

“For especially demanding service conditions such as structures **exposed to low temperatures**, particularly those with impact loading, the specification of **steels with superior notch toughness may be warranted.**”

 $K_c > \sigma\sqrt{\pi a}$

 185

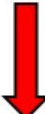
AISC 360-16 Specification for Structural Steel Buildings




Commentary A3. MATERIAL


1a. ASTM Designations

“**Good workmanship** and **good design details** incorporating joint geometry that **avoids severe stress concentrations** are generally the **most effective means of providing fracture-resistant construction.**”





$K_c > \sigma\sqrt{\pi a}$ 

 186


SPECIAL WELDING APPLICATIONS



Cold Temperature Applications: Summary

For “good design details” and joint geometries that “avoid severe stress concentrations”, consider Appendix 3 Design for Fatigue.

 187

SPECIAL WELDING APPLICATIONS



Today's Webinar

- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
-  14.15 Heat Shrinking
- 14.16 Buttering

 188

SPECIAL WELDING APPLICATIONS



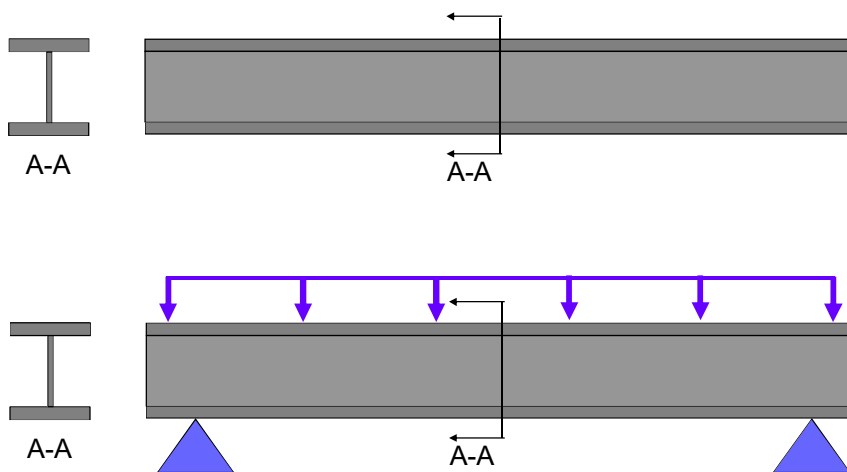
Heat Shrinking

- Used to curve straight steel
- Used to straighten bent steel
- Used to correct for distortion
- Also known as “heat straightening”



189


SPECIAL WELDING APPLICATIONS




190

SPECIAL WELDING APPLICATIONS

The diagram illustrates the shear flow in a beam with a central triangular weld. The top diagram shows a red weld with yellow arrows indicating shear flow. The bottom diagram shows a brown weld with yellow arrows indicating shear flow. Both diagrams include a cross-section 'A-A' and a shear flow diagram 'A-A'.



Welded Connections—
A Primer for
Engineers




191

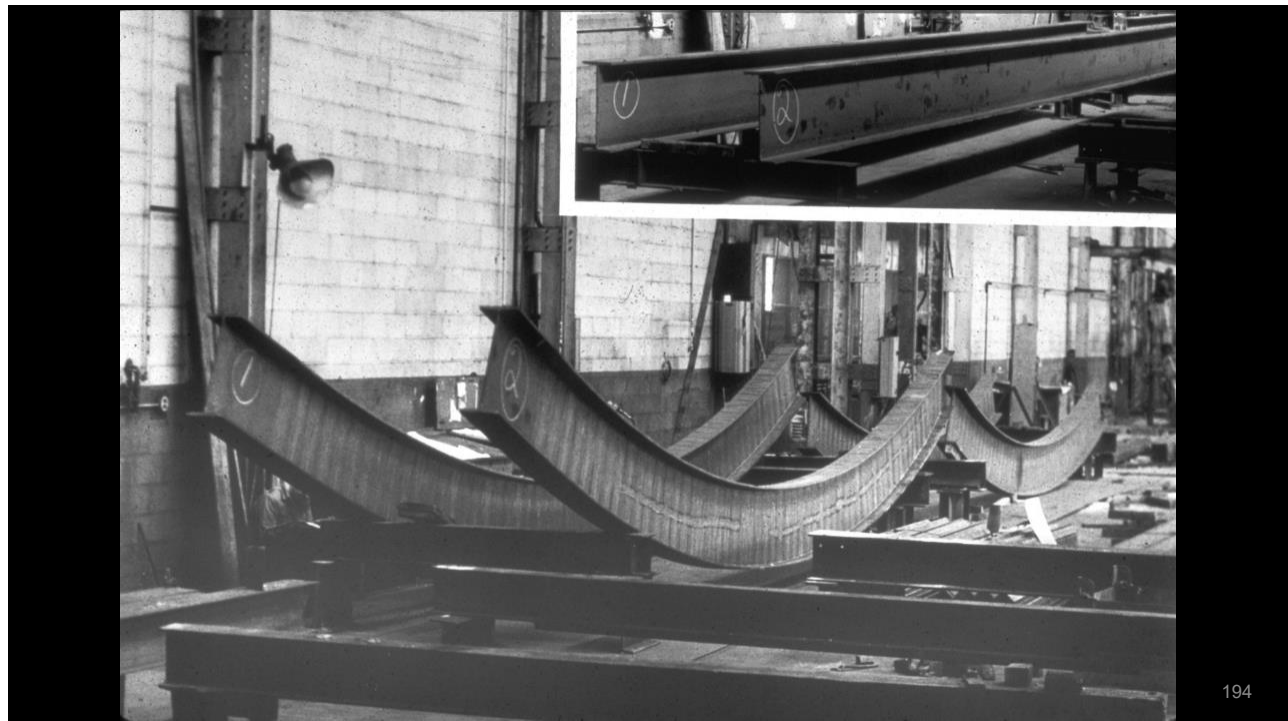
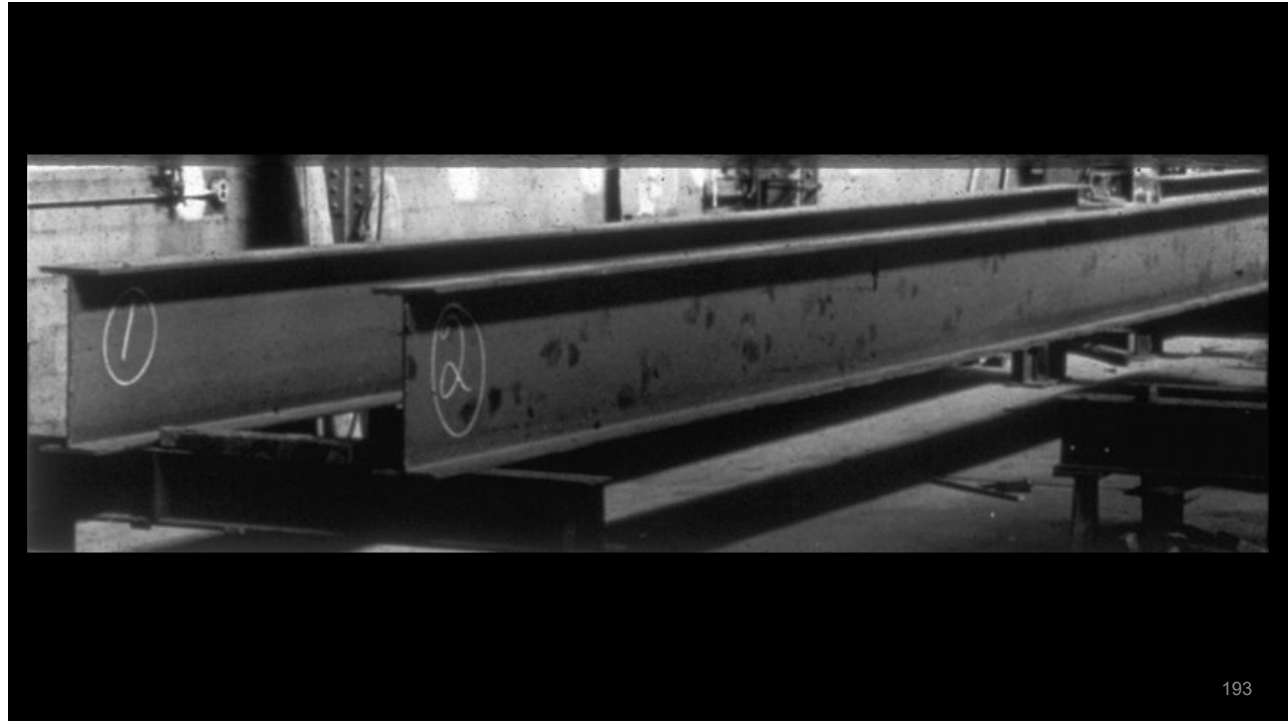
SPECIAL WELDING APPLICATIONS

The diagram illustrates the deformation of a beam under a uniformly distributed load. The top diagram shows the beam with a central triangular weld and a shaded area indicating the weld's contribution to the beam's strength. The bottom diagram shows the beam with a curved shape and a shaded area indicating the weld's contribution to the beam's strength.


Welded Connections—
A Primer for
Engineers



192





SPECIAL WELDING APPLICATIONS

Heat Shrinking

- 1200 °F temperature limit for hot rolled steels
- 1100 °F temperature limit for quenched and tempered steels
- Pre-stress of up to 50% of room temperature yield (Avent)



AWS D1.1:2015 STRUCTURAL WELDING CODE

5.25.2 Localized Heat Repair Temperature Limitations.

Members distorted by welding shall be straightened by mechanical means or by application of a limited amount of localized heat. The temperature of heated areas as measured by approved methods shall not exceed 1100°F [600°C] for quenched and tempered steel nor 1200°F [650°C] for other steels. The part to be heated for straightening shall be substantially free of stress and from external forces, except those stresses resulting from the mechanical straightening method used in conjunction with the application of heat.



197

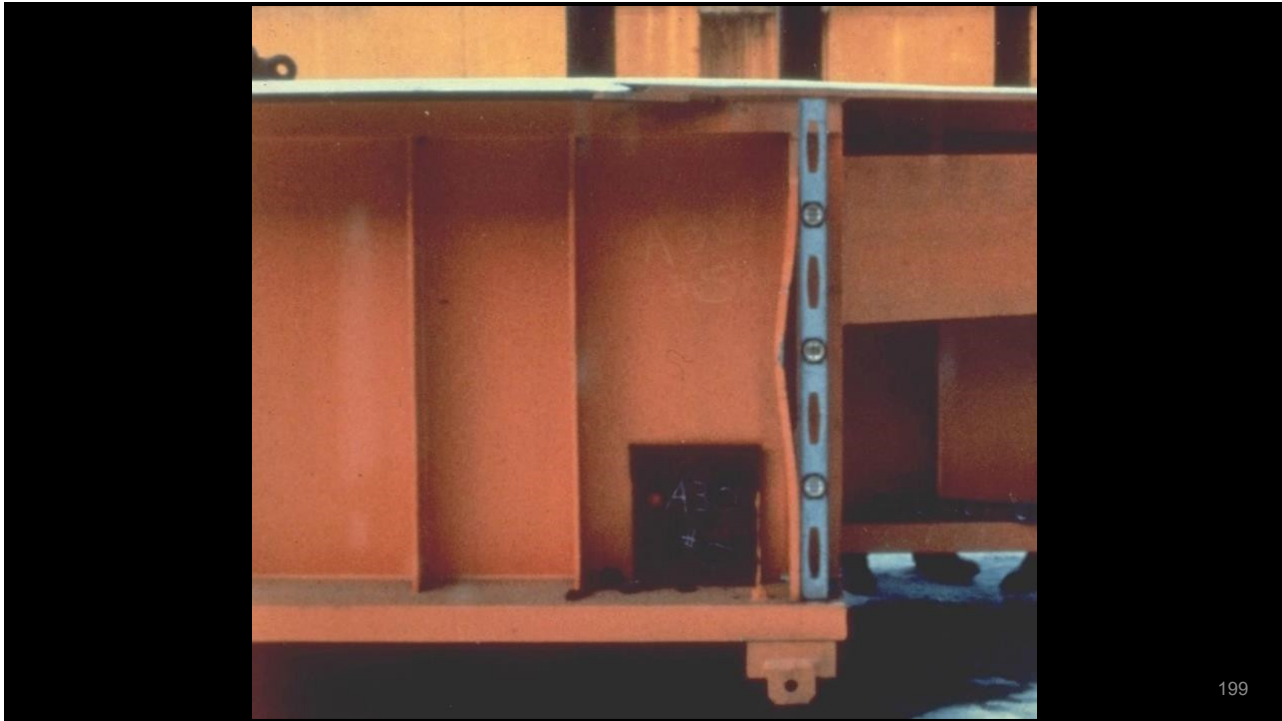
SPECIAL WELDING APPLICATIONS

Heat Shrinking

- For new steel being curved
 - No change in modulus of elasticity (E)
 - Slight increase in yield and tensile strength
 - 10-25% increase in ductility
- For bent steel being straightened
 - Yield strength increases 10%
 - Tensile strength increases 4-6%



198



199



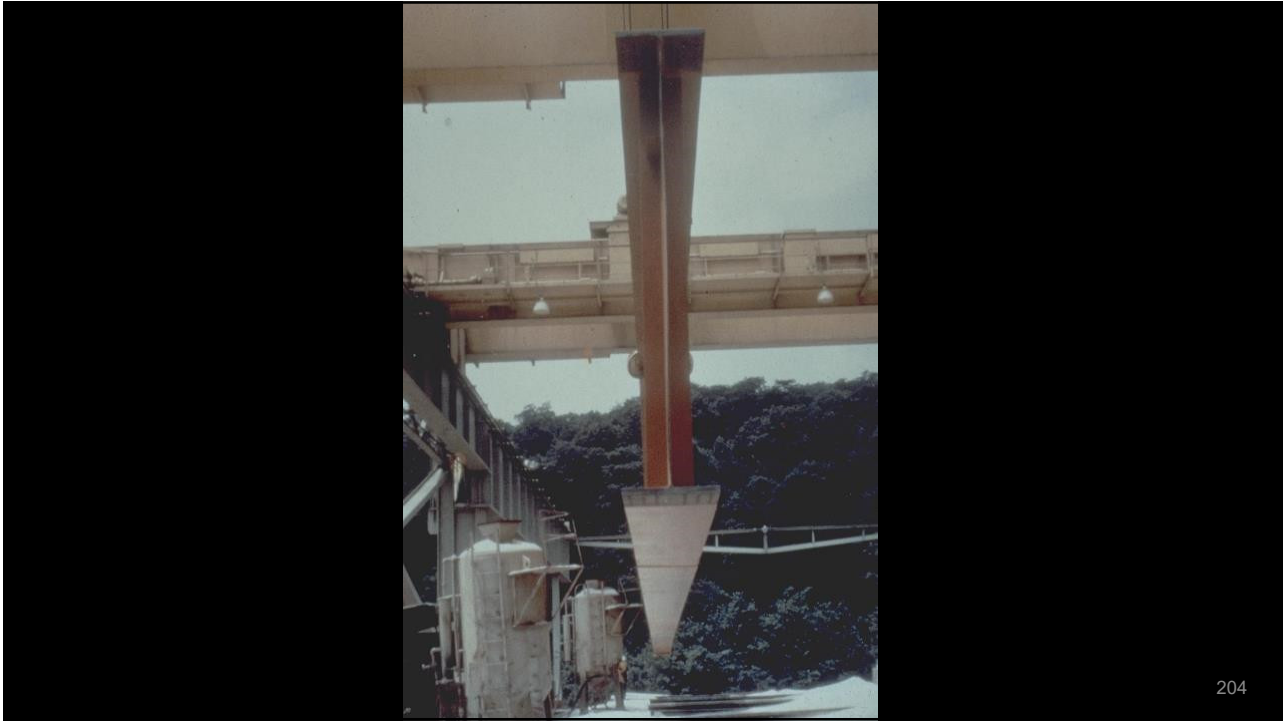
200

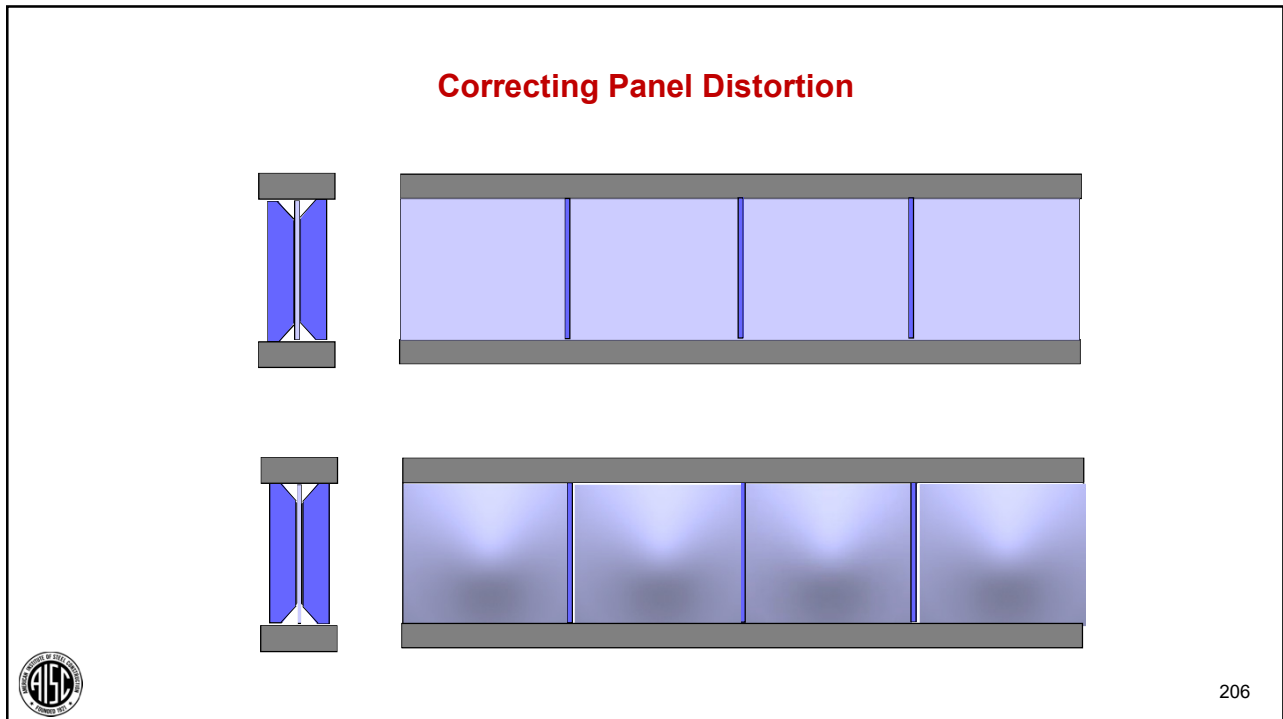
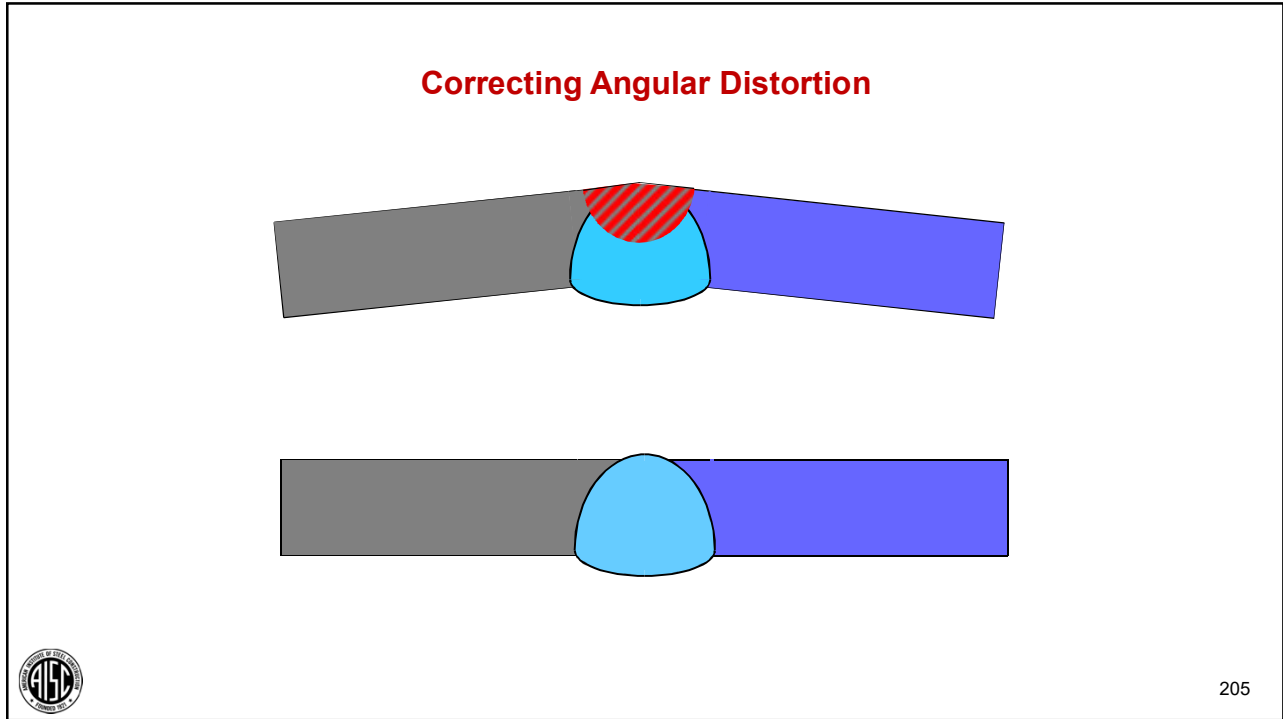


201

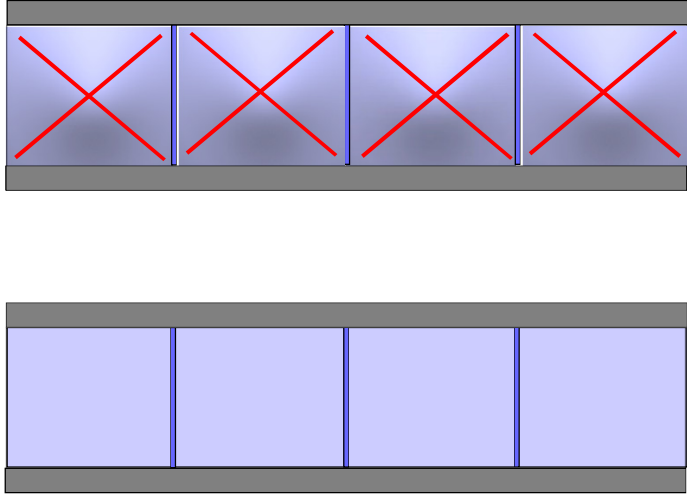


202






Correcting Panel Distortion




The diagram illustrates the process of correcting panel distortion. The top portion shows a horizontal panel divided into four rectangular sections. Each section is marked with a large red 'X', indicating that the panels are distorted or warped. The bottom portion shows the same panel after correction, now flat and straight, with the red 'X' marks removed.




207

SPECIAL WELDING APPLICATIONS



Heat Shrinking: Summary

- Used for shaping and straightening steel
- Code limits on temperatures
- Material is not damaged if properly done



208

SPECIAL WELDING APPLICATIONS

Today's Webinar

- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- ➔ 14.16 Buttering



209



SPECIAL WELDING APPLICATIONS

BUTTERING



210



AWS STANDARD WELDING TERMS & DEFINITIONS (A3.0:2010)



buttering.

A surface variation depositing surfacing metal on one or more surfaces to provide metallurgically compatible weld metal for the subsequent completing of the weld.



211

SPECIAL WELDING APPLICATIONS

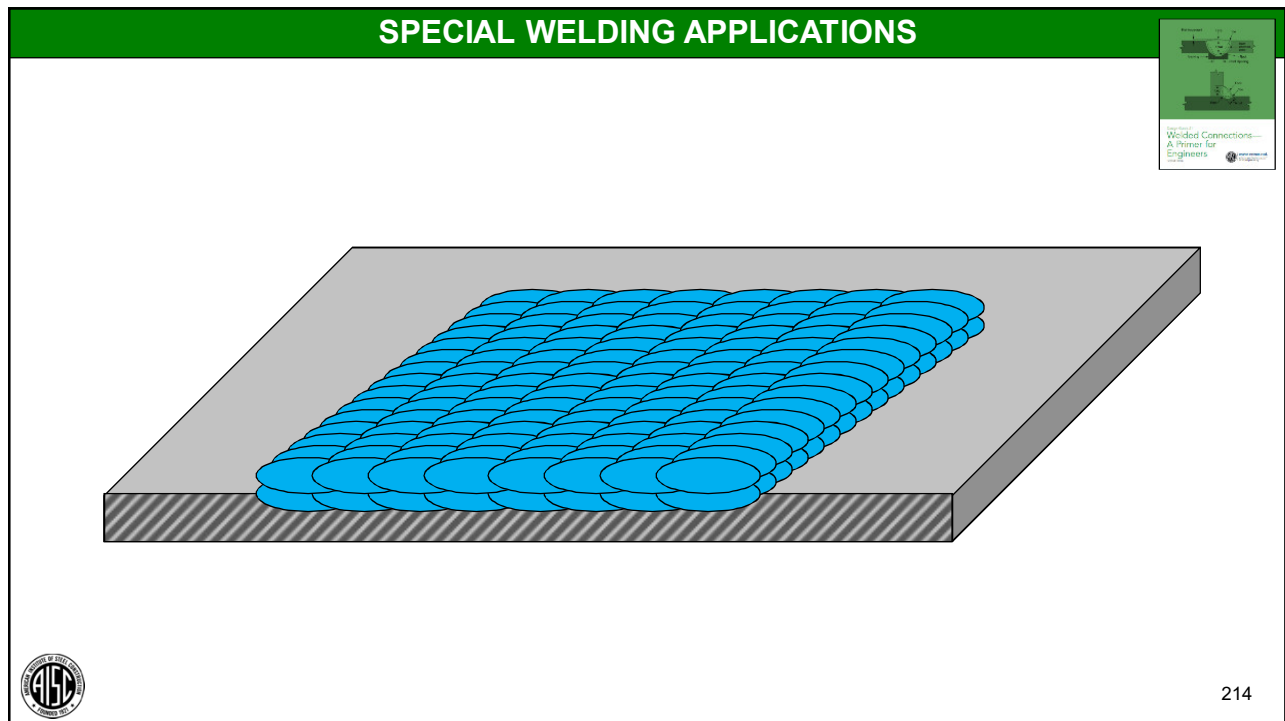
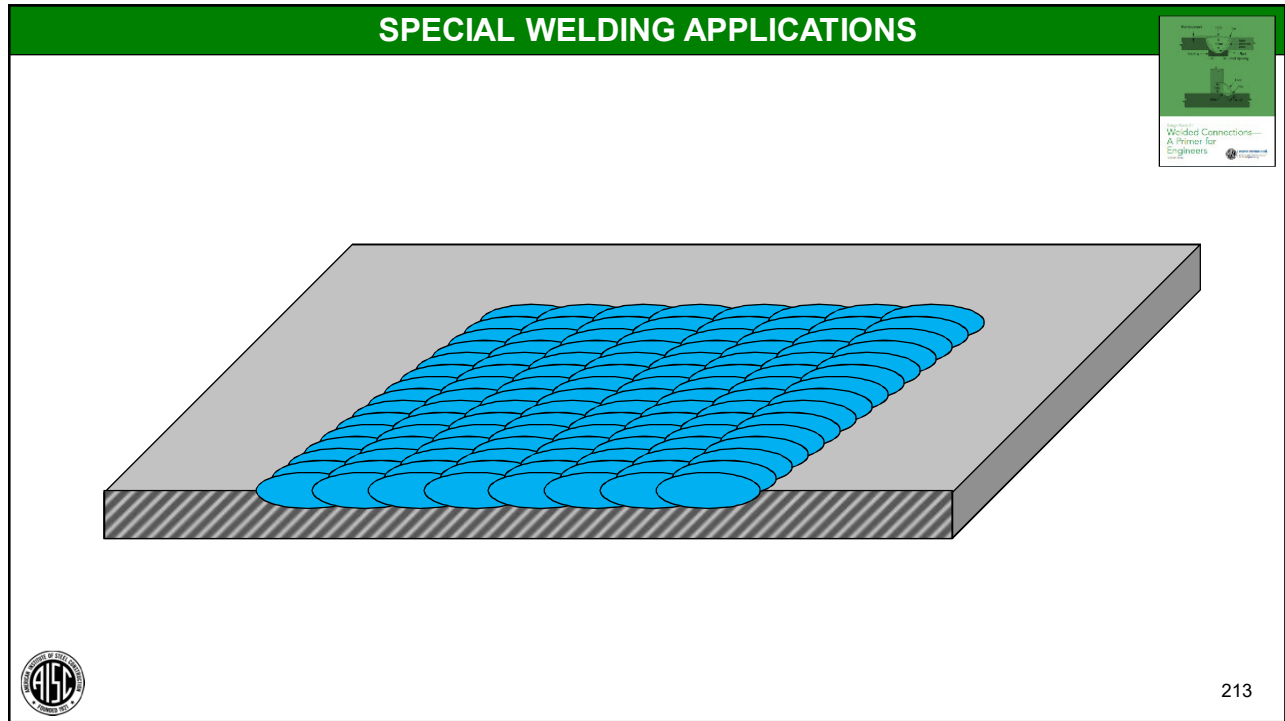


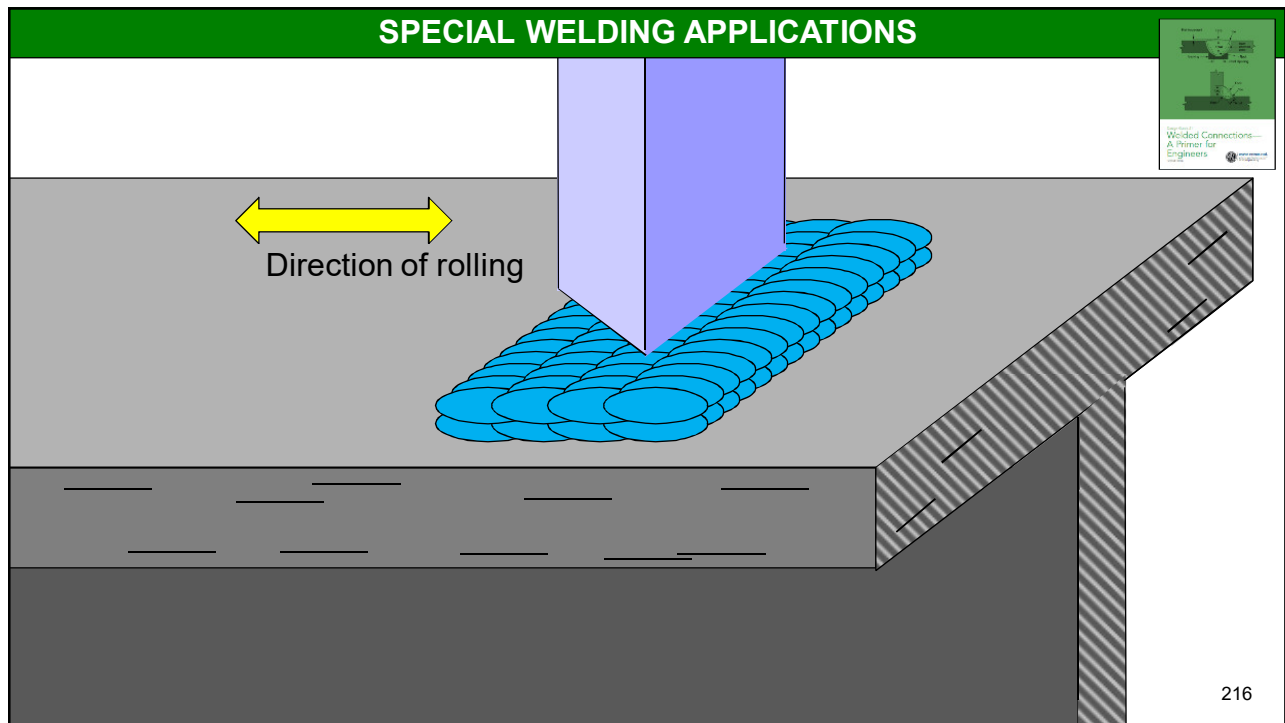
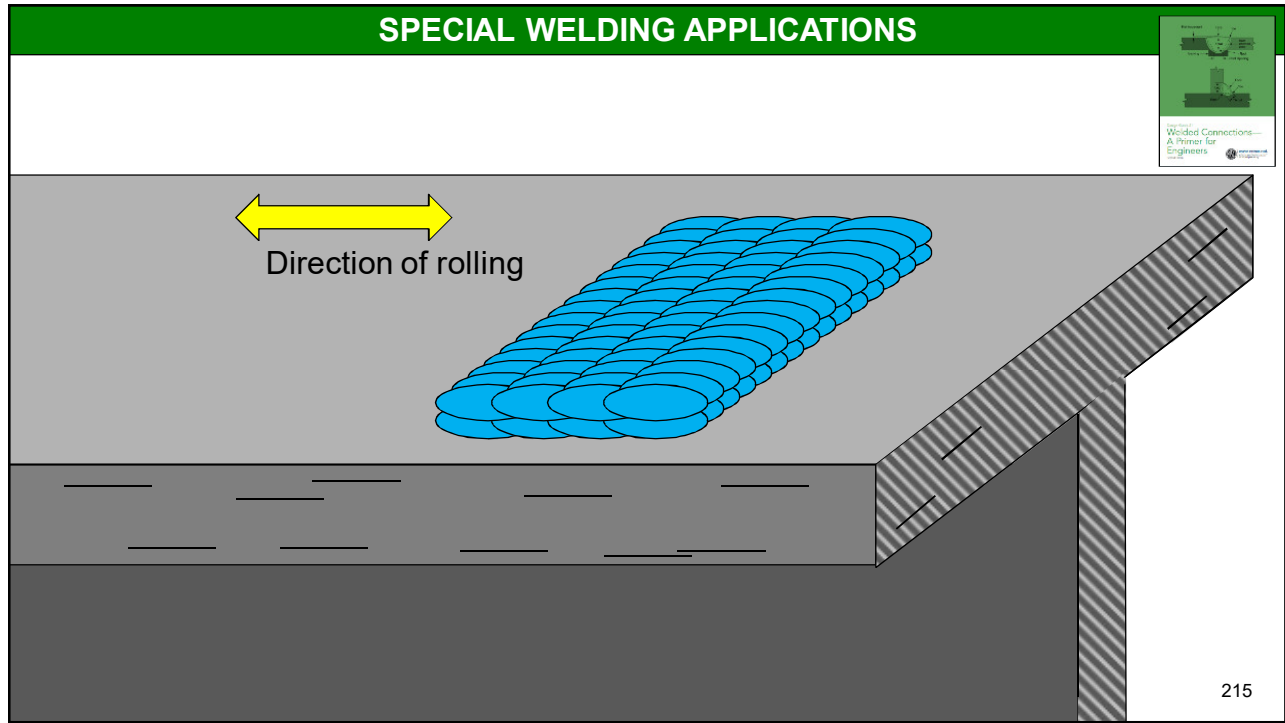
Buttering is used to:

- Mitigate lamellar tearing tendencies
- Build up the faces of groove weld joint cavities where root openings are excessive
- Restore material from steel that was damaged by corrosion
- Enable welding on “hard to weld” steels



212







SPECIAL WELDING APPLICATIONS

Buttering Solution

Sensitive Detail Buttered Detail





217

SPECIAL WELDING APPLICATIONS

Buttering Guidelines

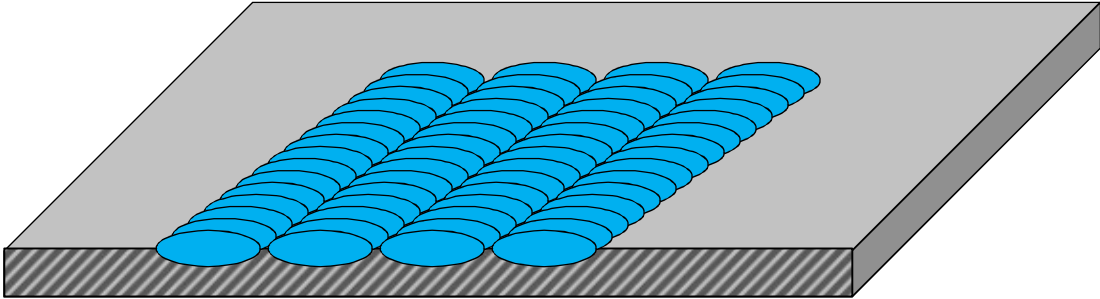
- Deposit butter layers with the same care and controls used for joining welds (WPSs, qualified welders, in process visual inspection, etc.)
- Overlap bead by approximately 50%





218

SPECIAL WELDING APPLICATIONS

Non-preferred: no overlap



The diagram shows a 3D perspective of a grey rectangular plate. On the top surface, there are two parallel rows of blue, semi-circular weld ripples. The ripples in the two rows are positioned such that they do not overlap at all, with a clear gap between the end of one ripple and the start of the next in the adjacent row.

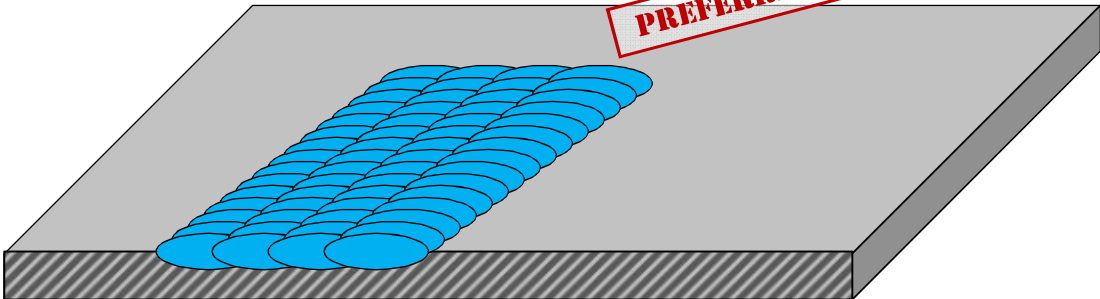


219



SPECIAL WELDING APPLICATIONS

Approximately 50% overlap

PREFERRED



The diagram shows a 3D perspective of a grey rectangular plate. On the top surface, there are two parallel rows of blue, semi-circular weld ripples. The ripples in the two rows overlap by approximately 50% of their length. A red rectangular stamp with the word "PREFERRED" in white, bold, capital letters is placed over the overlapping area.



220

SPECIAL WELDING APPLICATIONS



Buttering Guidelines

- Deposit butter layers with the same care and controls used for joining welds (WPSs. Qualified welders, in process visual inspection, etc.)
- Overlap bead by approximately 50%.
- If NDT of the weld to be made to the butter layer is required, the butter layer should also receive NDT.



221

SPECIAL WELDING APPLICATIONS



Buttering: Summary

- Build up out-of-tolerance joints
- One method to mitigate lamellar tearing
- Buttering procedures should be consistent with the applicable code, including final quality requirements



222

SPECIAL WELDING APPLICATIONS

Today's Webinar

- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering



223



SPECIAL WELDING APPLICATIONS



224



Thank you!

AISC | Questions?



**Smarter.
Stronger.
Steel.**

Individual Session Registrants

PDH Certificates

- You will receive an email on how to report attendance from: registration@aisc.org.
- Be on the lookout: Check your spam filter! Check your junk folder!
- Completely fill out online form. Don't forget to check the boxes next to each attendee's name!



**Smarter.
Stronger.
Steel.**

Individual Session Registrants

PDH Certificates

- Reporting site (URL will be provided in the forthcoming email).
- Username: Same as AISC website username.
- Password: Same as AISC website password.



Smarter.
Stronger.
Steel.

8-Session Registrants

PDH Certificates

One certificate will be issued at the conclusion of all 8 sessions.



Smarter.
Stronger.
Steel.

8-Session Registrants

Access to the quiz

Information for accessing the quiz will be emailed to you by Thursday. It will contain a link to access the quiz. EMAIL COMES FROM NIGHTSCHOOL@AISC.ORG.

Quiz and attendance records

Posted Thursday mornings. www.aisc.org/nightschool -- Click on Current Course Details.

Reasons for quiz

- EEU – You must take all quizzes and the final exam to receive EEU.
- PDHs – If you watch a recorded session, you must pass quiz for PDHs.
- REINFORCEMENT – Reinforce what you learn tonight. Get more out of the course.

Note: If you attend the live presentation, you do not have to take the quizzes to receive PDHs



Smarter.
Stronger.
Steel.

8-Session Registrants

Access to the recording

Information for accessing the recording will be emailed to you by Thursday. The recording will be available for four weeks. (For 8-session registrants only.) EMAIL COMES FROM NIGHTSCHOOL@AISC.ORG.

PDHs via recording

If you watch a recorded session, you must take *and pass* the quiz for PDHs.



Smarter.
Stronger.
Steel.

8-Session Registrants

Night School Resources

Find all your handouts, quizzes and quiz scores, recording access, and attendance information all in one place!



Smarter.
Stronger.
Steel.

8-Session Registrants

Night School Resources

Go to www.aisc.org and sign in.



Login

If you're an existing customer, please enter your username and password.

USERNAME

Enter your username

PASSWORD

Enter your password

Remember Me

DON'T HAVE AN ACCOUNT?

My AISC allows you to access Engineering Journal articles and Design Guides you have downloaded from the bookstore.

[REGISTER NOW](#)



Smarter.
Stronger.
Steel.

8-Session Registrants

Night School Resources

Go to www.aisc.org and sign in.

IN THIS SECTION

- Edit Profile
- My Downloads
- My Pending Quizzes
- My Events
- Order History
- Course History
- Course Resources**

MyAISC

MY PROFILE
Update your contact and address information.
[EDIT PROFILE](#)

MY PURCHASED DOWNLOADS
Access articles and documents that you have purchased.
[VIEW DOWNLOADS](#)

MY COURSE RESOURCES
View online resources for Night School and Live Webinar package registrations.
[VIEW RESOURCES](#)



Smarter.
Stronger.
Steel.

8-Session Registrants

Night School Resources

EDUCATION PUBLICATIONS NASCC: THE STEEL CONFERENCE STEEL SOLUTIONS CENTER AWARDS AND COMPETITIONS TECHNICAL RESOURCES

AISC

AISC > MYAISC > COURSE RESOURCES

Course Resources


Event	Start Date
NS 13 8-Session Package-Night School 13 - Design of Industrial Buildings	1/30/2017 7:00:00 PM
NS 14 8-Session Package-Night School 14 - Fundamentals of Stability	6/5/2017 7:00:00 PM



Smarter.
Stronger.
Steel.

8-Session Registrants

Night School Resources




Navigation: EDUCATION, PUBLICATIONS, NASCC: THE STEEL CONFERENCE, SAFETY, STEEL SOLUTIONS CENTER, AWARDS AND COMPETITIONS, RESEARCH LIBRARY

Night School 13: Design of Industrial Buildings

8-SESSION PACKAGE RESOURCES

Event	Date	Handouts	Video	Quiz	Attendance
NS13 - Design Criteria	1/30/2017 7:00:00 PM	Handouts	View Passcode: NS13DSN	Pass Score: 80	Pending
NS13 - Economic Considerations	2/6/2017 7:00:00 PM	Handouts	Available 02/08/2017 5pm EST	Available 02/08/2017 5pm EST	Pending
NS13 - Lateral Load Systems and Details	2/13/2017 7:00:00 PM	Handouts	Available 02/15/2017 5pm EST	Available 02/15/2017 5pm EST	Pending
NS13 - Preliminary Design Procedures	2/27/2017 7:00:00 PM	Handouts	Available 03/01/2017 5pm EST	Available 03/01/2017 5pm EST	Pending
NS13 - Crane Girder Design and Frame Analysis	3/6/2017 7:00:00 PM	Handouts	Available 03/08/2017 5pm EST	Available 03/08/2017 5pm EST	Pending
NS13 - Frame Member and Connection Design	3/13/2017 7:00:00 PM	Handouts	Available 03/15/2017 5pm EST	Available 03/15/2017 5pm EST	Pending
NS13 - Transfer Crane Girder & Longitudinal Bldg Bracing Dsn	3/27/2017 7:00:00 PM	Handouts	Available 03/29/2017 5pm EST	Available 03/29/2017 5pm EST	Pending



Smarter. Stronger. Steel.

8-Session Registrants

Night School Resources

- Weekly “quiz and recording” email.
- Weekly updates of the master quiz and attendance record, found at www.aisc.org/nightschool21. Scroll down to Quiz and Attendance records.
 - Updated on Thursday mornings.



8-Session Registrants

Night School Resources

- Webinar connection information
 - Reminder email sent out Tuesday mornings
- Links to handouts also found here



AISC | Thank you

