Night School 27: Fundamentals of Welding and Bolting

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Session 3 – Special Welding Applications

October 18, 2021 | Duane K. Miller

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Course Description

Special Welding Applications
October 18, 2021

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.

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Learning Objectives

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

Night School 27: Fundamentals of Welding and Bolting

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Night School 27: Fundamentals of Welding and Bolting

Welding Part 3: Special Welding Applications
October 18, 2021

Duane K. Miller, PE, ScD, The Lincoln Electric Company

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SPECIAL WELDING APPLICATIONS

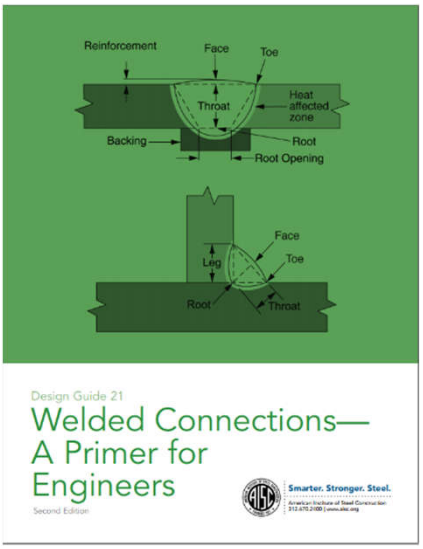
10

AISC Design Guide 21, 2nd Edition

Welded Connections–

A Primer for Engineers

Chapter 14 Special Welding Applications



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

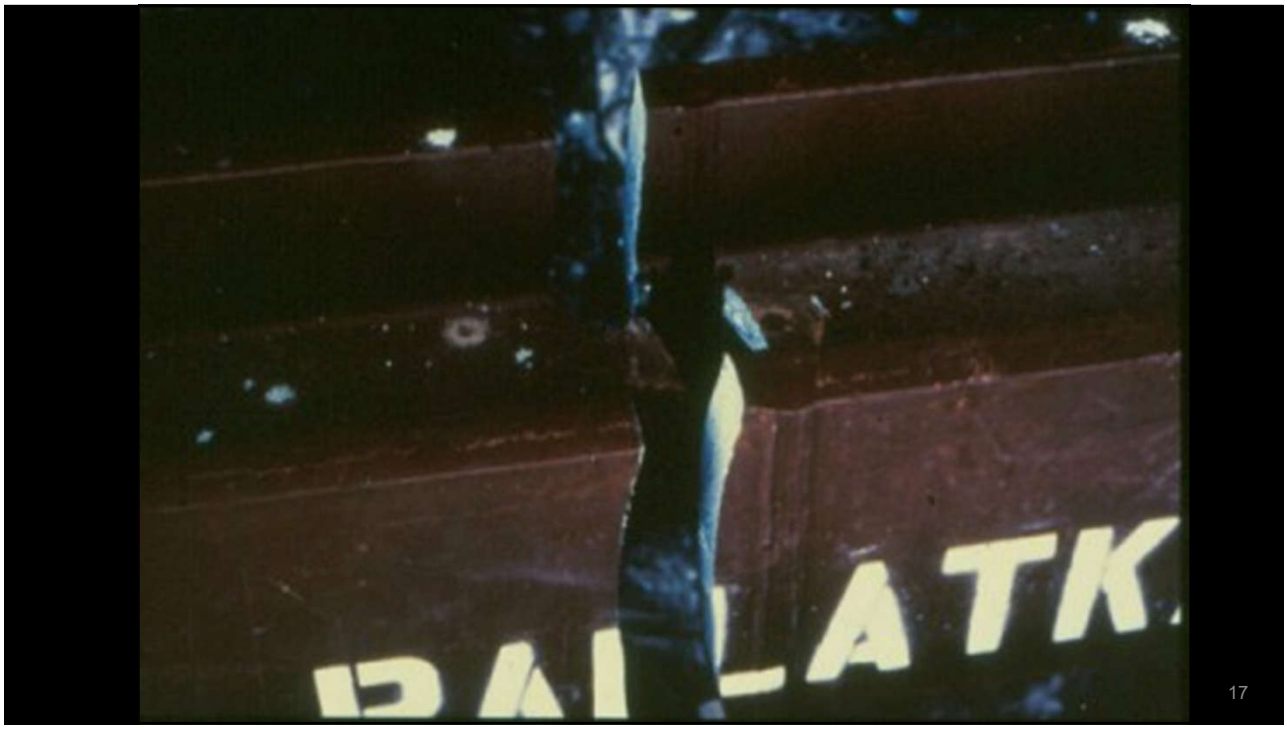
SPECIAL WELDING APPLICATIONS

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



SPECIAL WELDING APPLICATIONS

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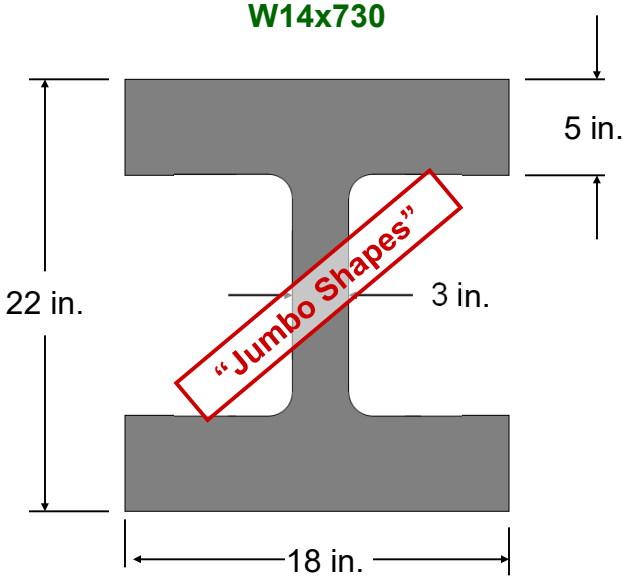


19

AISC 360-16 SPECIFICATION

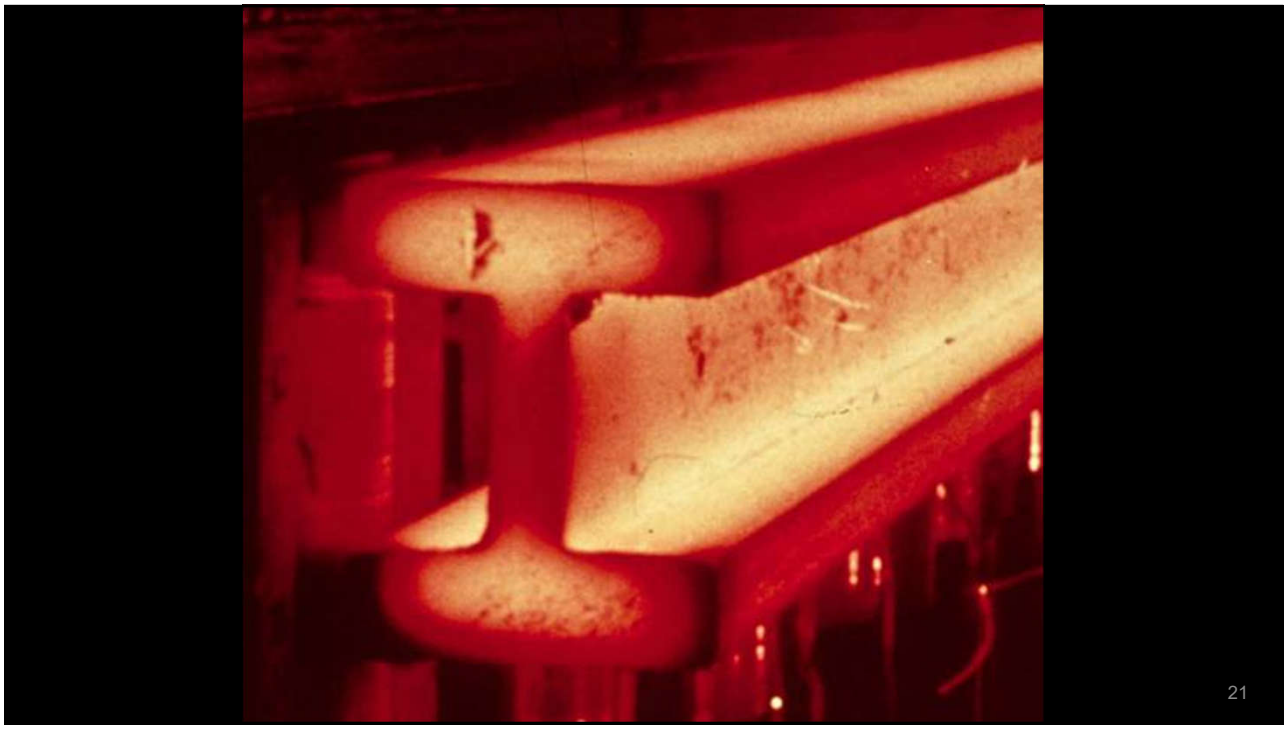
Commentary A3

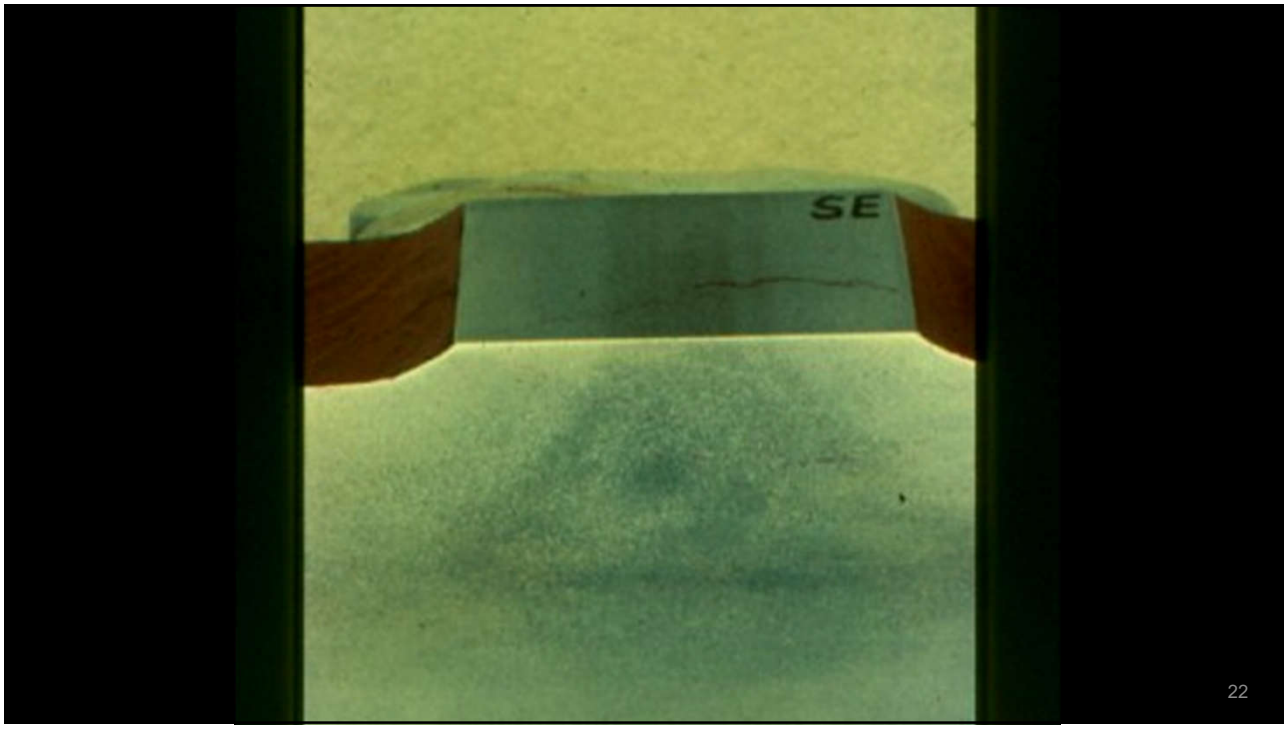
1c. Rolled Heavy Shapes

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**

20





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

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Commentary A3

1a. ASTM Designations

Rolled 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

Material

CHAPTER A
GENERAL PROVISIONS

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

Material

CHAPTER A
GENERAL PROVISIONS

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).

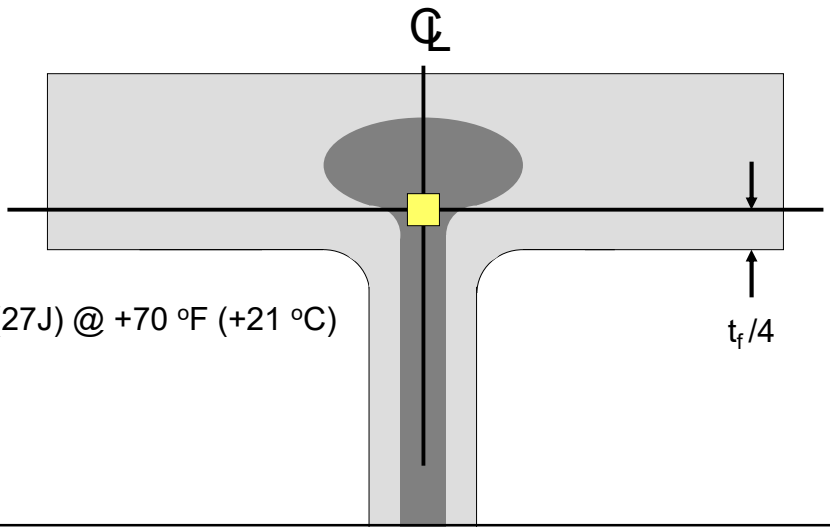
26

ASTM A6 Supplementary Requirements

Material

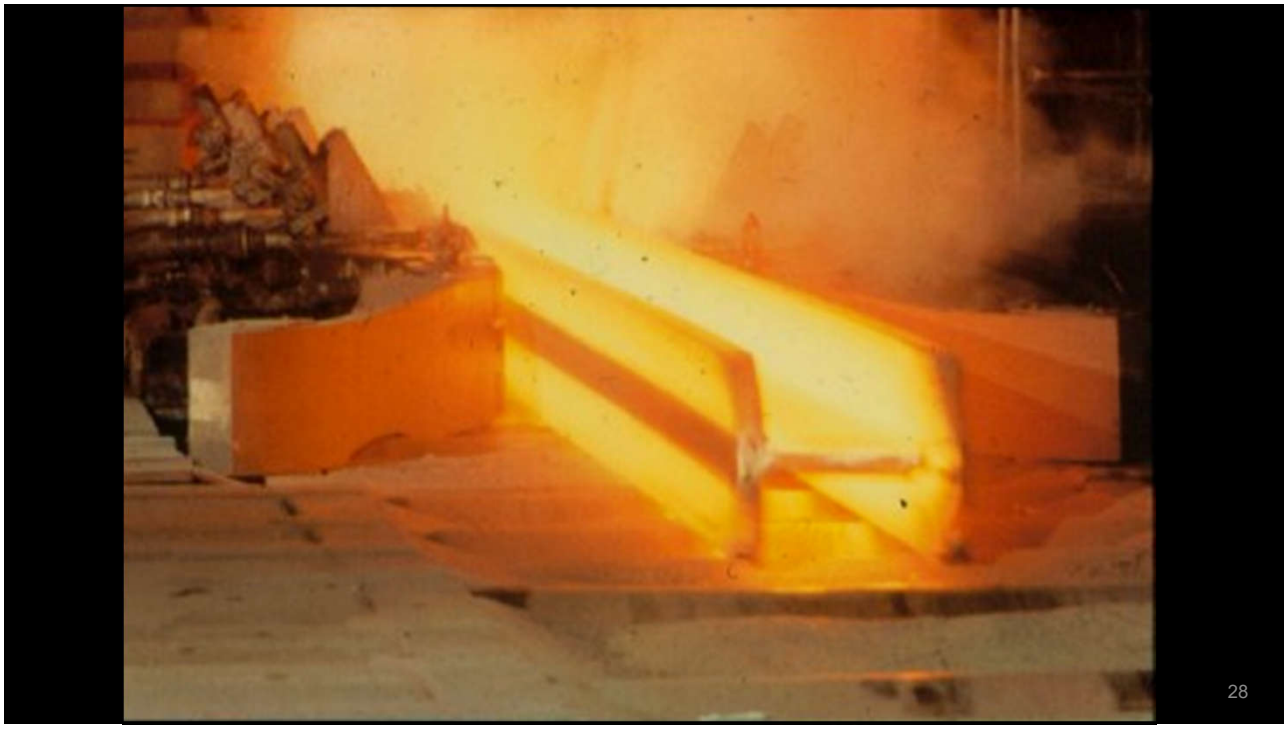
S30 Charpy V-Notch Impact Tests for Structural Shapes:

Alternate Core Location



20 ft-lbs (27J) @ +70 °F (+21 °C)

27



28

AISC 360-16 Specification for Structural Steel Buildings

Material

CHAPTER A
GENERAL PROVISIONS

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

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Material

CHAPTER A
GENERAL PROVISIONS

A3 MATERIAL

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

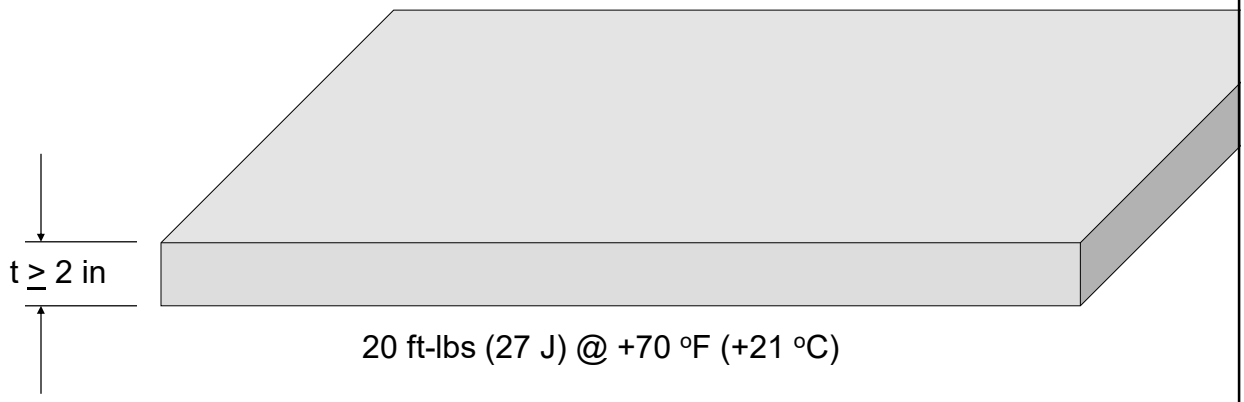
The structural design documents shall require that the steel be supplied with Charpy V-notch impact test results in accordance with ASTM A6/A6M, Supplementary Requirement S5, Charpy V-Notch Impact Test. The impact test shall be conducted in accordance with ASTM A673/A673M, Frequency P, and shall meet 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

Material

S5 Charpy V-Notch Impact Test



20 ft-lbs (27 J) @ +70 °F (+21 °C)

For built-up cross sections

31

AISC 360-16 Specification for Structural Steel Buildings

Material

CHAPTER J

DESIGN OF CONNECTIONS

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

Material

J2.6 Filler Metal Requirements

20 ft-lbs (27 J) @ +40 °F (+4 °C)

33

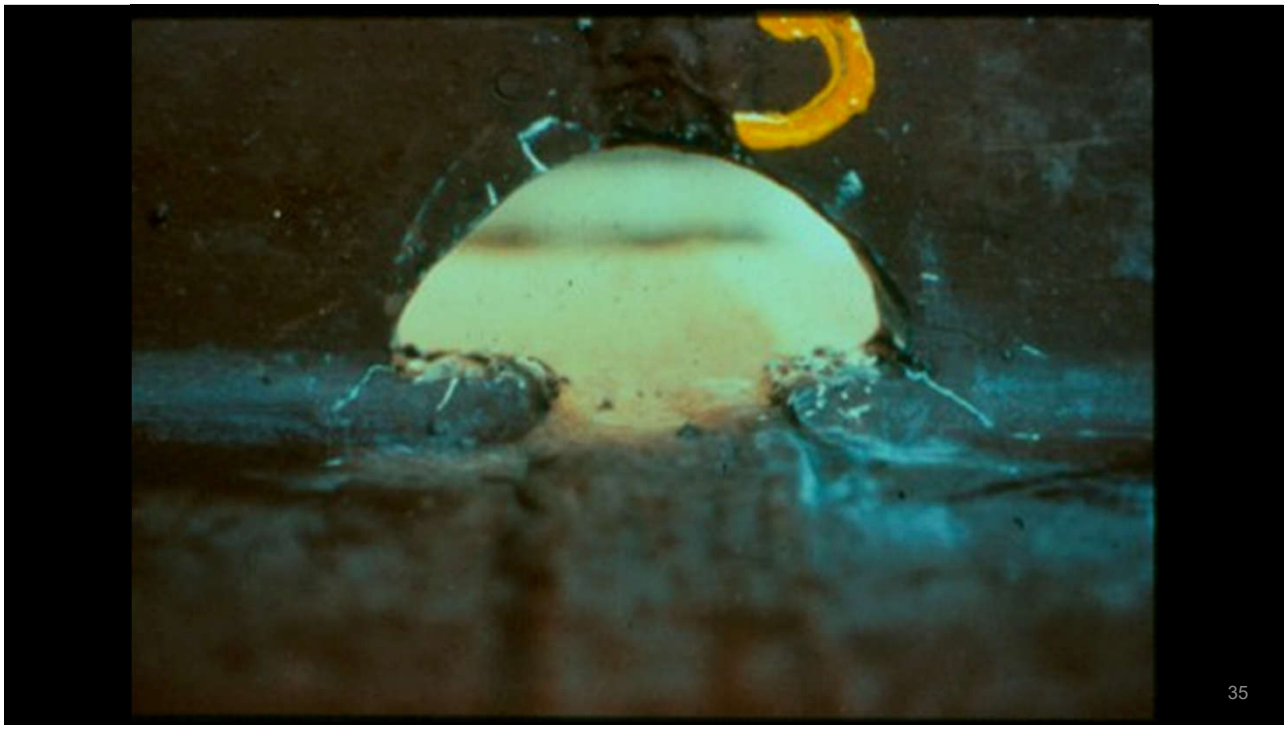
AISC 360-16 Specification for Structural Steel Buildings

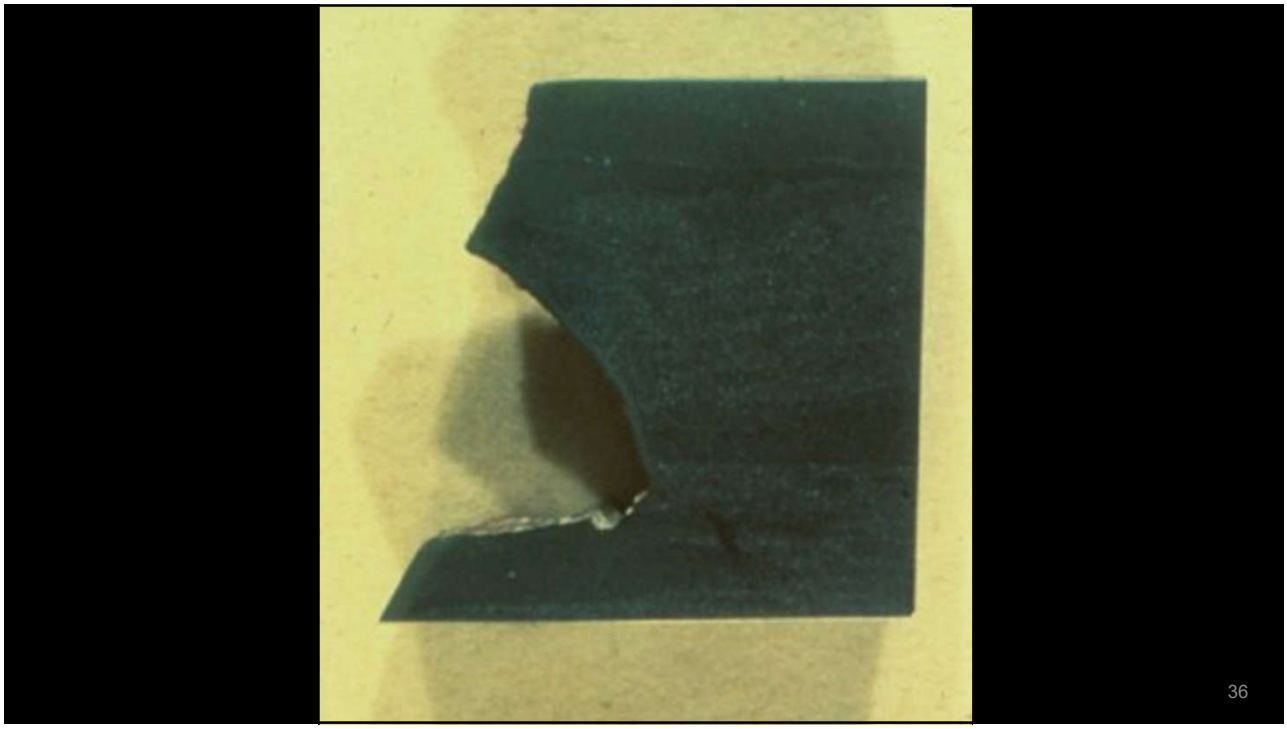
Commentary A3

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.

34





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Details

CHAPTER J
DESIGN OF CONNECTIONS

J1.6. Weld Access Holes

Weld access holes shall meet the following requirements:

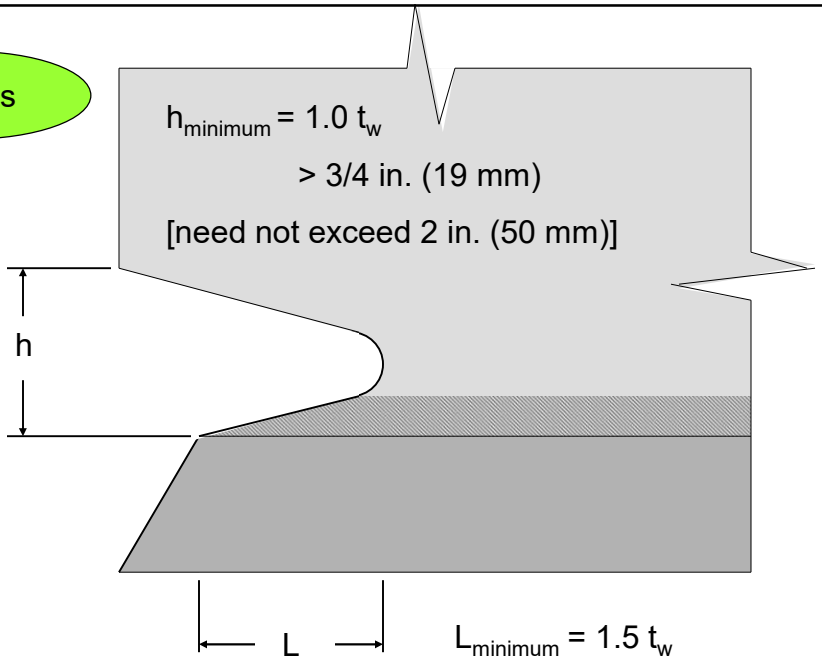
(a) All weld access holes required to facilitate welding operations shall be detailed to provide room for weld backing as needed.

(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).

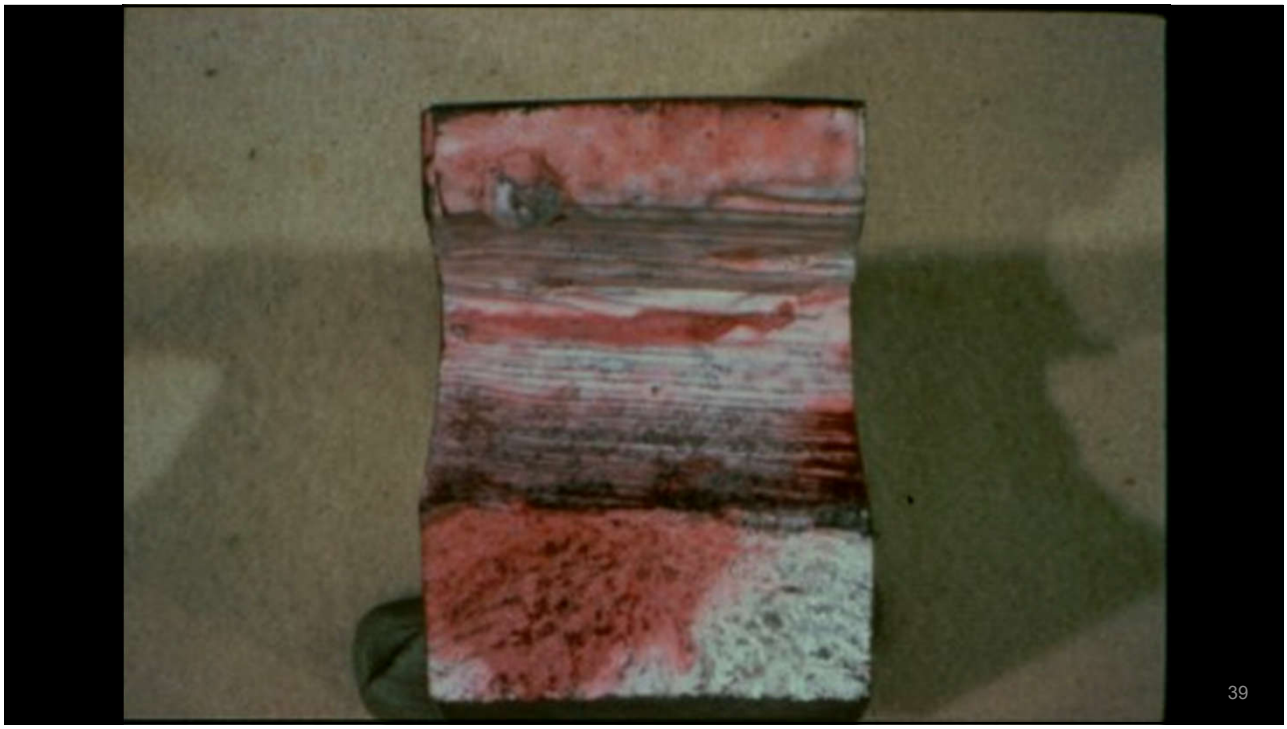
(c) The access hole shall have a height not less than the thickness of the material with the access hole, nor less than 3/4 in. (19 mm), nor does it need to…

37

Details



38



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 D1.1:2020 STRUCTURAL WELDING CODE

Table 5.8

Prequalified Minimum

Preheat/Interpass Temperatures

Table 5.8 (Continued)
Prequalified Minimum Preheat and Interpass Temperature (see 5.7)

Category	Steel Specification		Welding Process	Thickness of Thickest Part at Point of Welding, in	Thickness of Thickest Part at Point of Welding, mm	Minimum Preheat and Interpass Temperature, °F	Minimum Preheat and Interpass Temperature, °C
B (cont'd)	ASTM A710	Grade A, Class 2 >2 in [50 mm]	SMAW with low-hydrogen electrodes, SAW, GMAW, FCAW	1/8 to 3/4 incl.	3 to 20 incl.	32*	0*
	ASTM A847			Over 3/4 thru 1-1/2 incl.	Over 20 thru 38 incl.	50	10
	ASTM A913	Grade 50		Over 1-1/2 thru 2-1/2 incl.	Over 38 thru 65 incl.	150	65
	ASTM A992			Over 2-1/2	Over 65	225	110
	ASTM A1008 HSLAS	Grade 45 Class 1 Grade 45 Class 2 Grade 50 Class 1 Grade 50 Class 2 Grade 55 Class 1 Grade 55 Class 2					
	ASTM A1008 HSLAS-F	Grade 50					
	ASTM A1011 SS	Grades 50, 55					
	ASTM A1011 HSLAS	Grade 45 Class 1 Grade 45 Class 2 Grade 50 Class 1 Grade 50 Class 2 Grade 55 Class 1 Grade 55 Class 2					
	ASTM A1011 HSLAS-F	Grade 50					
	ASTM A1018 HSLAS	Grade 45 Class 1 Grade 45 Class 2 Grade 50 Class 1 Grade 50 Class 2 Grade 55 Class 1 Grade 55 Class 2					
	ASTM A1018 HSLAS-F	Grade 50					
	ASTM A1018 SS	Grades 30, 33, 36, 40					
	ASTM A1066	Grade 50					
	ASTM A1085						
	API 5L	Grades B, X42					
	API Spec. 2H	Grades 42, 50					
	API 2MT1	Grade 50					
	API 2W	Grades 42, 50, 50T					
	API 2Y	Grades 42, 50, 50T					
	AB5	Grades A, B, D, E AH 32, 36 DH 32, 36 EH 32, 36					

(Continued)

41

AWS D1.1:2020 STRUCTURAL WELDING CODE

B (Cont'd)	ASTM A808		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		Over 3/4 thru 1-1/2 incl.	Over 20 thru 38 incl.	50	10
	ASTM A992			Over 1-1/2 thru 2-1/2 incl.	Over 38 thru 65 incl.	150	65
	ASTM A1008 HSLAS	Grade 45 Class 1 Grade 45 Class 2 Grade 50 Class 1 Grade 50 Class 2 Grade 55 Class 1 Grade 55 Class 2		Over 2-1/2	Over 65	225	110
	ASTM A1008 HSLAS-F	Grade 50					
	ASTM A1011 HSLAS	Grade 45 Class 1 Grade 45 Class 2 Grade 50 Class 1 Grade 50 Class 2 Grade 55 Class 1 Grade 55 Class 2					
	ASTM A1011 HSLAS-F	Grade 50					
	ASTM A1018 HSLAS	Grade 45 Class 1 Grade 45 Class 2 Grade 50 Class 1 Grade 50 Class 2 Grade 55 Class 1 Grade 55 Class 2					

42

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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

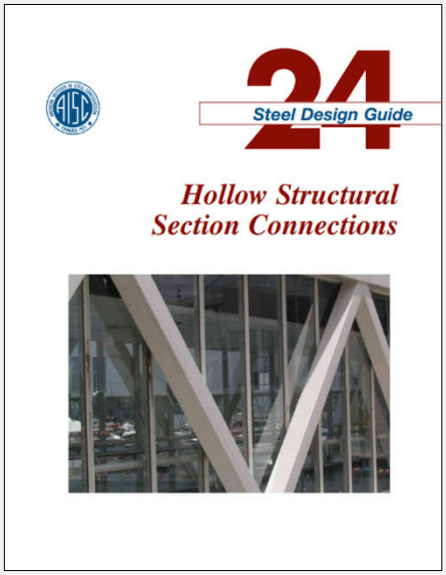
46

Design Guide 24

Hollow Structural Section Connections

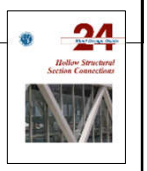
by

Packer, Sherman, Lecce



47

Design Guide 24 Hollow Structural Section Connections



Chapter 1

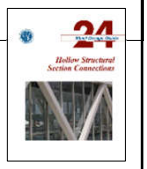
Introduction

"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



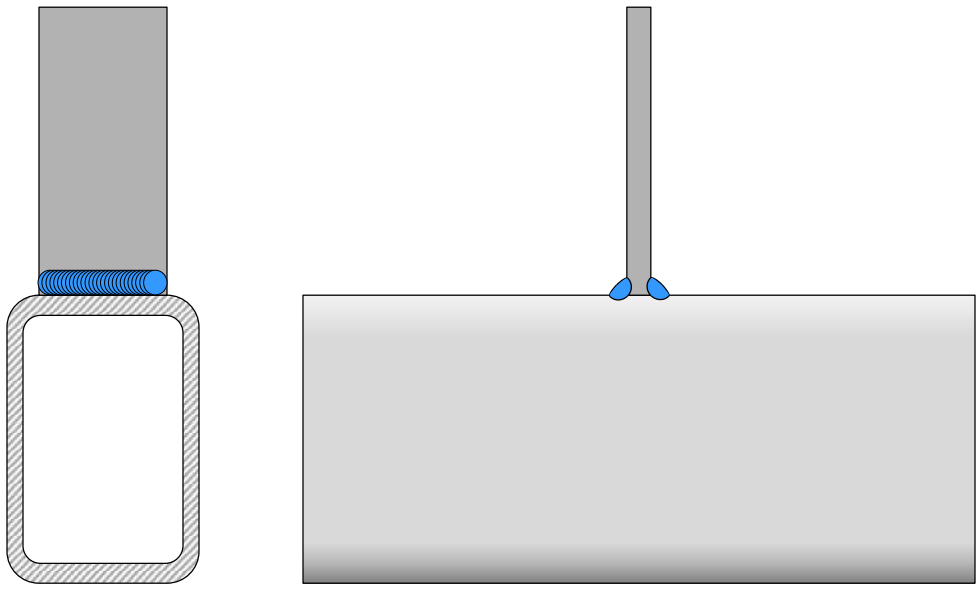
Chapter 2

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



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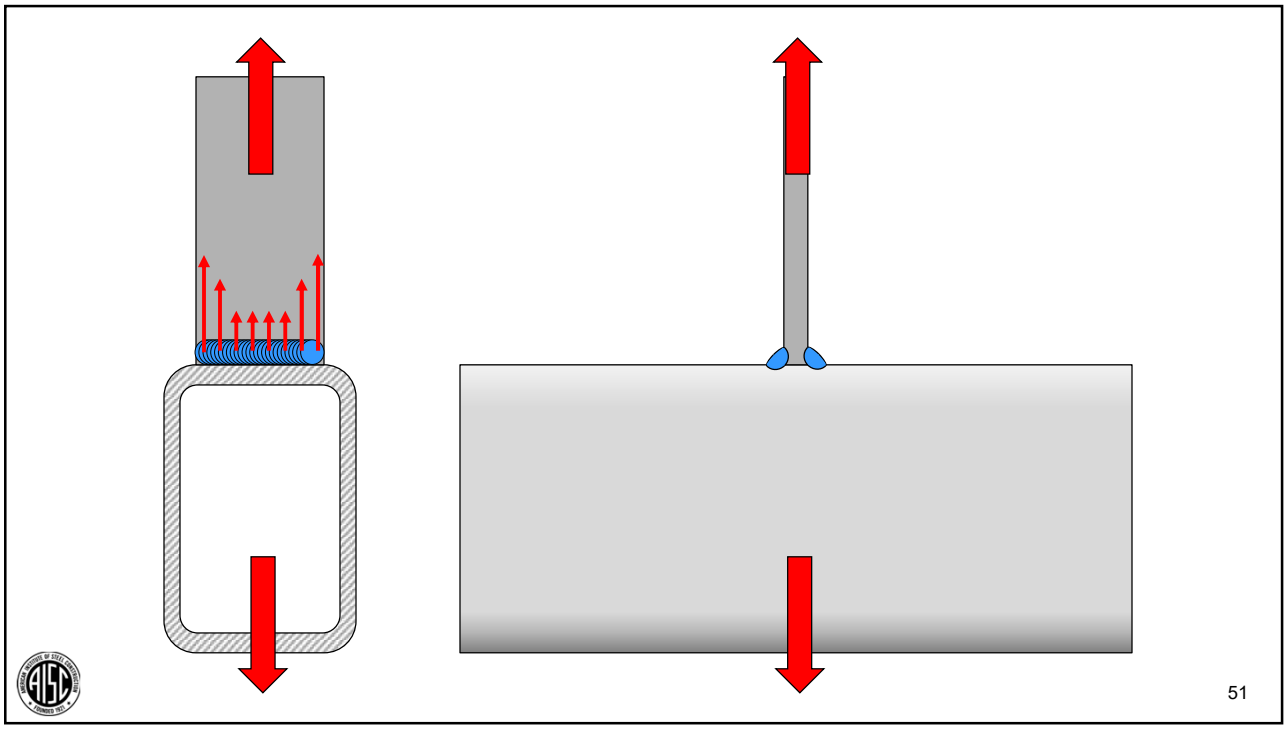
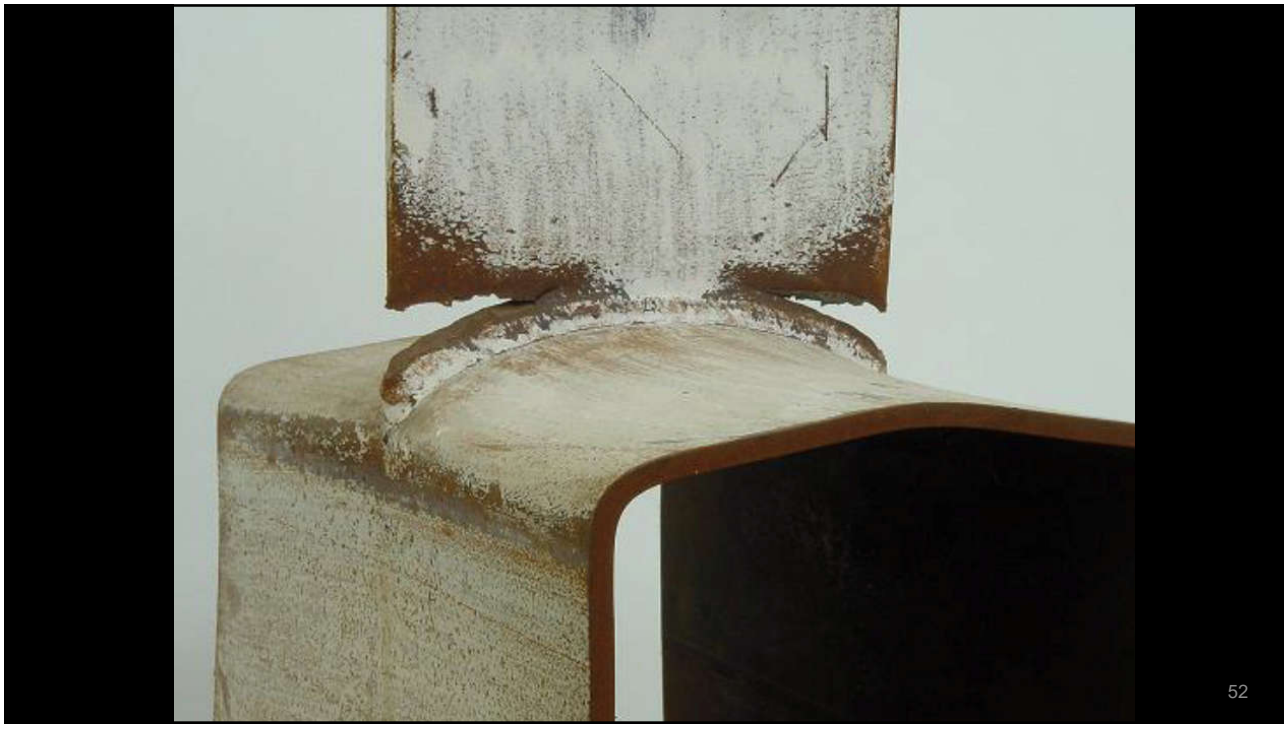
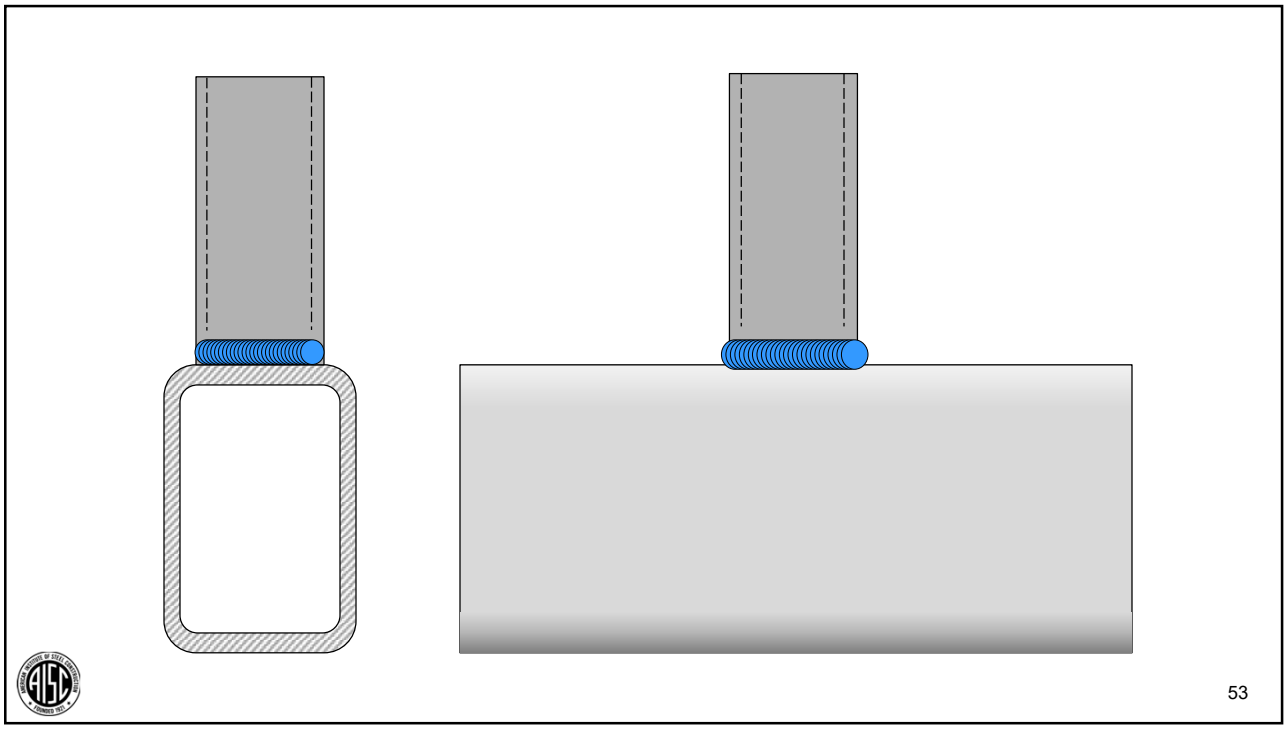
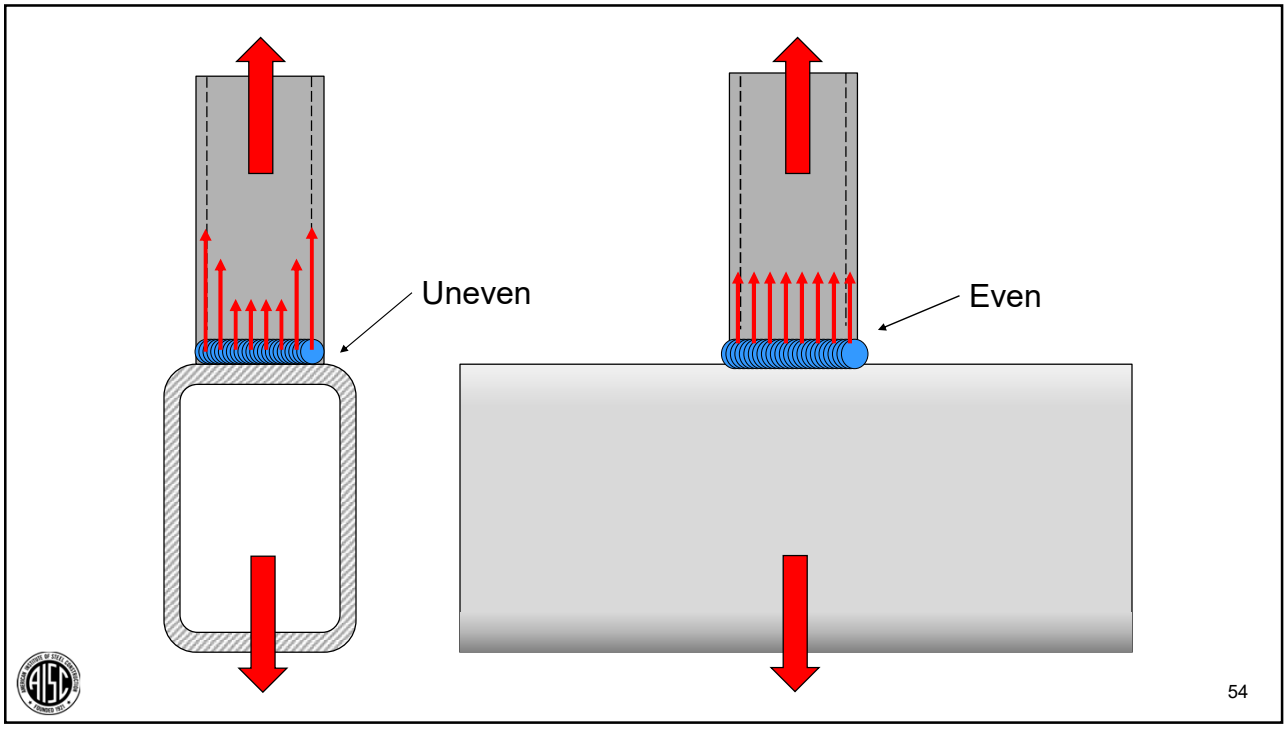






53



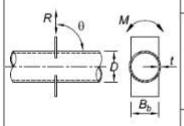
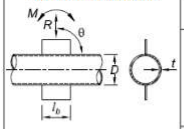
54

AISC 360:16 Specification for Structural Steel Buildings

TABLE K2.1

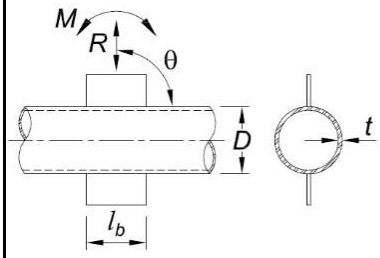
Available Strength of Plate-to-Round HSS Connections

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

Connection Type	Connection Available Strength		
Transverse Plate T- and Cross-Connections 	Limit State: HSS Local Yielding		
	Plate Axial Load	In-Plane	Out-of-Plane
	$R_n \sin\theta = F_y t^2 \left(\frac{5.5}{1 - 0.81\frac{B_b}{D}} \right) Q_f$ (K2-1a)	–	$M_n = 0.5 B_b R_n$ (K2-1b)
	$\phi = 0.90$ (LRFD) $\quad \Omega = 1.67$ (ASD)		
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) $\quad \Omega = 1.67$ (ASD)		
Functions			
$Q_f = 1$ for HSS (connecting surface) in tension $= 1.0 - 0.3U(1 + U)$ for HSS (connecting surface) in compression (K2-3) $U = \left\lvert \frac{P_{ro}}{F_c A_g} + \frac{M_{ro}}{F_c S} \right\rvert$ (K2-4) where P_{ro} and M_{ro} are determined on the side of the joint that has the lower compression stress. P_{ro} and M_{ro} refer to required strengths in the HSS: $P_{ro} = P_u$ for LRFD, and P_a for ASD; $M_{ro} = M_u$ for LRFD, and M_a for ASD.			

55

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) $\quad \Omega = 1.67$ (ASD)		

56

AISC 360:16 Specification for Structural Steel Buildings

TABLE K5.1

Effective Weld Properties for

Connection to Rectangular HSS

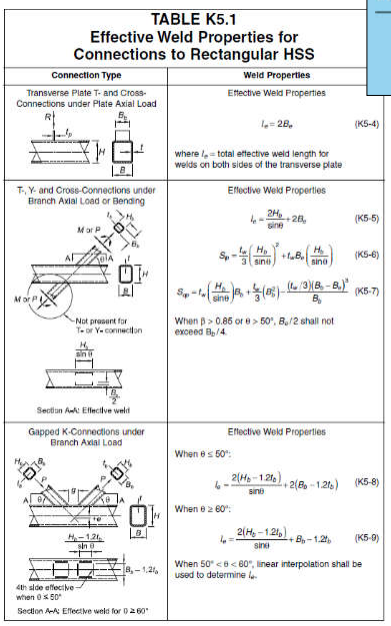


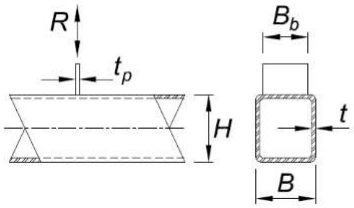
TABLE K5.1
Effective Weld Properties for
Connections to Rectangular HSS

Connection Type	Weld Properties
Transverse Plate T- and Cross-Connections under Plate Axial Load	Effective Weld Properties $l_e = 2B_e$ (K5-4) where l_e = total effective weld length for welds on both sides of the transverse plate
T-, Y- and Cross-Connections under Branch Axial Load or Bending	Effective Weld Properties $l_e = \frac{2H_b}{\sin\theta} + 2B_b$ (K5-5) $S_p = \frac{t_w}{3}\left(\frac{H_b}{\sin\theta}\right)^2 + t_w B_b\left(\frac{H_b}{\sin\theta}\right)$ (K5-6) $S_{wp} = t_w\left(\frac{H_b}{\sin\theta}\right)B_b + \frac{t_w}{3}\left(B_b^2\right) - \frac{(t_w/3)(B_b - B_b)^3}{B_b}$ (K5-7) When $\beta > 0.85$ or $\theta > 50°$, $B_b/2$ shall not exceed $B_b/4$.
Gapped K-Connections under Branch Axial Load	Effective Weld Properties When $\theta \le 50°$: $l_e = \frac{2(H_b - 1.2t_b)}{\sin\theta} + 2(B_b - 1.2t_b)$ (K5-8) When $\theta \ge 60°$: $l_e = \frac{2(H_b - 1.2t_b)}{\sin\theta} + B_b - 1.2t_b$ (K5-9) When $50° < \theta < 60°$, linear interpolation shall be used to determine l_e.

57

AISC 360:16 Specification for Structural Steel Buildings

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

Connection Type	Weld Properties
Transverse Plate T- and Cross-Connections under Plate Axial Load 	Effective Weld Properties $l_e = 2B_e$ (K5-4) where l_e = total effective weld length for welds on both sides of the transverse plate

58

SPECIAL WELDING APPLICATIONS

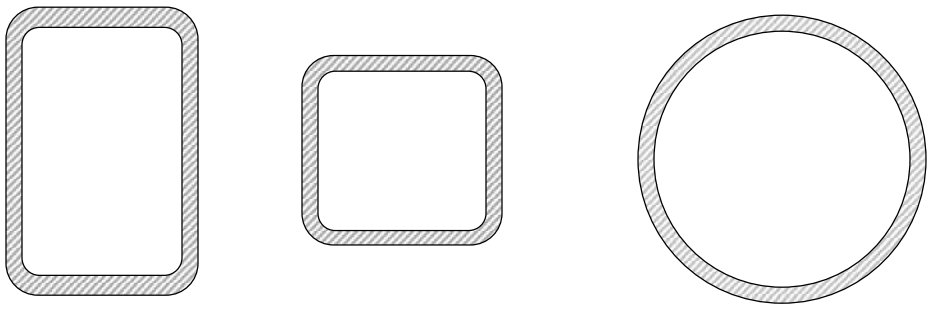
14.6 Welding HSS

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

59

SPECIAL WELDING APPLICATIONS

Rectangular **Round**

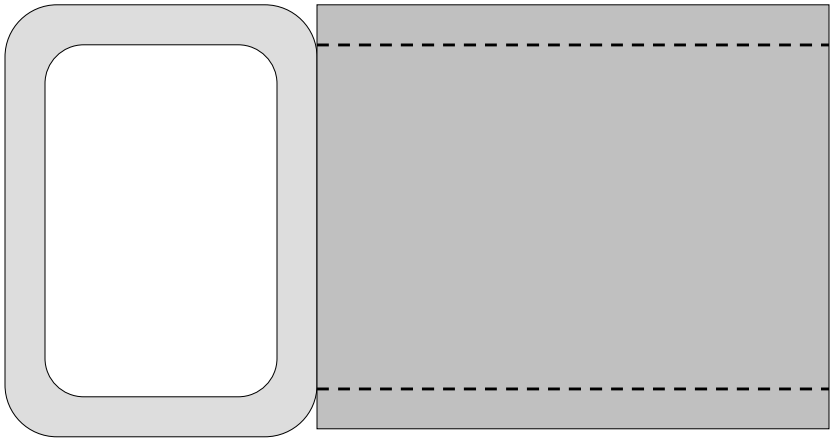


Rectangular is nearly always easier to fabricate

60

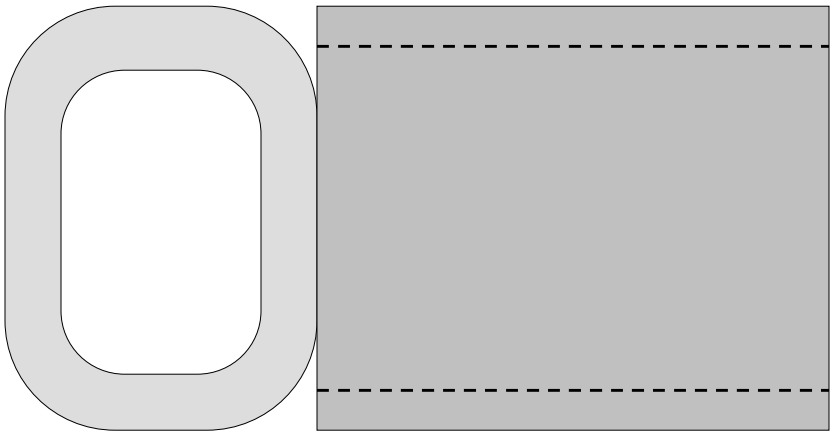
SPECIAL WELDING APPLICATIONS

Matched Connection



61

SPECIAL WELDING APPLICATIONS



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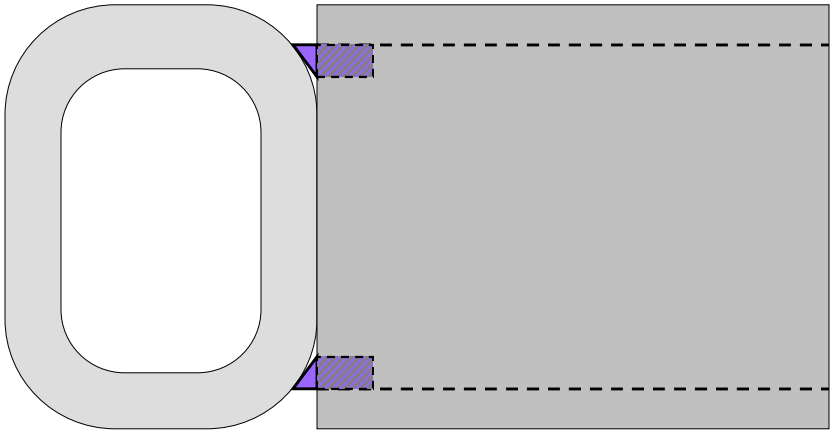
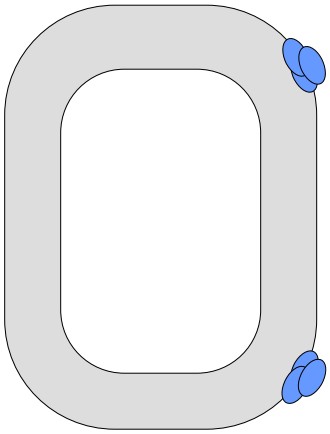
SPECIAL WELDING APPLICATIONS



63

SPECIAL WELDING APPLICATIONS



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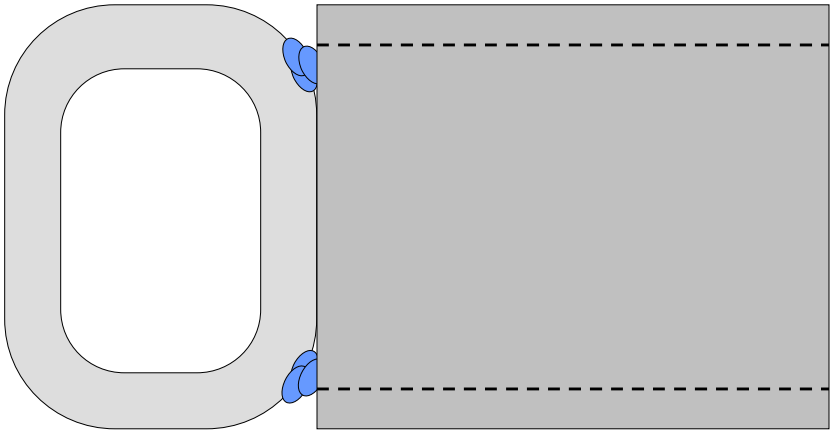
SPECIAL WELDING APPLICATIONS



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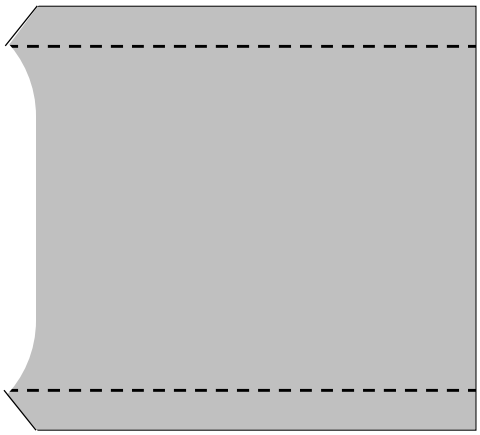
SPECIAL WELDING APPLICATIONS



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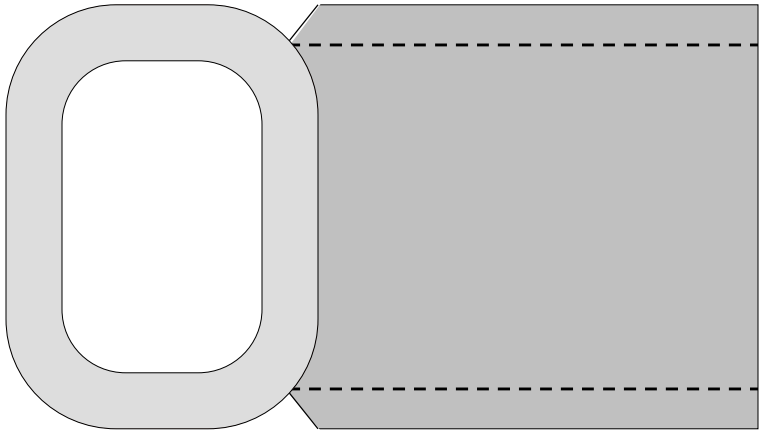
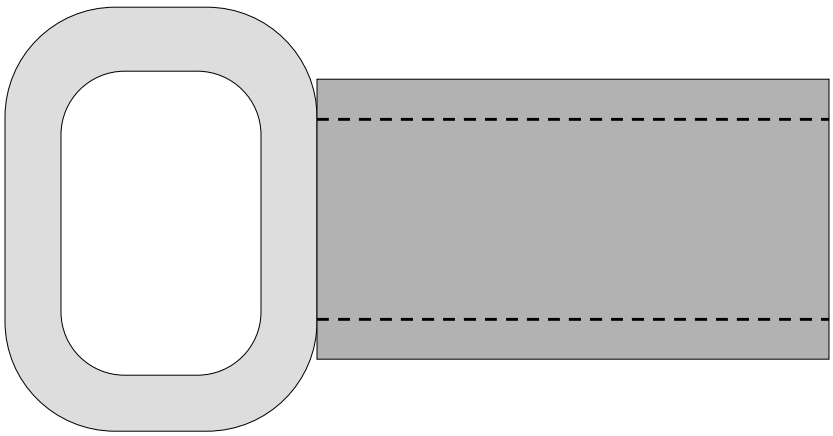
SPECIAL WELDING APPLICATIONS



67

SPECIAL WELDING APPLICATIONS

Stepped Connection



68

SPECIAL WELDING APPLICATIONS

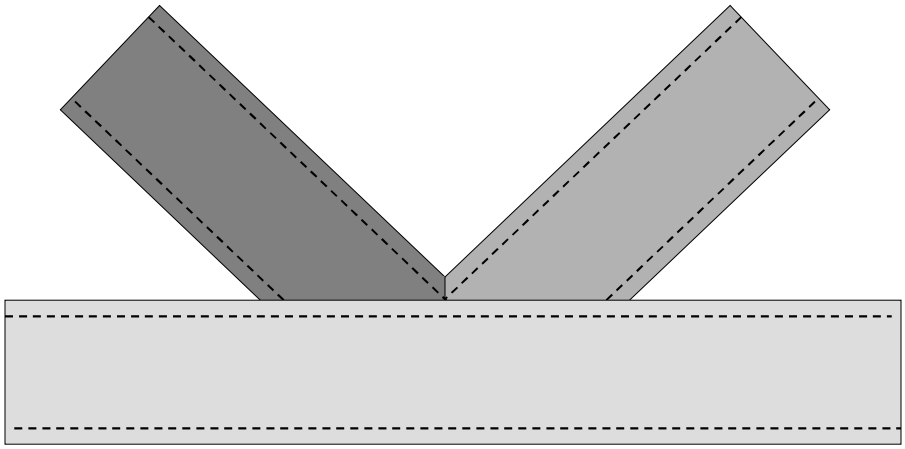
14.6 Welding HSS

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

69

SPECIAL WELDING APPLICATIONS

Overlapped



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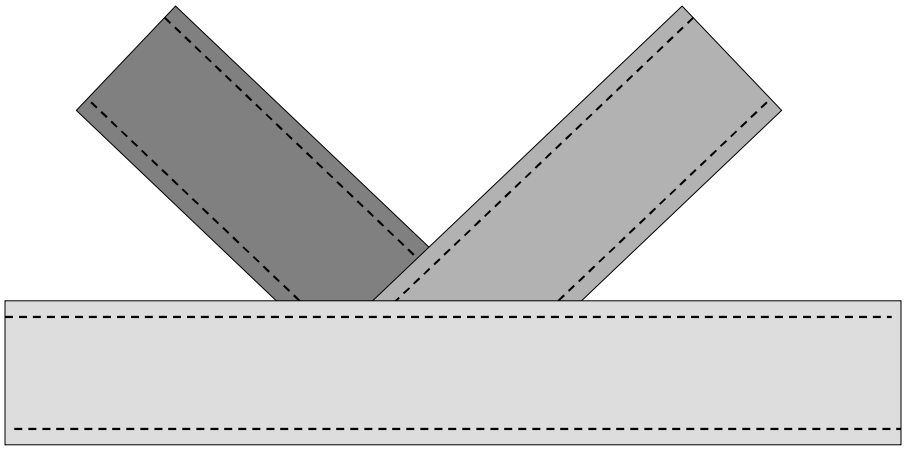
SPECIAL WELDING APPLICATIONS

Overlapped



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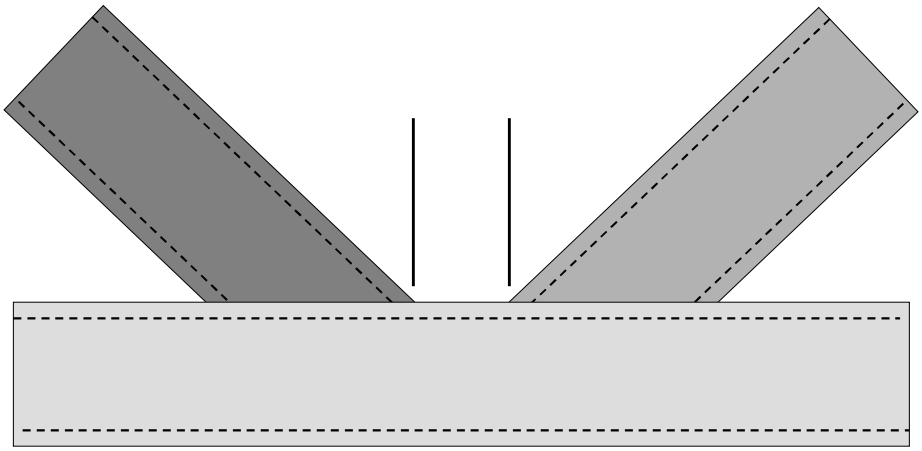
SPECIAL WELDING APPLICATIONS

Gapped



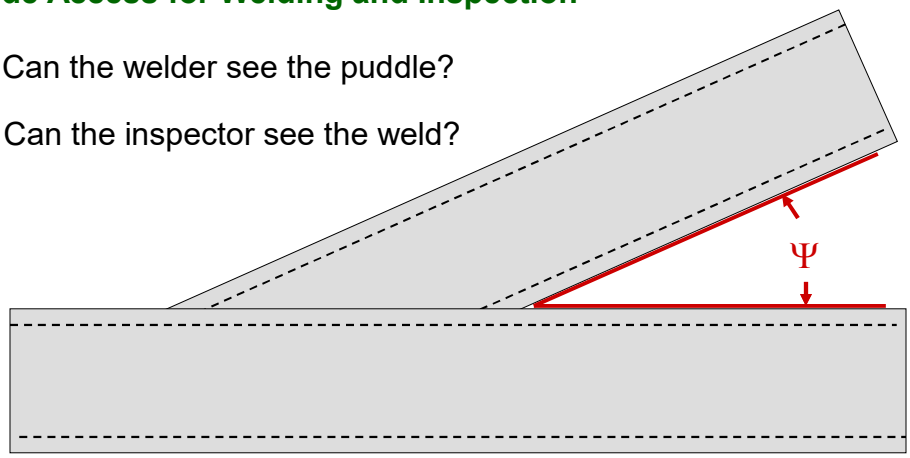
Preferred

72

SPECIAL WELDING APPLICATIONS

Provide Access for Welding and Inspection

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



Ψ = 30° minimum

73

SPECIAL WELDING APPLICATIONS

14.6 Welding HSS

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

74

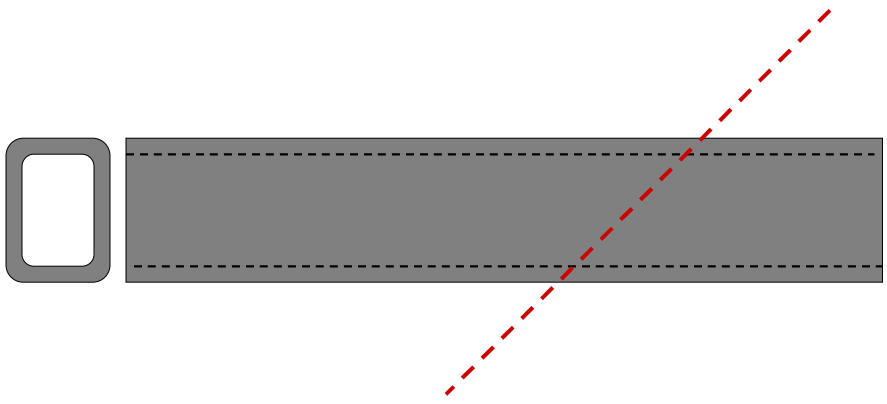
SPECIAL WELDING APPLICATIONS

Box HSS

75

SPECIAL WELDING APPLICATIONS

Box HSS



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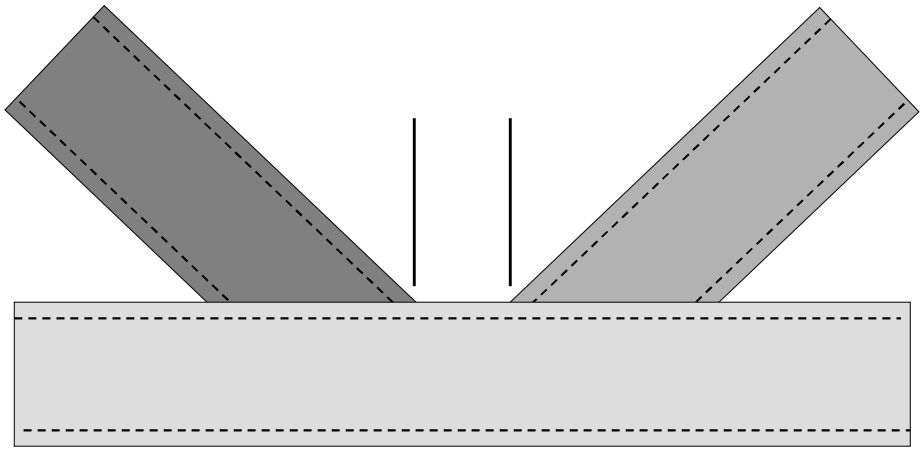
SPECIAL WELDING APPLICATIONS

Box HSS

77

SPECIAL WELDING APPLICATIONS

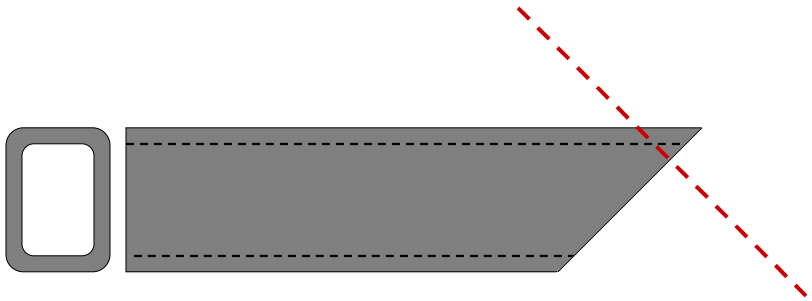
Gapped



78

SPECIAL WELDING APPLICATIONS

Box HSS



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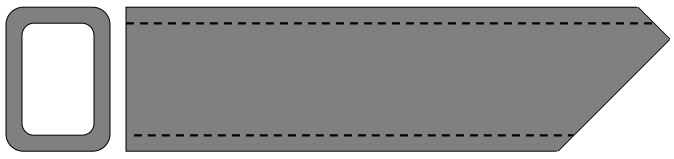
SPECIAL WELDING APPLICATIONS

Box HSS



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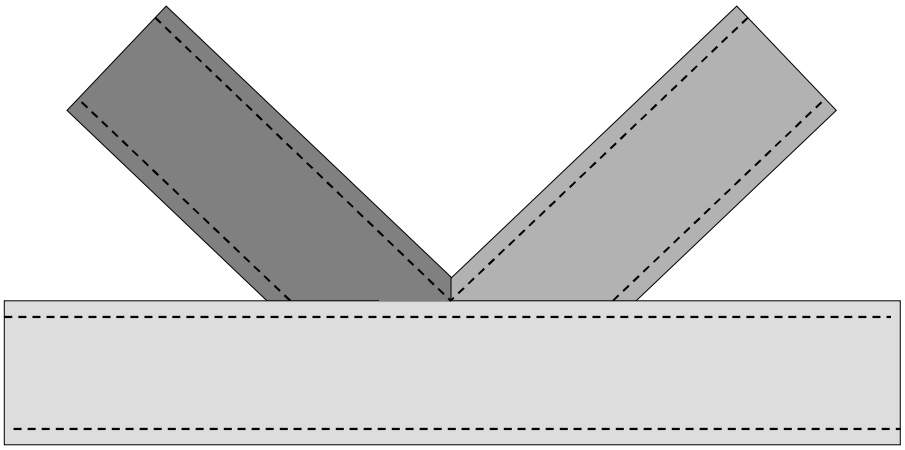
SPECIAL WELDING APPLICATIONS

Overlapped



81

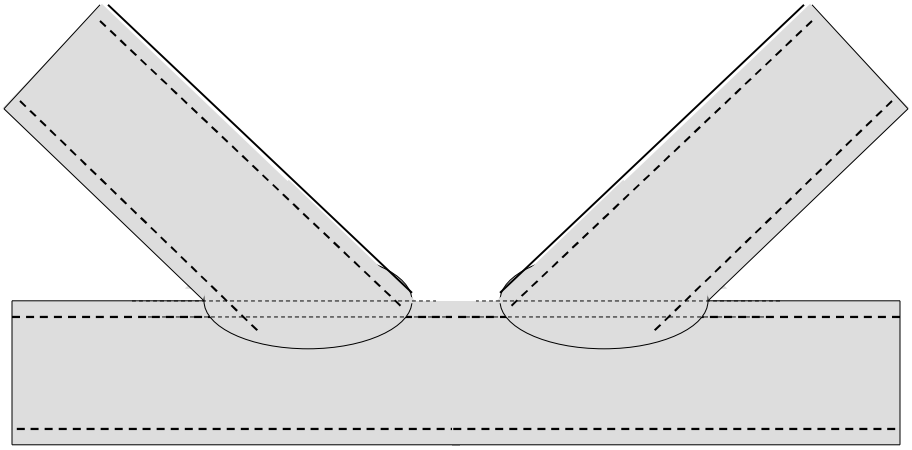
SPECIAL WELDING APPLICATIONS

Round HSS

82

SPECIAL WELDING APPLICATIONS

Round HSS



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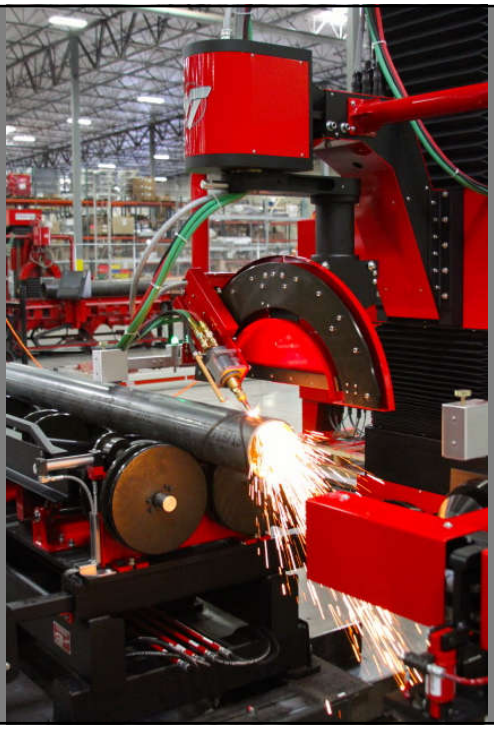
84



85

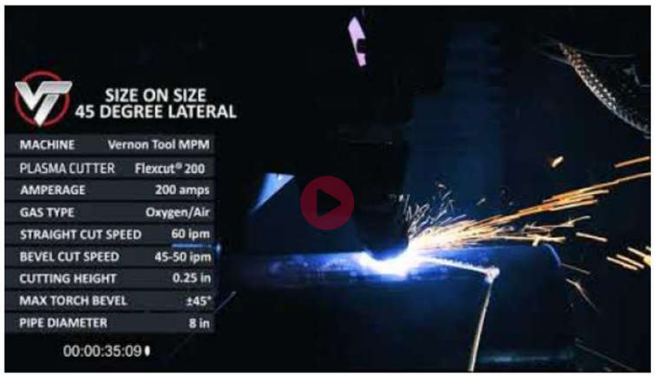
90 degree saddle cut

90 Degree Saddle

86

Size on size, 45 degree lateral

Size on Size 45 Degree Lateral



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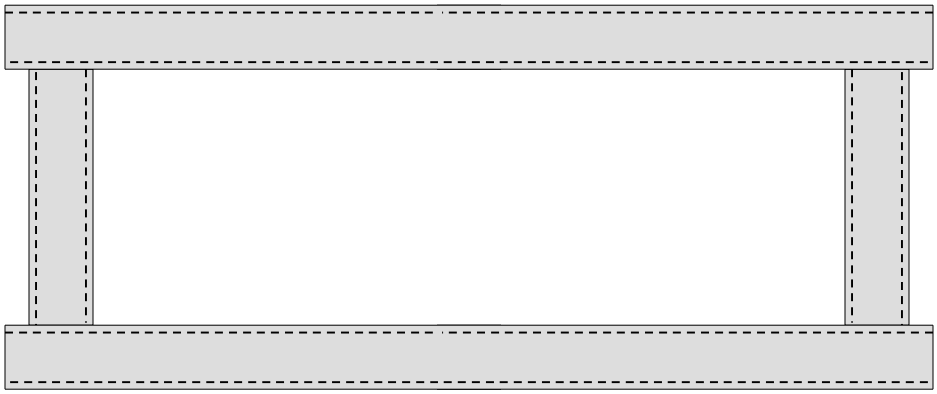
SPECIAL WELDING APPLICATIONS

Box HSS



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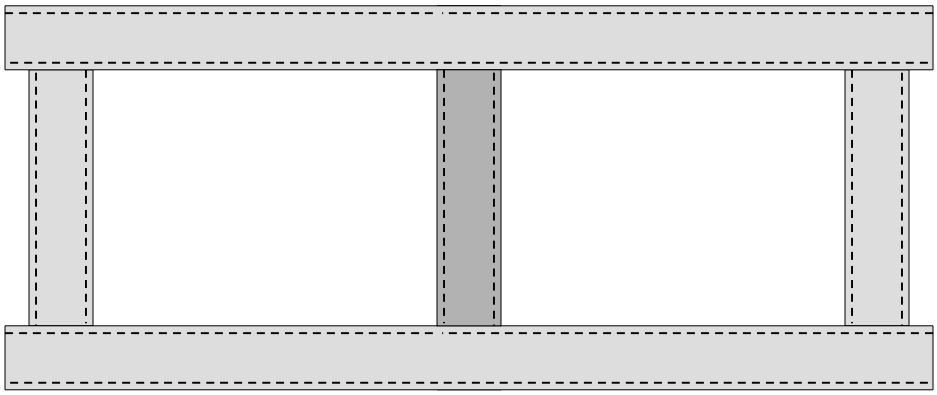
SPECIAL WELDING APPLICATIONS

Box HSS



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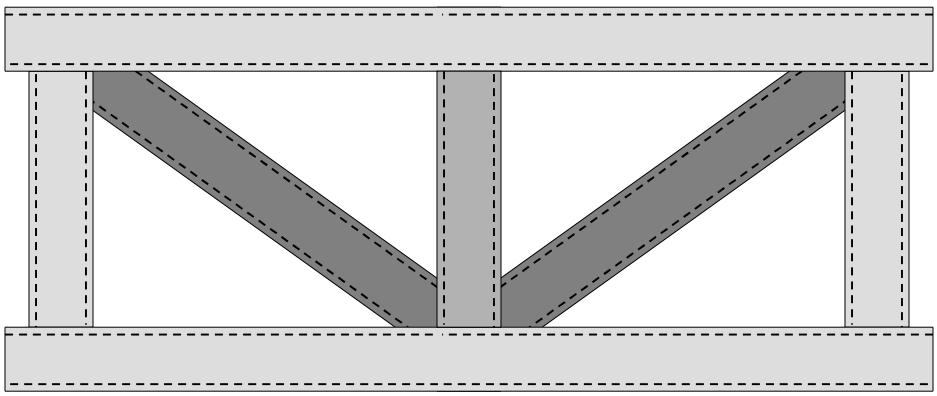
SPECIAL WELDING APPLICATIONS

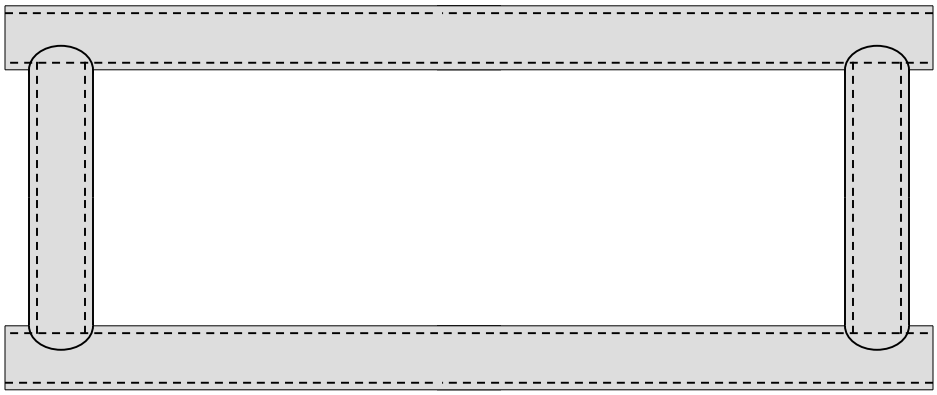
Box HSS



90

SPECIAL WELDING APPLICATIONS

Round HSS



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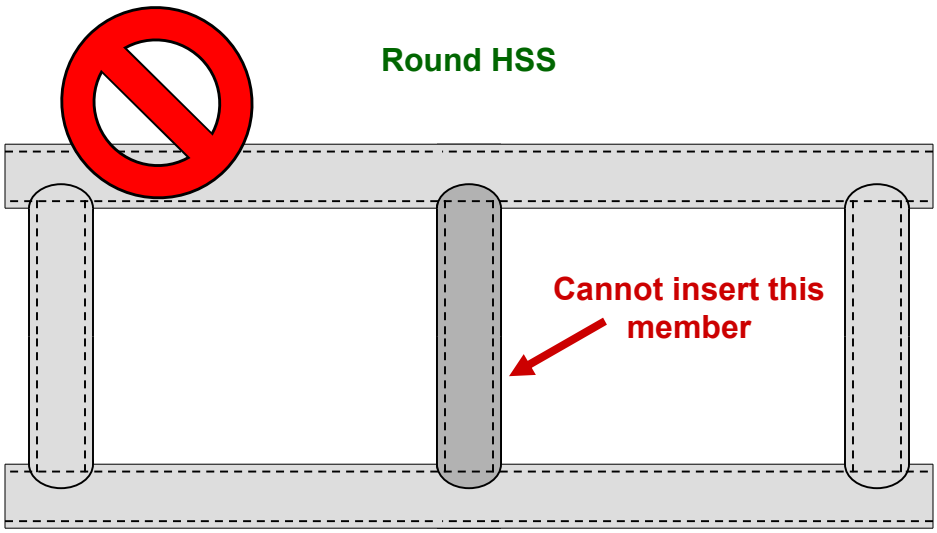
SPECIAL WELDING APPLICATIONS

Round HSS



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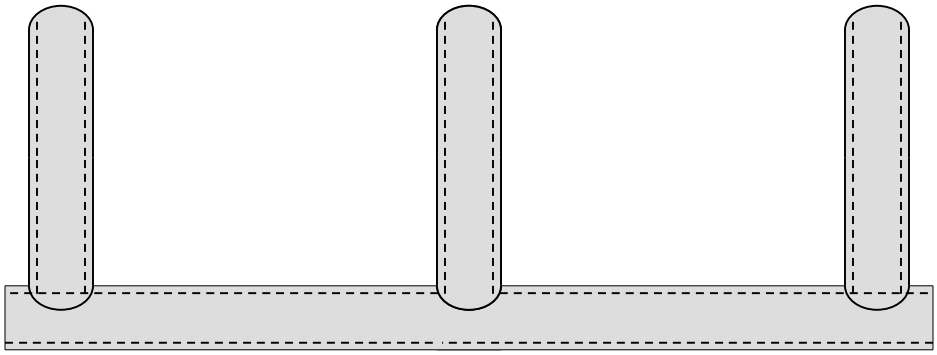
SPECIAL WELDING APPLICATIONS

Round HSS



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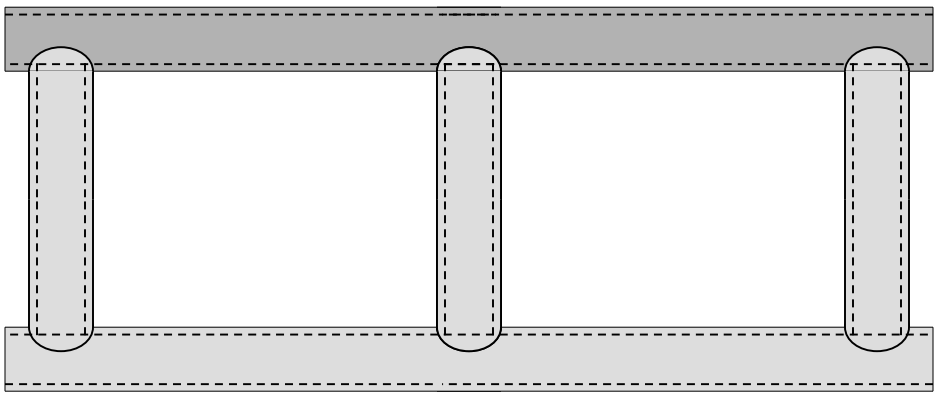
SPECIAL WELDING APPLICATIONS

Round HSS



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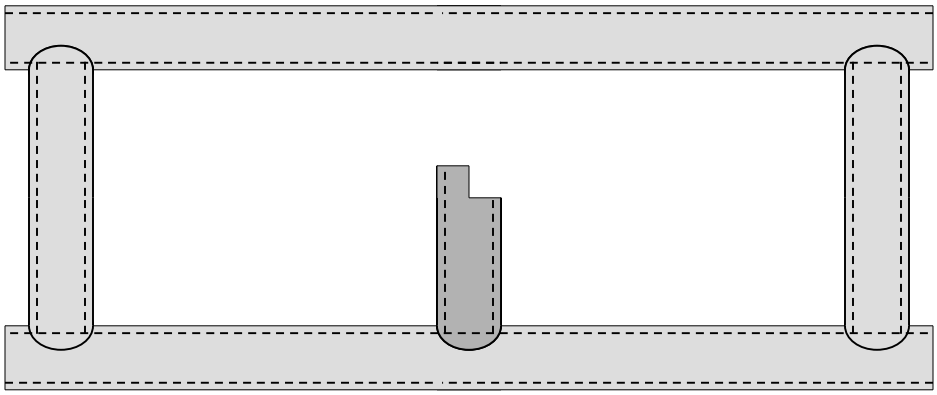
SPECIAL WELDING APPLICATIONS

Round HSS



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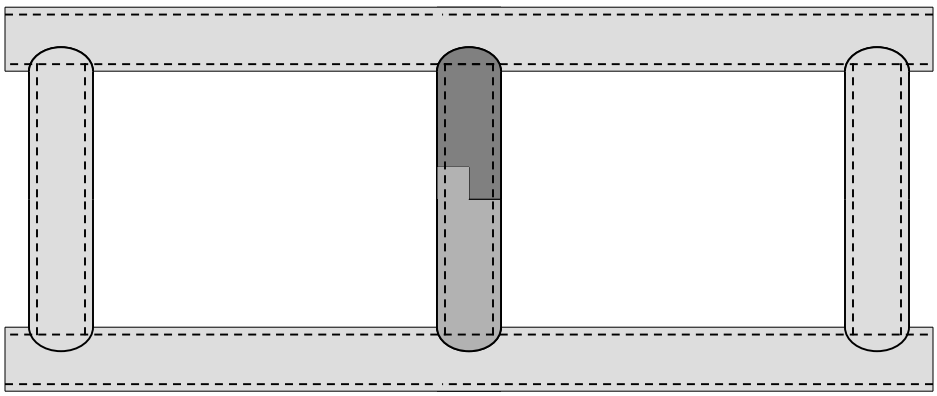
SPECIAL WELDING APPLICATIONS

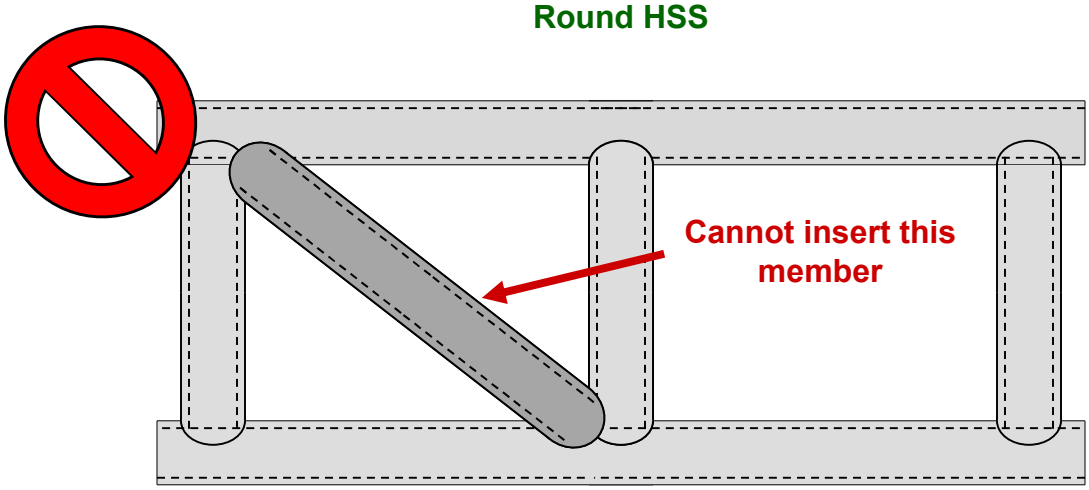
Round HSS



96

SPECIAL WELDING APPLICATIONS

Round HSS



97

AWS D1.1:2020 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: $D/t \le 210/\sqrt{F_y}$ [for F_y in ksi], $550/\sqrt{F_y}$ (for F_y in MPa) but not more than 35

(3) Box section overlap connections: $D/t \le 190/\sqrt{F_y}$ [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

98

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

99

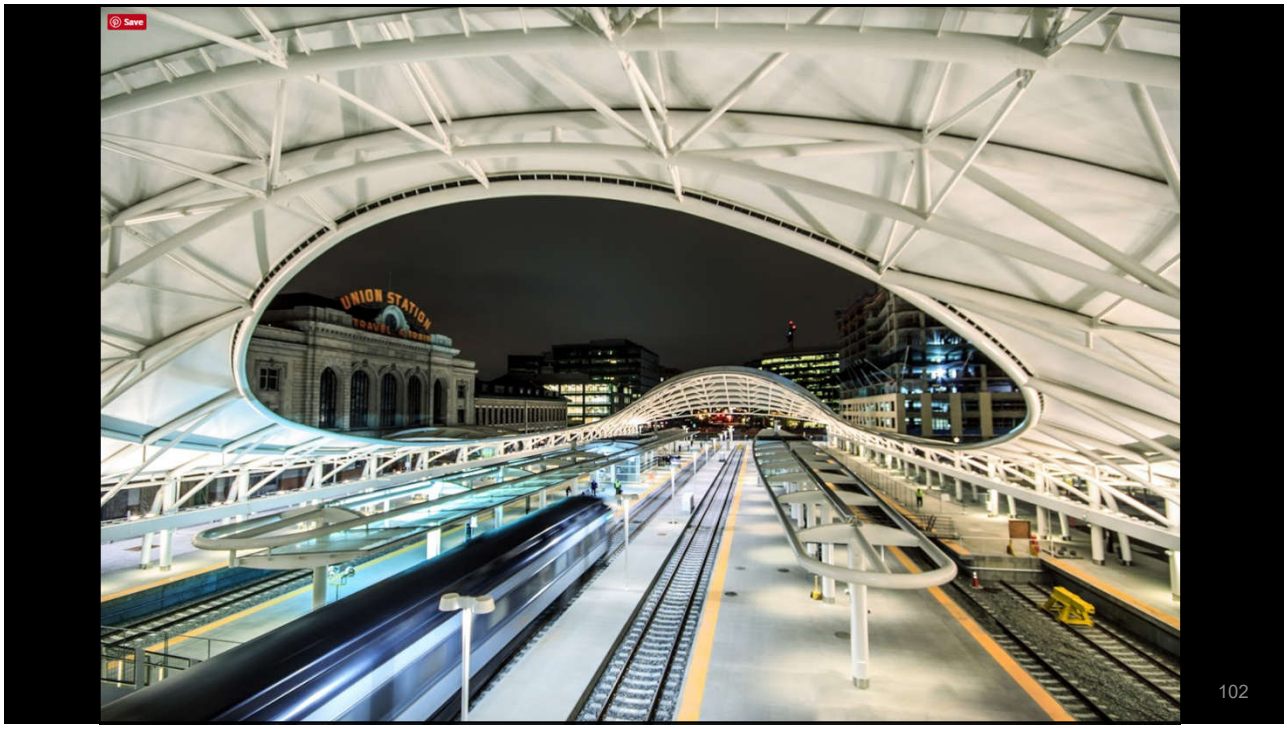
SPECIAL WELDING APPLICATIONS

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

100

101



102

SPECIAL WELDING APPLICATIONS

Welding AESS

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

105

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	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		•	•	•		
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		•				
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 corrosive enviro-

106

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TABLE 10.1
AESS Category Matrix

Id	Characteristics	AESS C Custom Elements	AESS 4 Showcase Elements	AESS 3 Feature Elements in close view	AESS 2 Feature Elements not in close view	AESS 1 Basic Elements	SSS Standard Structural Steel
1.1	Surface preparation to SSPC-SP 6		•	•	•	•	
1.2	Sharp edges ground smooth		•	•	•	•	
1.3	Continuous weld apprearance		•	•	•	•	
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		•				
C.1							
C.2							
C.3							
C.4							
C.5							

107

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TABLE 10.1
AESS Category Matrix

Id	Characteristics	AESS C Custom Elements	AESS 4 Showcase Elements	AESS 3 Feature Elements in close view	AESS 2 Feature Elements not in close view	AESS 1 Basic Elements	SSS Standard Structural Steel
1.1	Surface preparation to SSPC-SP 6		•	•	•	•	
1.2	Sharp edges ground smooth		•	•	•	•	
1.3	Continuous weld apprearance		•	•	•	•	
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

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 apprearance		•	•	•	•	
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		•	•	•		

109

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 apprearance		•	•	•	•
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

110

111

112

SPECIAL WELDING APPLICATIONS

Welding AESS

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

113

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 apprearance		•	•	•	•
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

114

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.

115

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

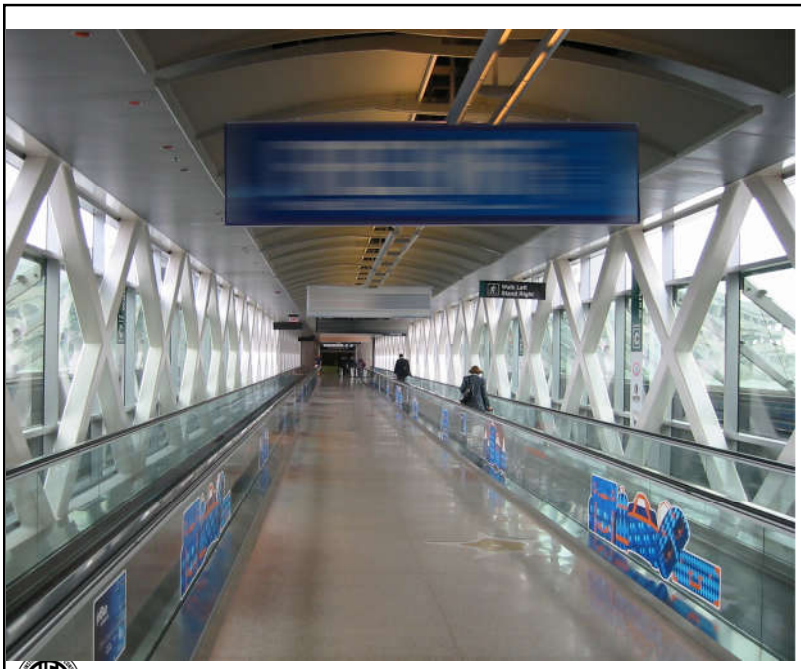
SECTION 10. ARCHITECTURALLY EXPOSED STRUCTURAL STEEL

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.

116



117

SPECIAL WELDING APPLICATIONS

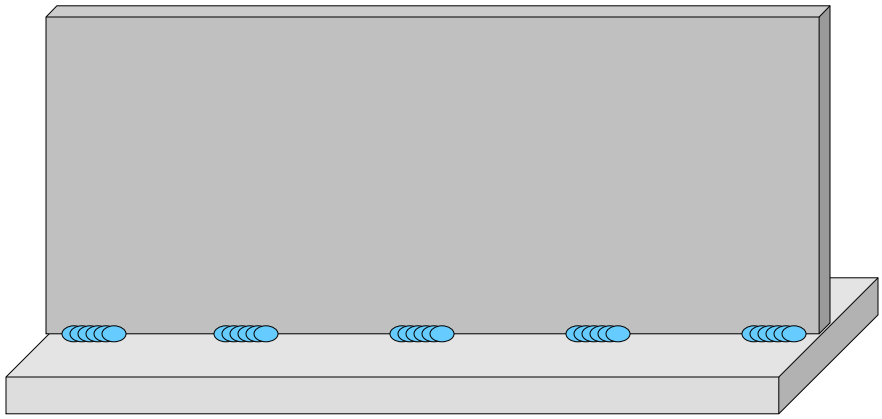
Welding AESS

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

118

SPECIAL WELDING APPLICATIONS

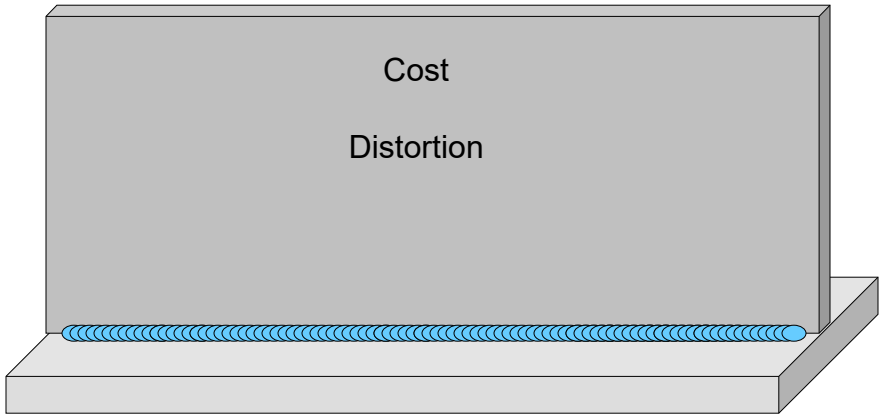
Sufficient for strength



119

SPECIAL WELDING APPLICATIONS

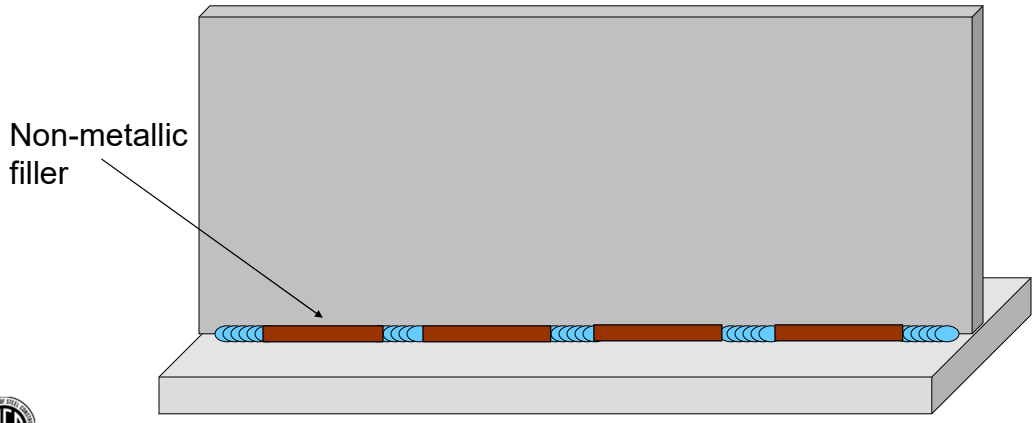
May be required for AESS



120

SPECIAL WELDING APPLICATIONS

Sufficient for strength

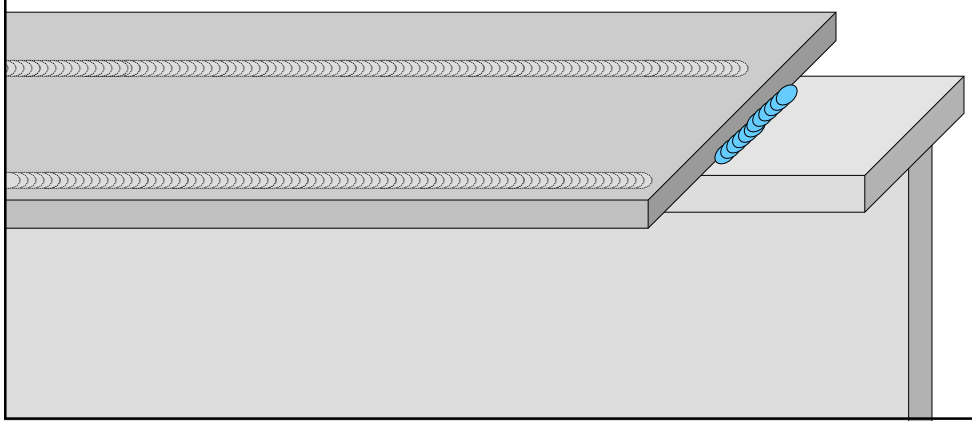


121

SPECIAL WELDING APPLICATIONS

D1.1 code required practice*

*modified in 2015 edition



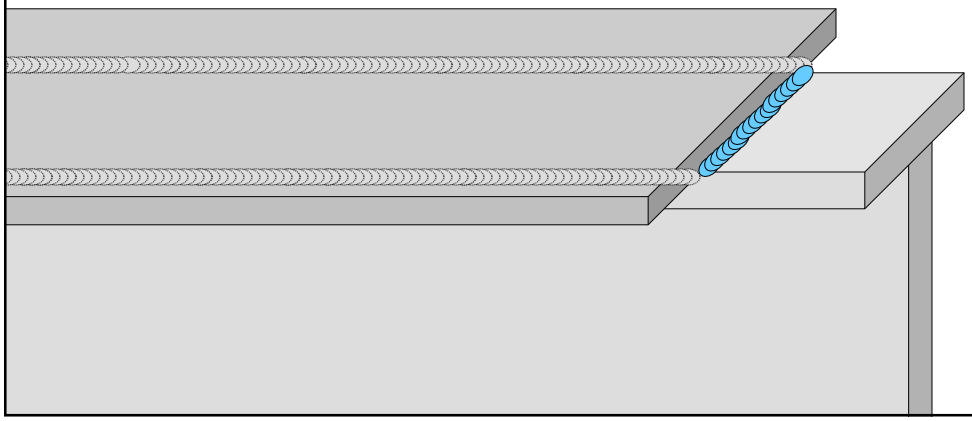
122

SPECIAL WELDING APPLICATIONS

May be AESS specified practice

Workmanship Concerns

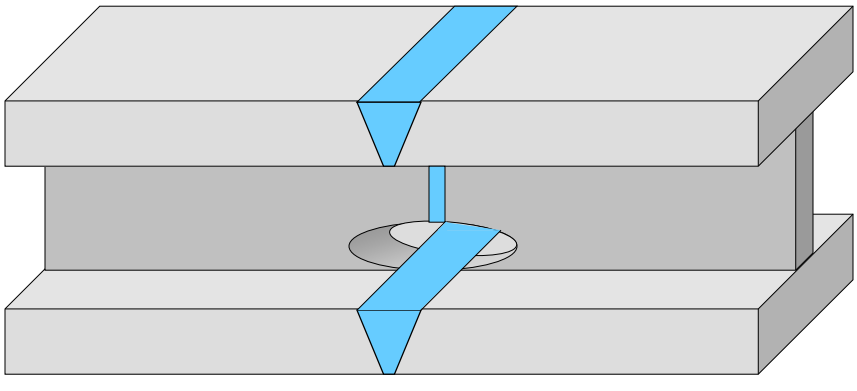
Inspection Concerns



123

SPECIAL WELDING APPLICATIONS

Code required practice



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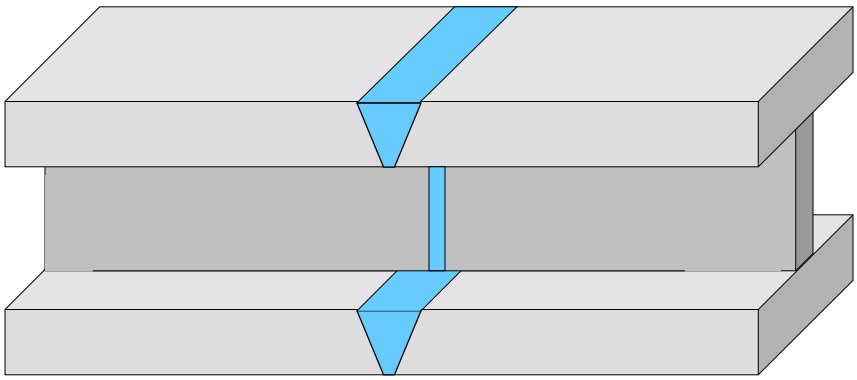
SPECIAL WELDING APPLICATIONS

May be AESS specified practice

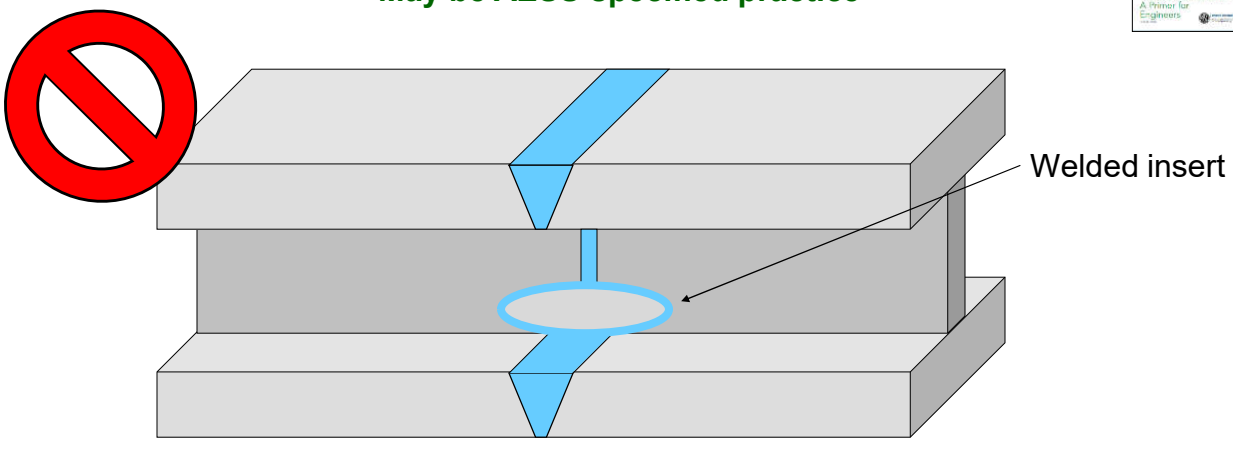


How can flange CJP groove weld be made?

125

SPECIAL WELDING APPLICATIONS

May be AESS specified practice

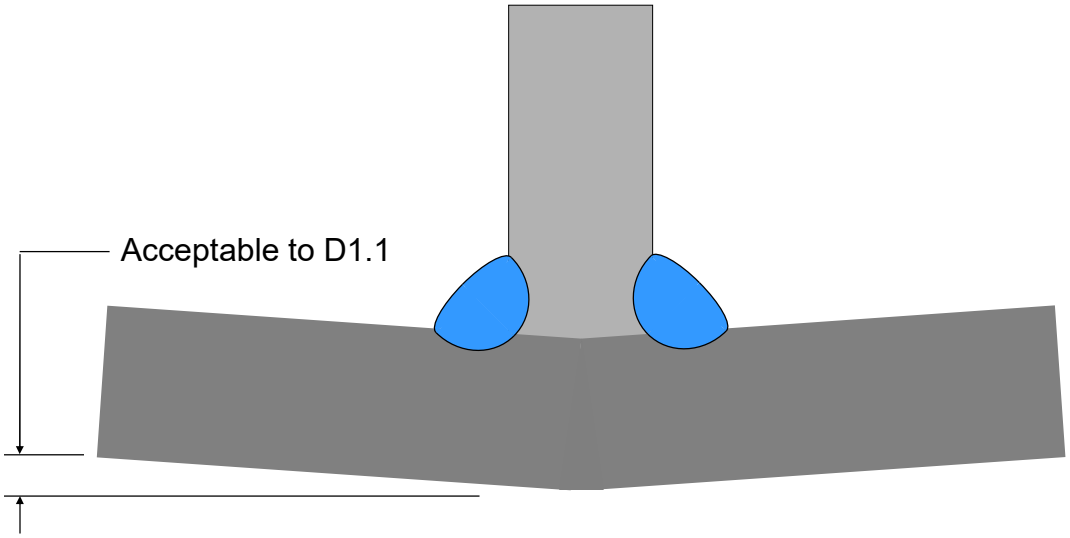


Will splice crack when insert is welded?

126

SPECIAL WELDING APPLICATIONS

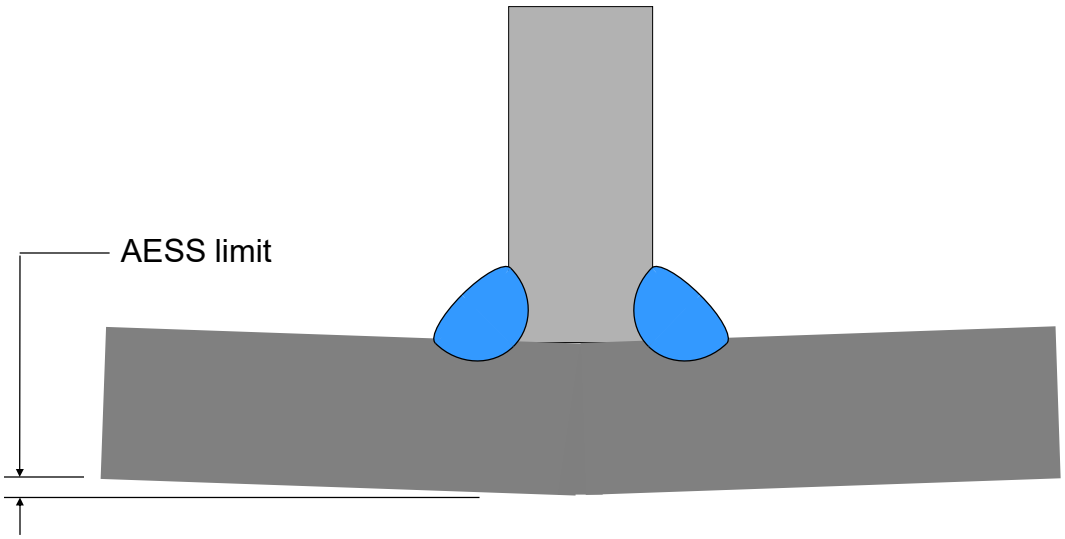
Distortion



127

SPECIAL WELDING APPLICATIONS

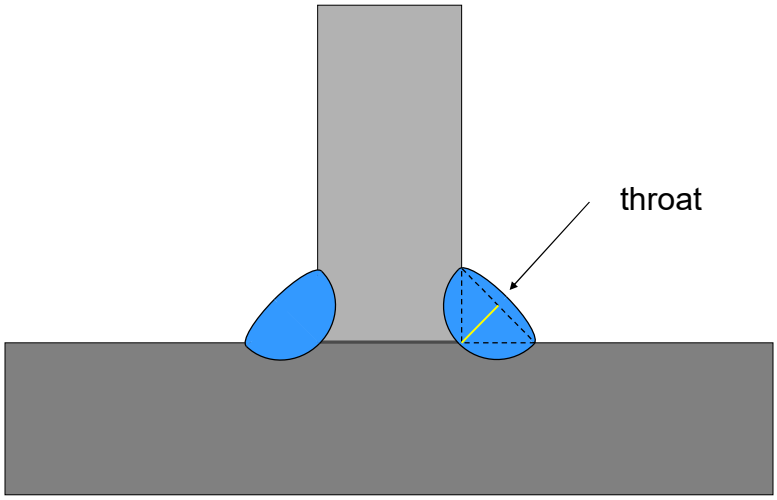
Distortion



128

SPECIAL WELDING APPLICATIONS

Weld Throats

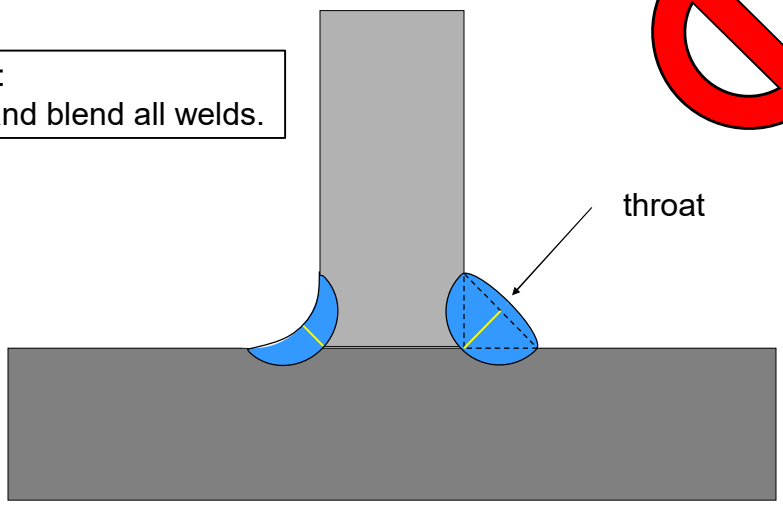


129

SPECIAL WELDING APPLICATIONS

Weld Throats

Project note:
1. Contour and blend all welds.



130

SPECIAL WELDING APPLICATIONS

Welding AESS

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

132

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

133

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

134

135

SPECIAL WELDING APPLICATIONS

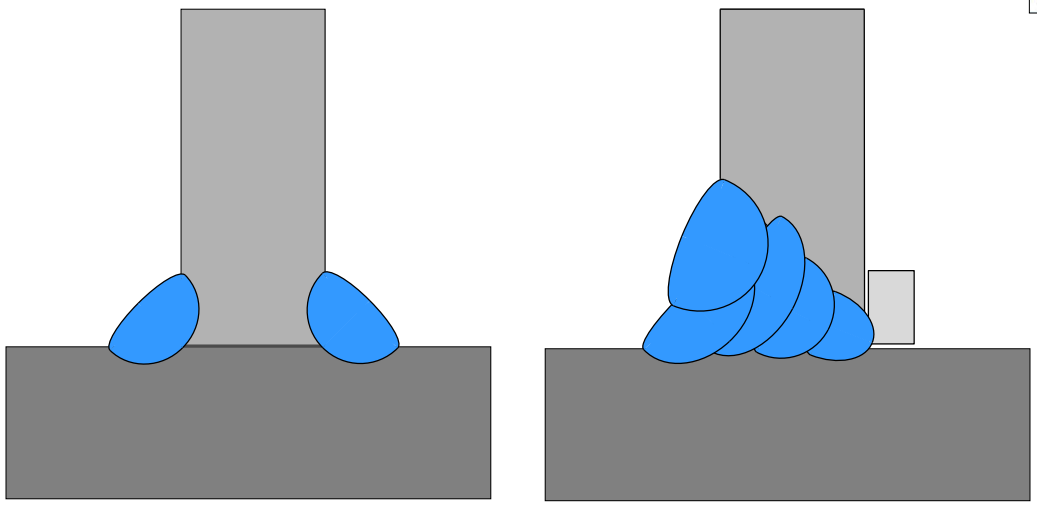
Shop versus Field Welding

- Primarily an issue of cost
- Some environmental issues (cold, wind, rain, etc.)
- Out-of-positon welding may be needed

136

SPECIAL WELDING APPLICATIONS

Usually Preferred

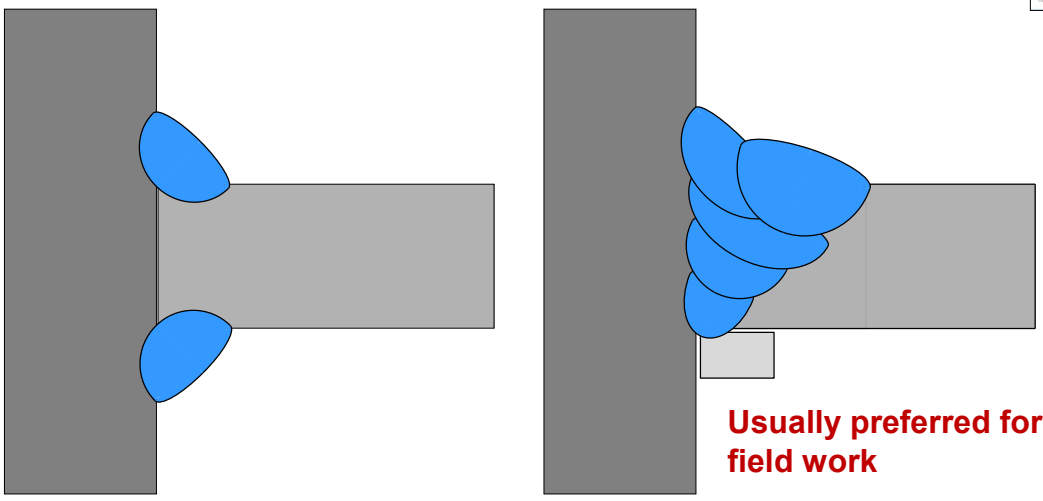


137

SPECIAL WELDING APPLICATIONS

Requires overhead welding

All flat welding



Usually preferred for field work

138

SPECIAL WELDING APPLICATIONS

Shop versus Field Welding

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

139

SPECIAL WELDING APPLICATIONS

Myths

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

140

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]	

141

SPECIAL WELDING APPLICATIONS

Myths

- You can't get quality welds out-of-positon
- You can't get quality in the field

142

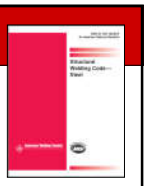
SPECIAL WELDING APPLICATIONS

Myths

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

144

AWS D1.1:2020 Structural Welding Code--Steel



7. Fabrication

7.1 Scope

This clause contains requirements for the fabrication and erection of welded assemblies and structures produced by any process applicable under this code (see 5.5 and 6.15) related to:

(1) Materials

(2) Processes and WPSs

(3) Weld Details

(4) Weld Quality and Repairs

(5) Member Dimensional Tolerances

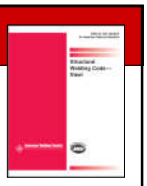
SPECIAL WELDING APPLICATIONS

Myths

- You can't get quality welds out-of-positon
- You can't get quality in the field
- Codes do not apply to field welding
- Field welders are not "certified" (qualified)

146

AWS D1.1:2020 Structural Welding Code--Steel



6. Qualification

6.2.2.2 Qualification Responsibility

Each manufacturer or Contractor shall be responsible for the qualification of welders, welding operators and tack welders, whether the qualification is conducted by the manufacturer, Contractor, or an independent testing agency.

SPECIAL WELDING APPLICATIONS

Myths

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

148

AISC 360-16 Specification for Structural Steel Buildings

CHAPTER N

QUALITY CONTROL AND QUALITY ASSURANCE

TABLE N5.4-1
Inspection Tasks Prior to Welding

Inspection Tasks Prior to Welding	QC	
Welder qualification records and continuity records	P	O
WPS available	P	P
Manufacturer certifications for welding consumables available	P	P
Material identification (type/grade)	O	O
Welder identification system[a]	O	O
Fit-up of groove welds (including joint geometry) • Joint preparations • Dimensions (alignment, root opening, root face, bevel) • Cleanliness (condition of steel surfaces) • Tacking (tack weld quality and location) • Backing type and fit (if applicable)	O	O
Fit-up of CJP groove welds of HSS T-, Y- and K-joints without backing (including joint geometry) • Joint preparations • Dimensions (alignment, root opening, root face, bevel) • Cleanliness (condition of steel surfaces) • Tacking (tack weld quality and location)	P	O
Configuration and finish of access holes	O	O
Fit-up of fillet welds • Dimensions (alignment, gaps at root) • Cleanliness (condition of steel surfaces) • Tacking (tack weld quality and location)	O	O
Check welding equipment	O	–

[a] The fabricator or erector, as applicable, shall maintain a system by which a welder who has welded a joint or member can be identified. Stamps, if used, shall be the low-stress type.

149

AISC 360-16 Specification for Structural Steel Buildings

TABLE N5.4-1
Inspection Tasks Prior to Welding

Inspection Tasks Prior to Welding	QC	QA
Welder qualification records and continuity records	P	O
WPS available	P	P
Manufacturer certifications for welding consumables available	P	P
Material identification (type/grade)	O	O
Welder identification system[a]	O	O
Fit-up of groove welds (including joint geometry) • Joint preparations • Dimensions (alignment, root opening, root face, bevel) • Cleanliness (condition of steel surfaces) • Tacking (tack weld quality and location) • Backing type and fit (if applicable)	O	O

150

SPECIAL WELDING APPLICATIONS

Myths

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

151

AMERICAN INSTITUTE OF STEEL CONSTRUCTION
CERTIFICATION PROGRAMS

PROUDLY RECOGNIZE THAT

ABC Company

MAINTAINS OPERATIONS LOCATED AT

123 Main St., Chicago, IL 60600

THAT SUCCESSFULLY MEET THE QUALITY CERTIFICATION REQUIREMENTS FOR

Erector (Advanced)
Bridge Endorsement
Seismic Endorsement
Metal Deck Endorsement

PRESIDENT

CERTIFICATION NUMBER: C-00011111
ISSUED: September 7, 2021
VALID THROUGH: September 30, 2021

SPECIAL WELDING APPLICATIONS

Myths

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

153

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.

154

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

155

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

156

SPECIAL WELDING APPLICATIONS

14.9 Welding on Existing Structures

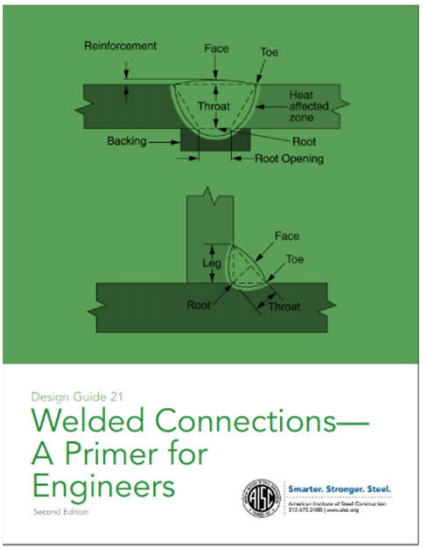
- Historic steels
- Welding under load
- Fire
- Cold working / strain aging

157

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)



158

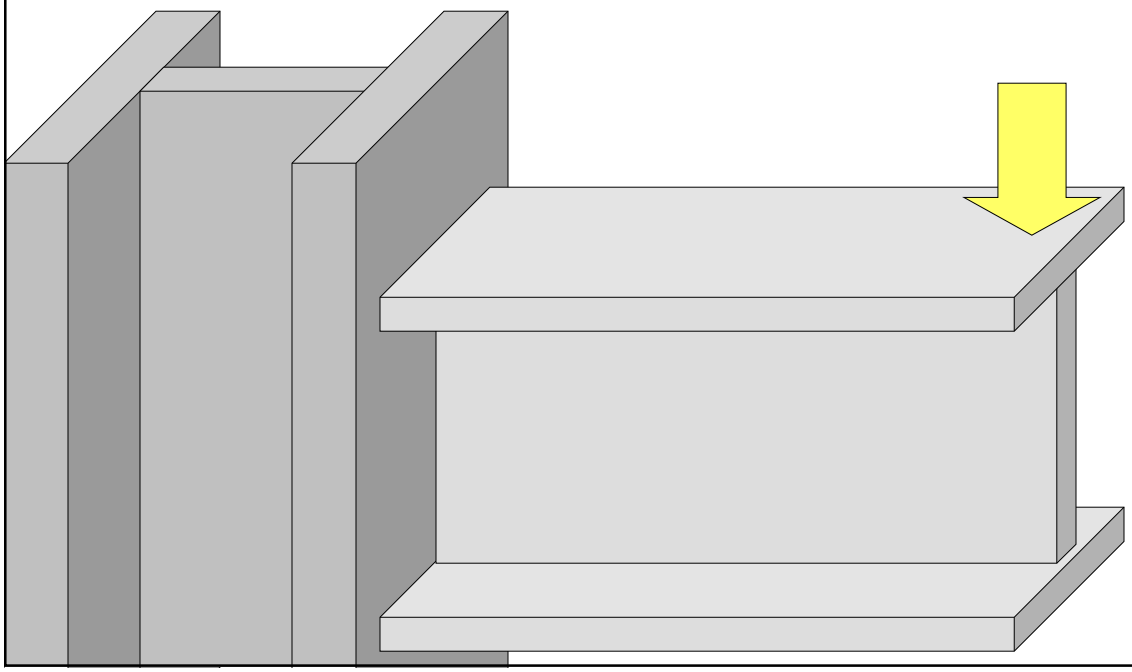
SPECIAL WELDING APPLICATIONS

14.9 Welding on Existing Structures

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

159

SPECIAL WELDING APPLICATIONS



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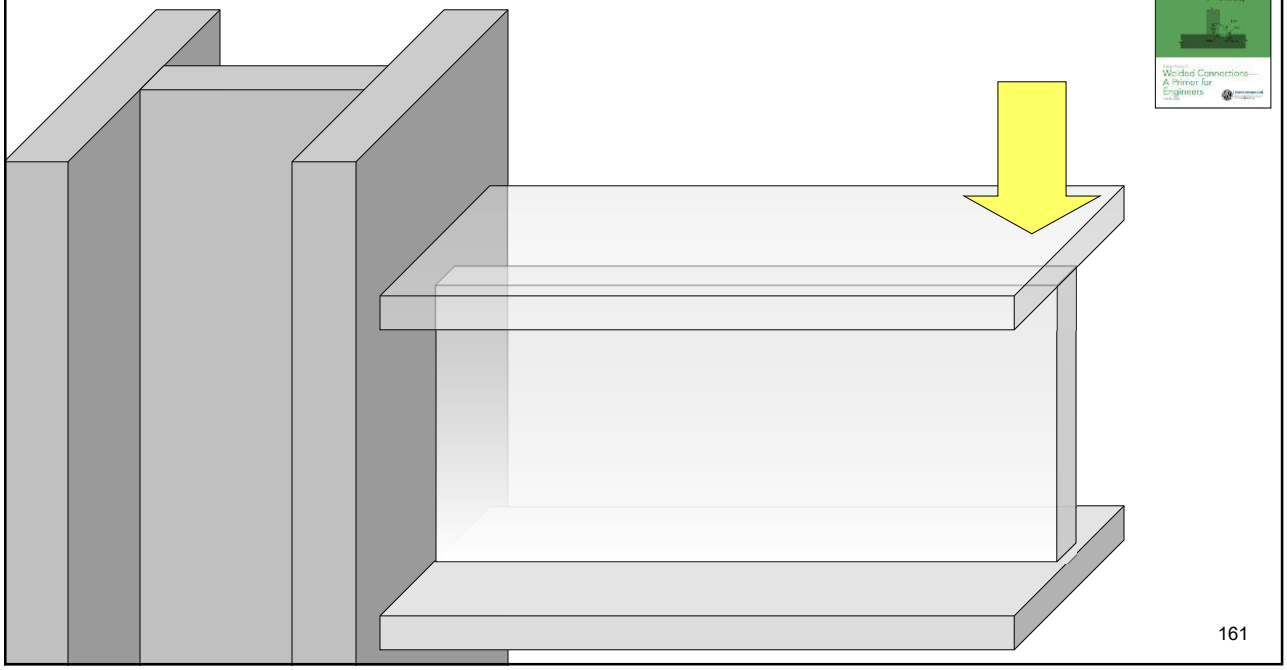
SPECIAL WELDING APPLICATIONS



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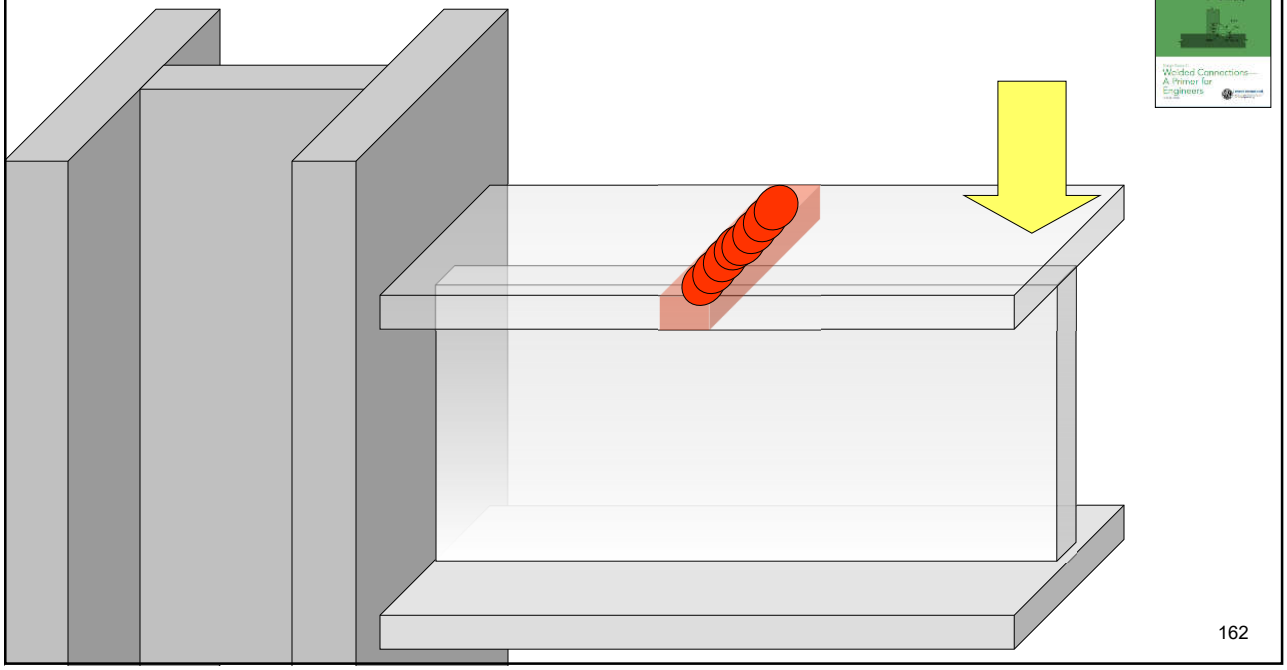
SPECIAL WELDING APPLICATIONS



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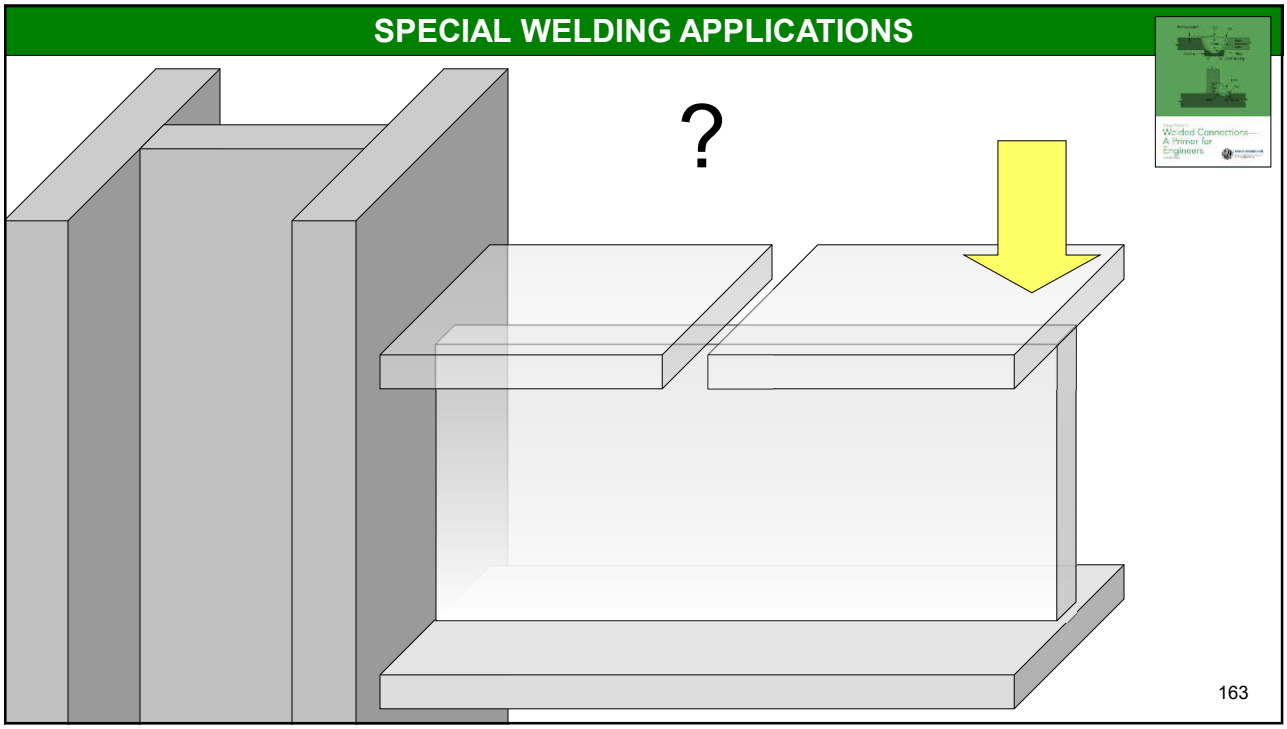
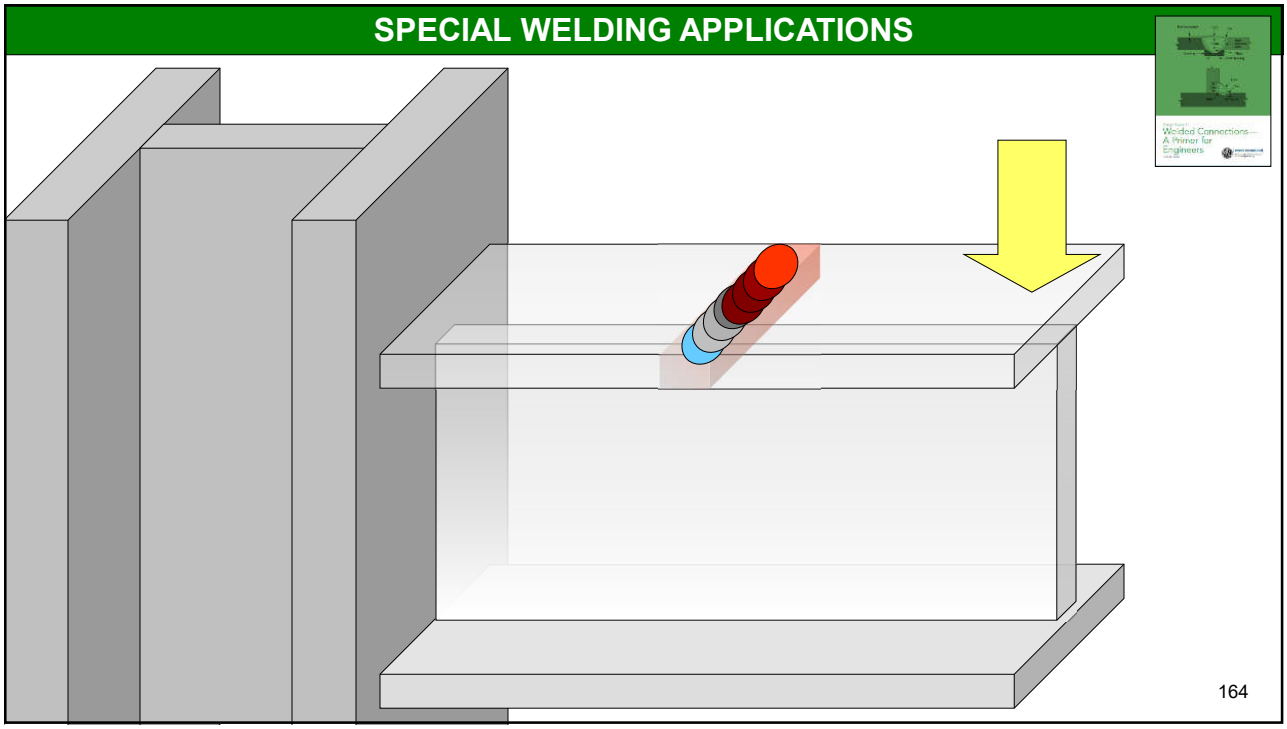
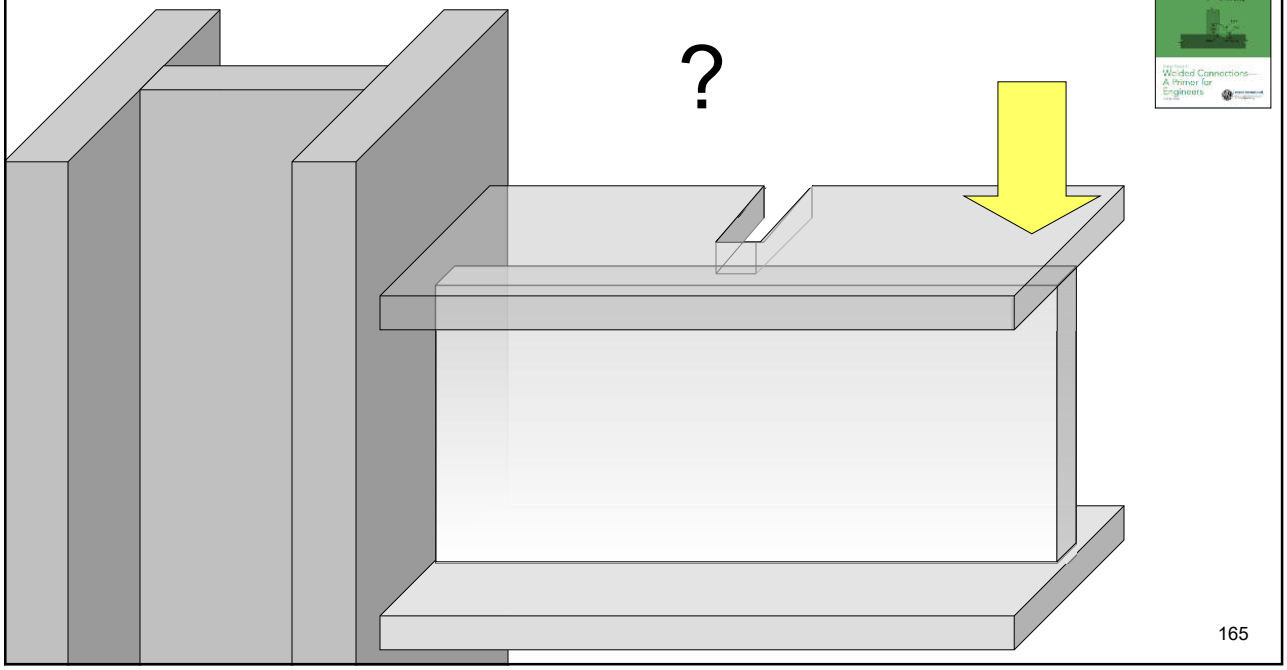
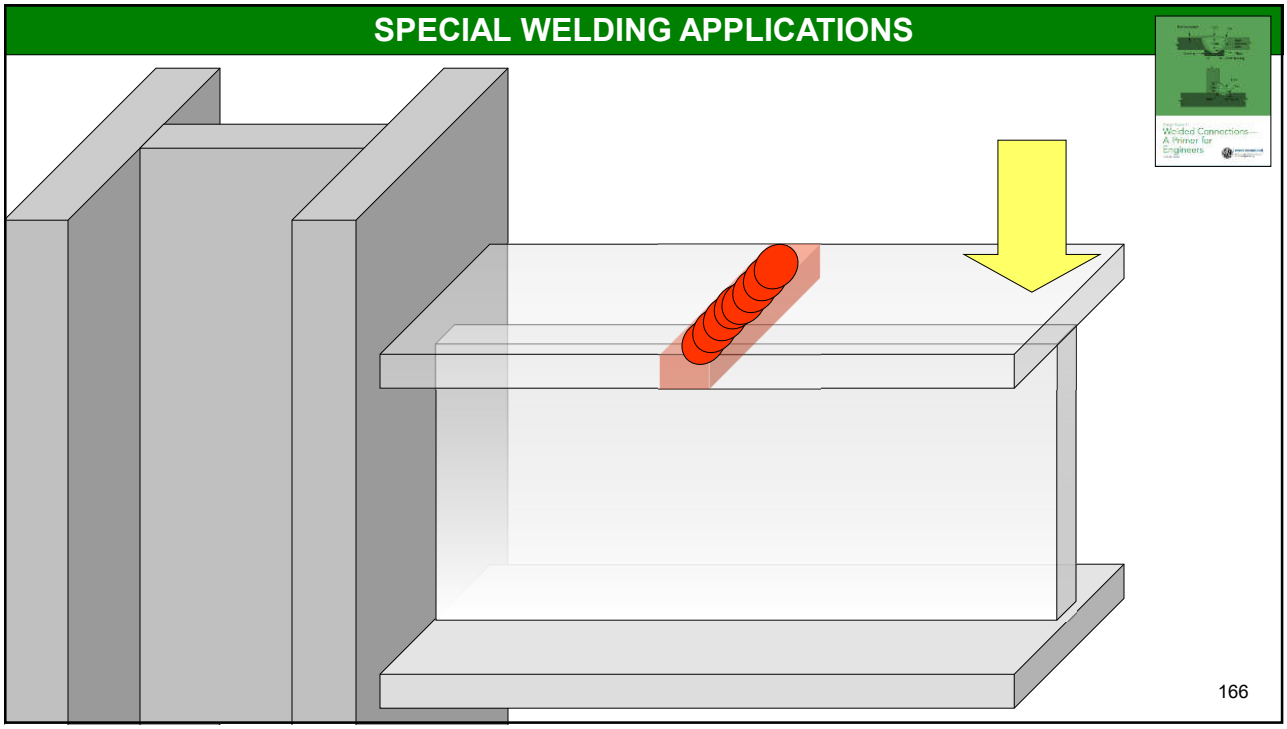




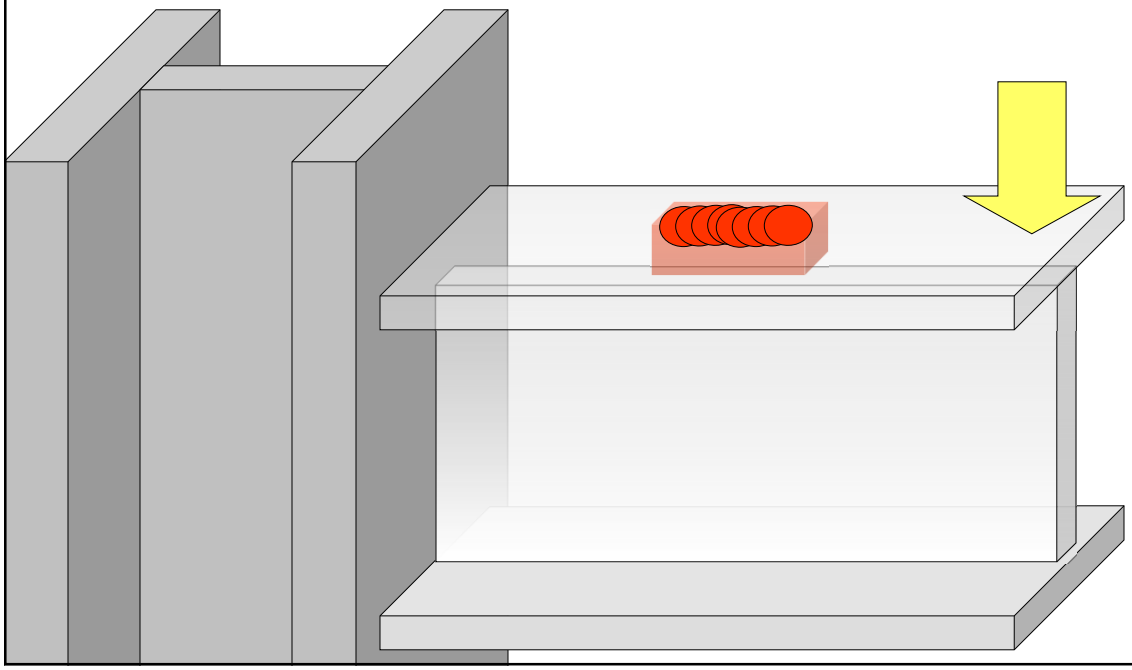
SPECIAL WELDING APPLICATIONS



SPECIAL WELDING APPLICATIONS

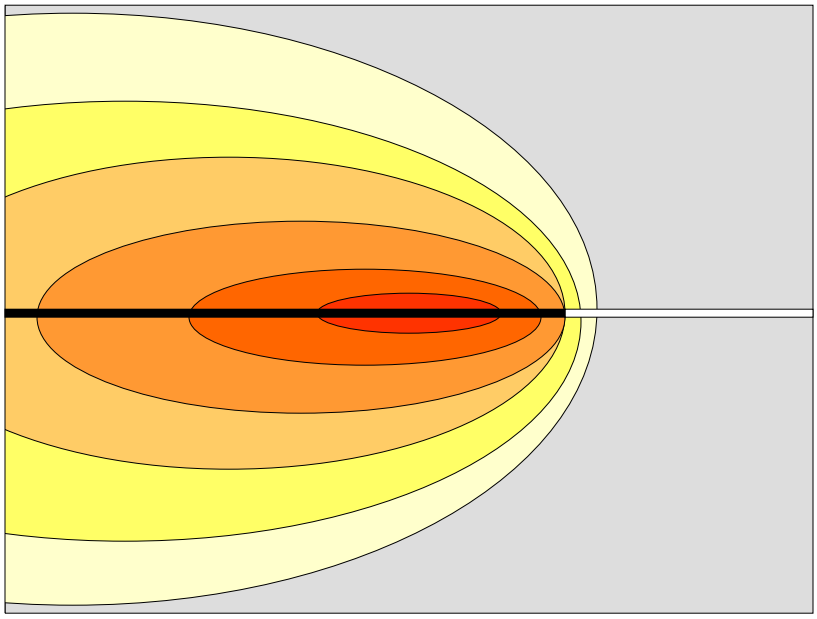


SPECIAL WELDING APPLICATIONS



167

SPECIAL WELDING APPLICATIONS



168

AISC 360-16 Specification for Structural Steel Buildings

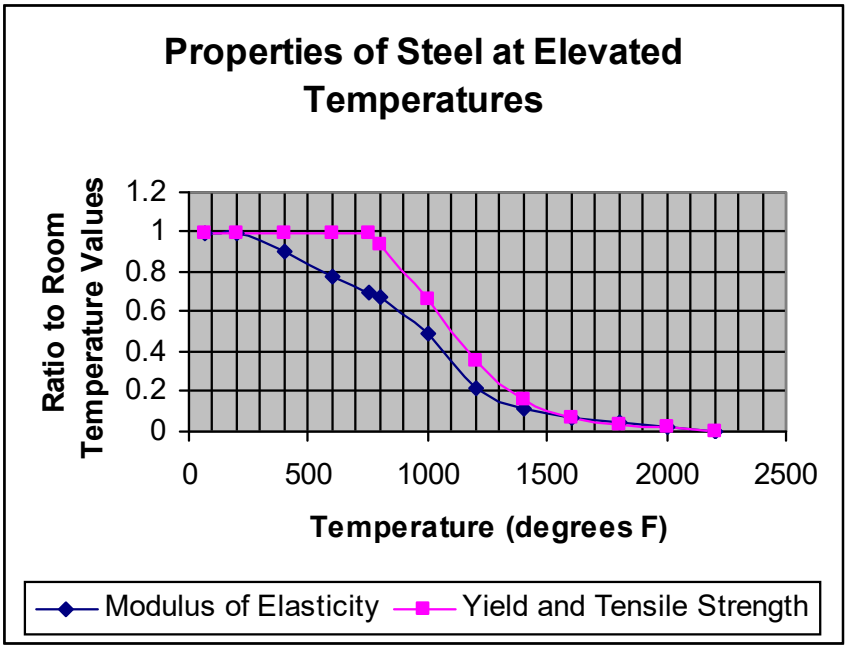
Table A-4.2.1
Properties of Steel at Elevated Temperatures

Steel Tempreature (°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.

169

SPECIAL WELDING APPLICATIONS



170

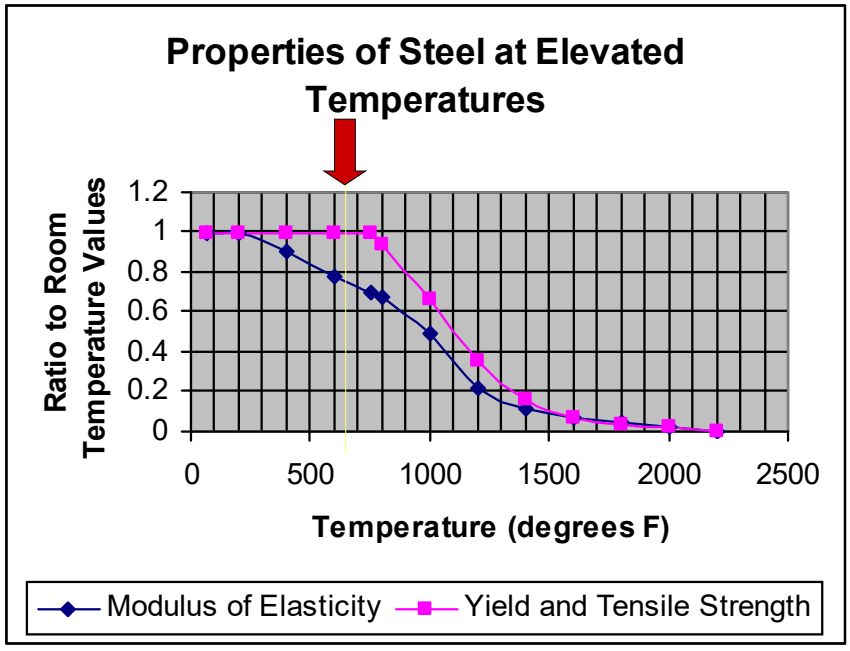
SPECIAL WELDING APPLICATIONS

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

171

SPECIAL WELDING APPLICATIONS



172

SPECIAL WELDING APPLICATIONS

14.9 Welding on Existing Structures

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

173

SPECIAL WELDING APPLICATIONS

Welding on Existing Structures

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

174

SPECIAL WELDING APPLICATIONS

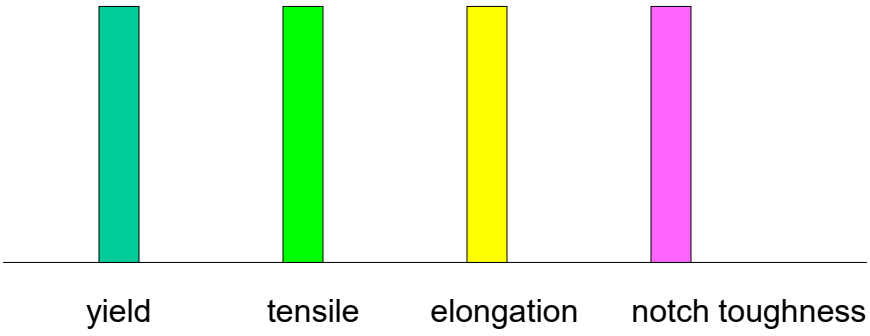
14.9 Welding on Existing Structures

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

175

SPECIAL WELDING APPLICATIONS

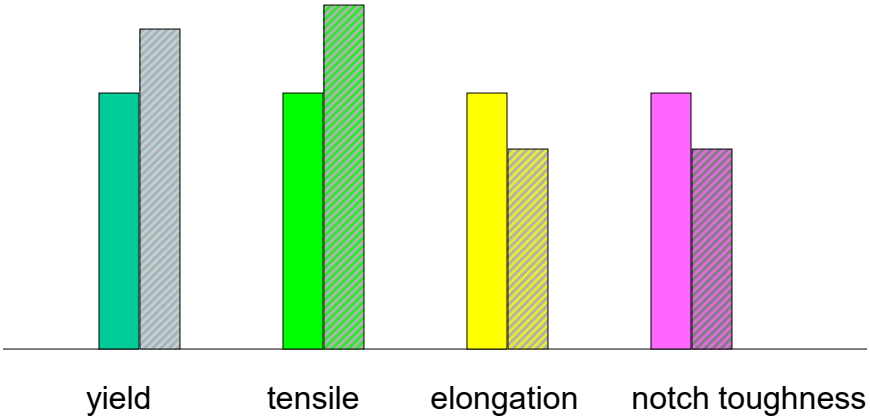
As received hot rolled steel



176

SPECIAL WELDING APPLICATIONS

Effects of cold working



177

SPECIAL WELDING APPLICATIONS

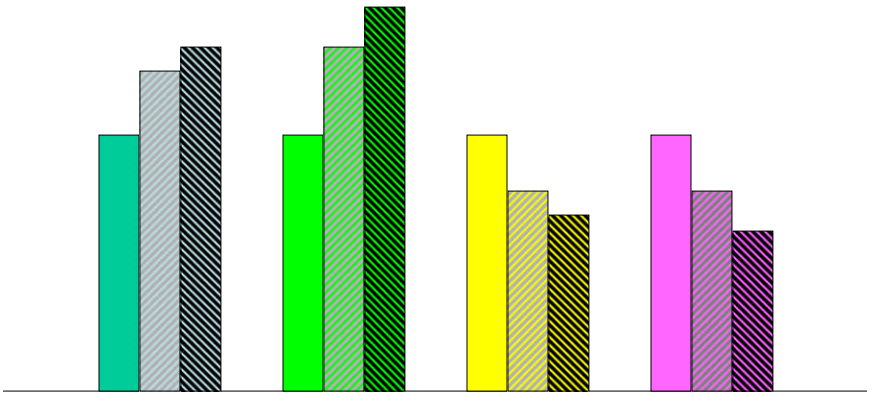
Strain Aging

- 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)

178

SPECIAL WELDING APPLICATIONS

Effects of strain aging



179

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

180

AWS D1.1:2020 STRUCTURAL WELDING CODE

11. Strengthening and Repair of Existing Structures

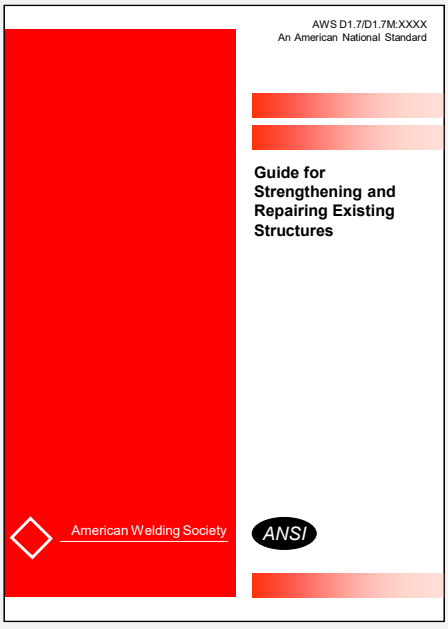
11.1 Scope

Strengthening or repair of an existing structure shall consist of modifications to meet design requirements, specified by the Engineer. This clause includes requirements for a comprehensive plan for the work, including design, workmanship, inspection, and documentation. The use of fatigue life enhancement methods is also described.

181

AWS D1.7

Guide for Strengthening and Repairing Exiting Structures



182

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

183

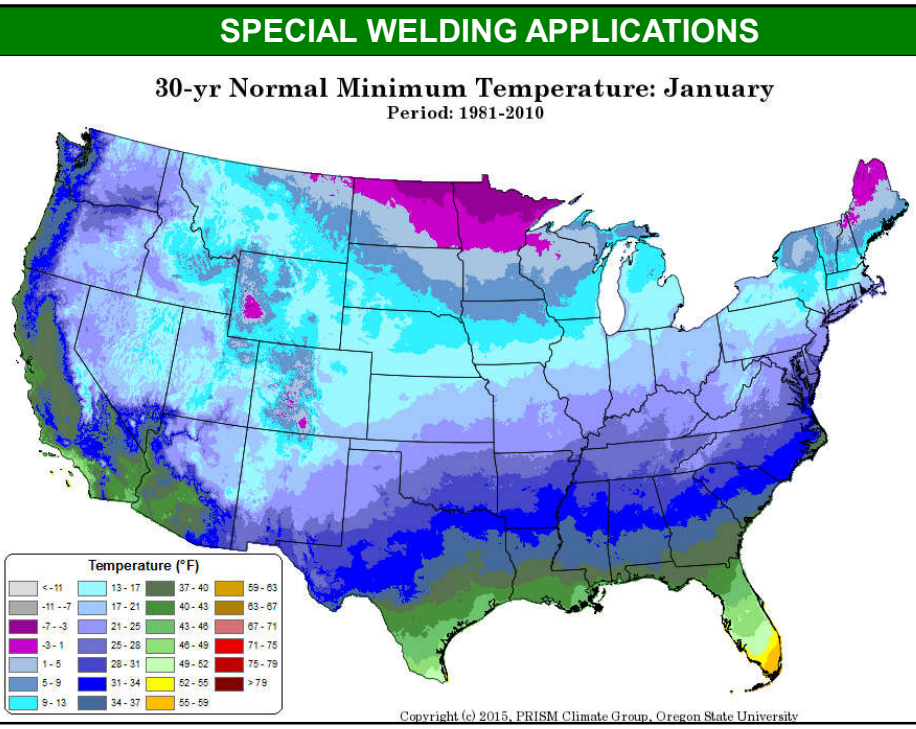
SPECIAL WELDING APPLICATIONS

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

184

SPECIAL WELDING APPLICATIONS



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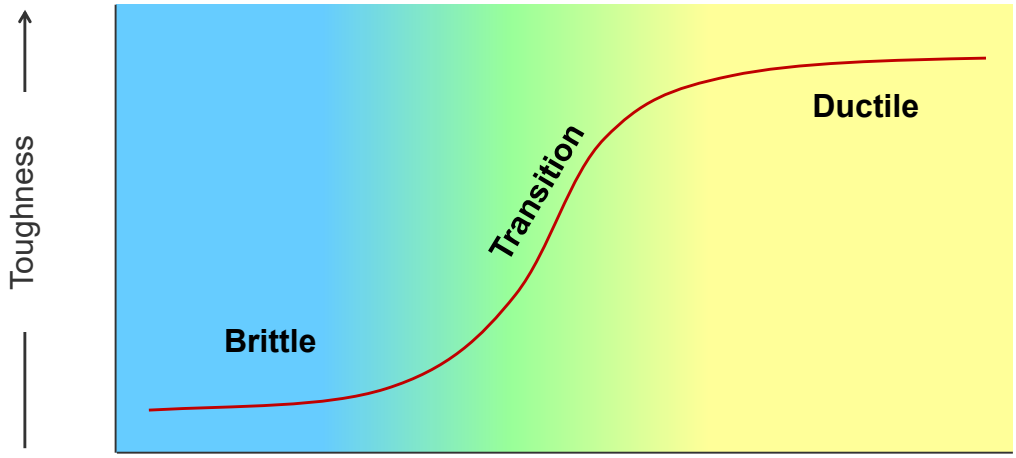
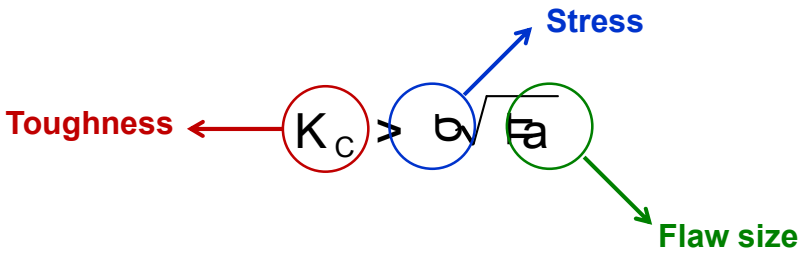
SPECIAL WELDING APPLICATIONS



186

SPECIAL WELDING APPLICATIONS

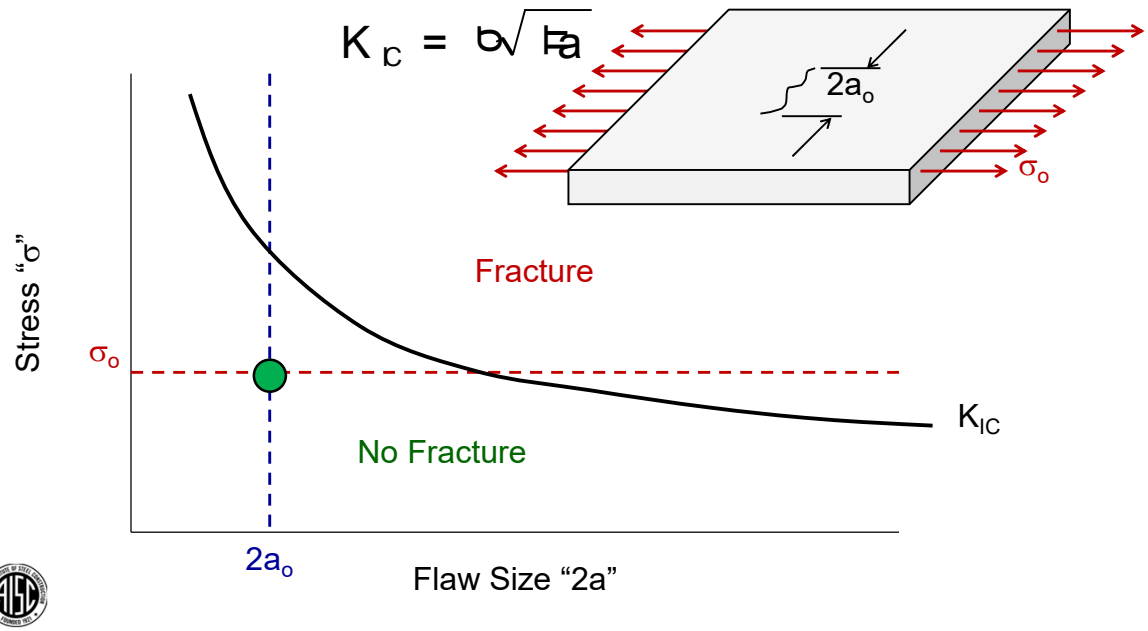
An infinite number of **correct** answers.



An infinite number of **incorrect** answers.

187

SPECIAL WELDING APPLICATIONS



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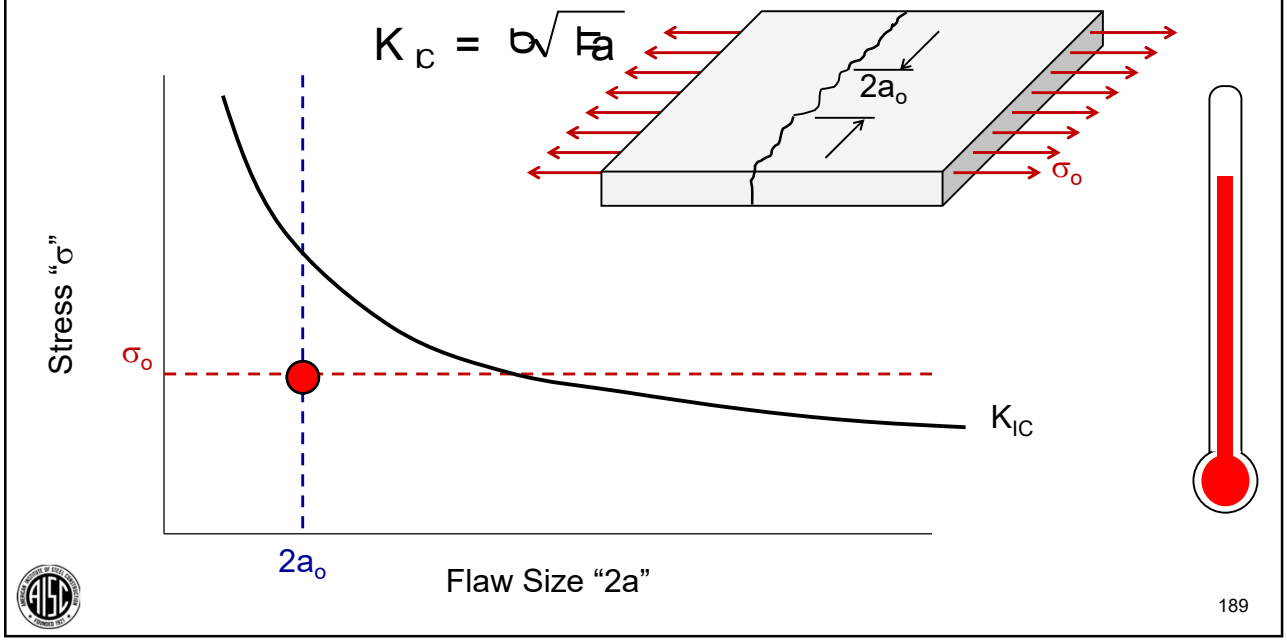
SPECIAL WELDING APPLICATIONS



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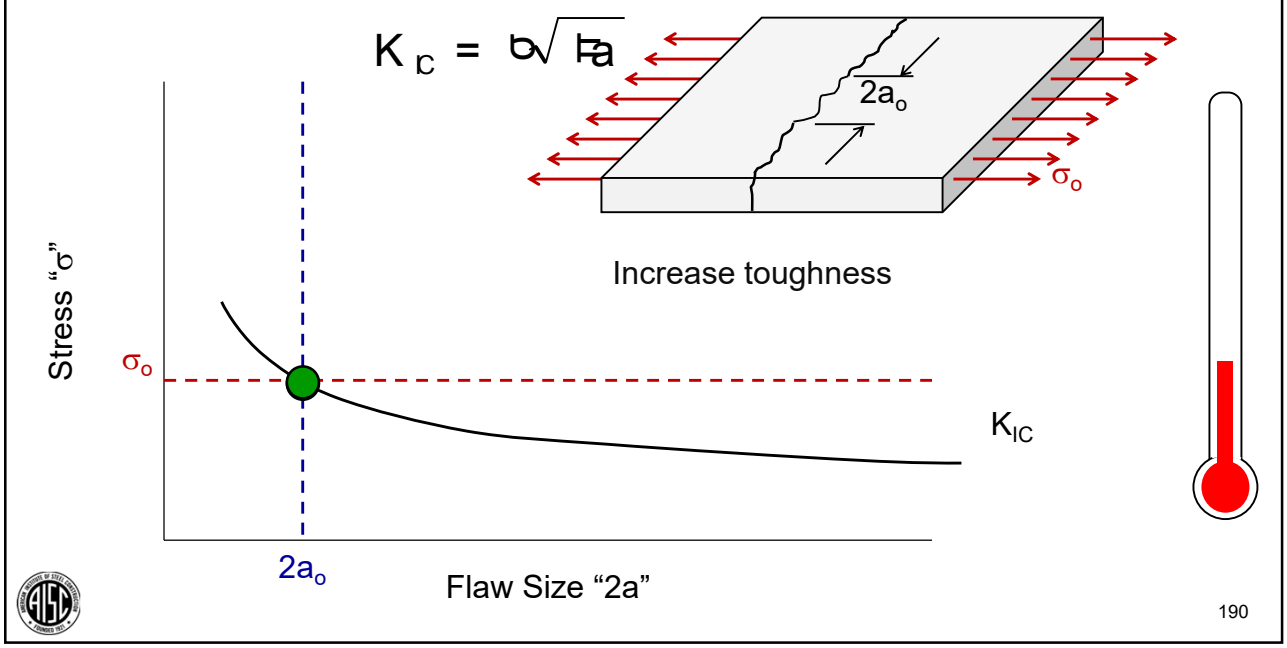
SPECIAL WELDING APPLICATIONS



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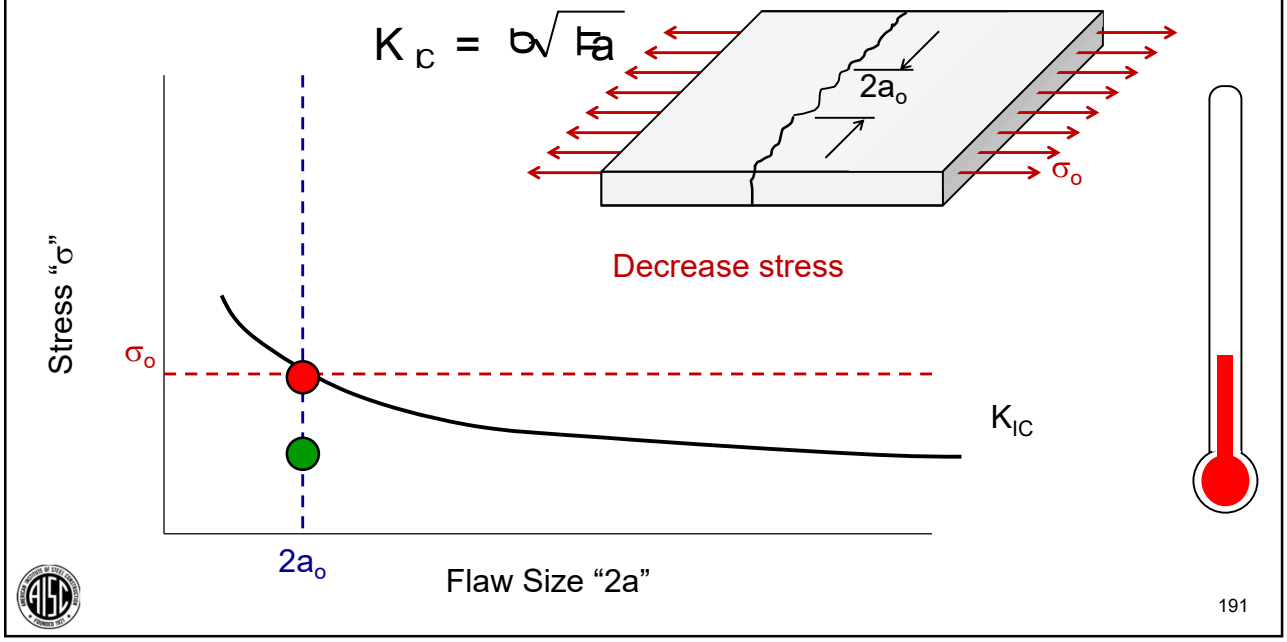
SPECIAL WELDING APPLICATIONS



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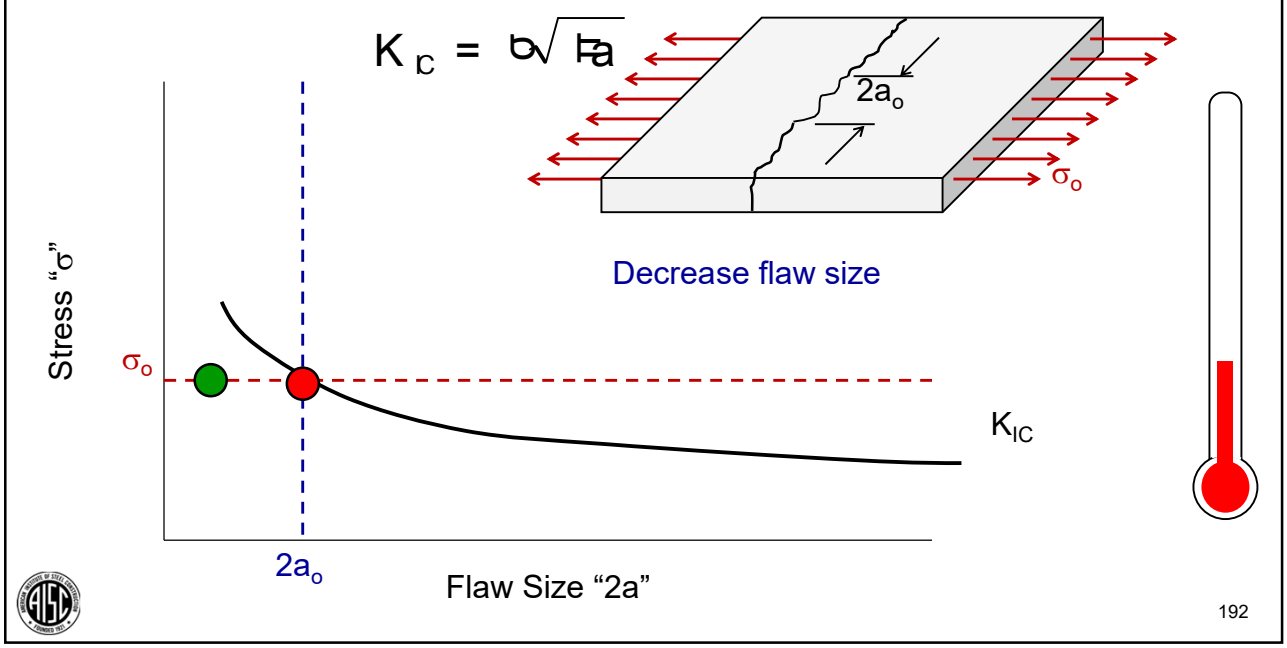
SPECIAL WELDING APPLICATIONS



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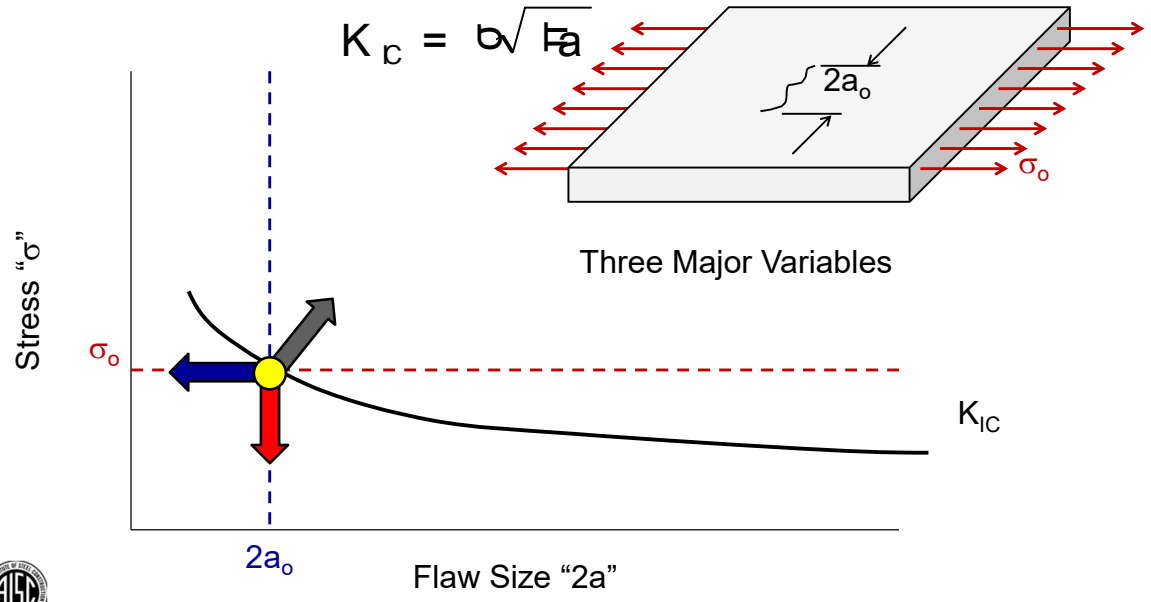
SPECIAL WELDING APPLICATIONS



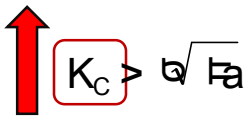
193

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."



194

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."

$K_c > \sqrt{a}$

195

SPECIAL WELDING APPLICATIONS

Cold Temperature Applications: Summary

Material | Details | Workmanship | Inspection

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

196

SPECIAL WELDING APPLICATIONS

Today's Webinar

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14.15 Heat Shrinking
14.16 Buttering

197

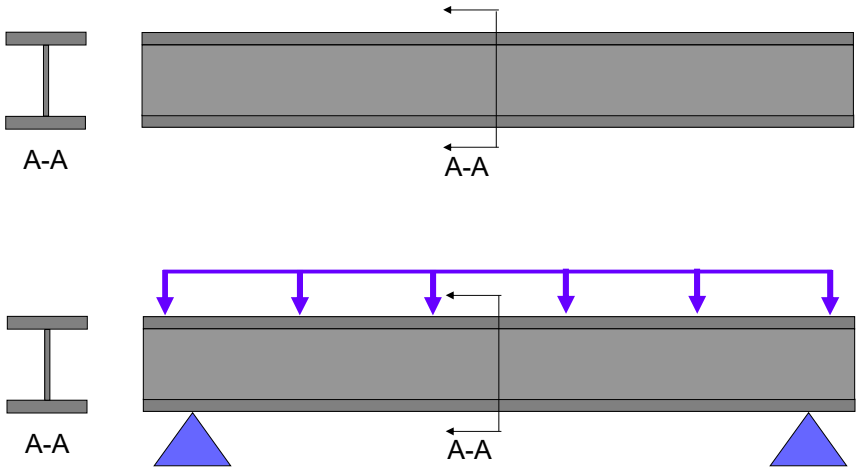
SPECIAL WELDING APPLICATIONS

Heat Shrinking

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

198

SPECIAL WELDING APPLICATIONS



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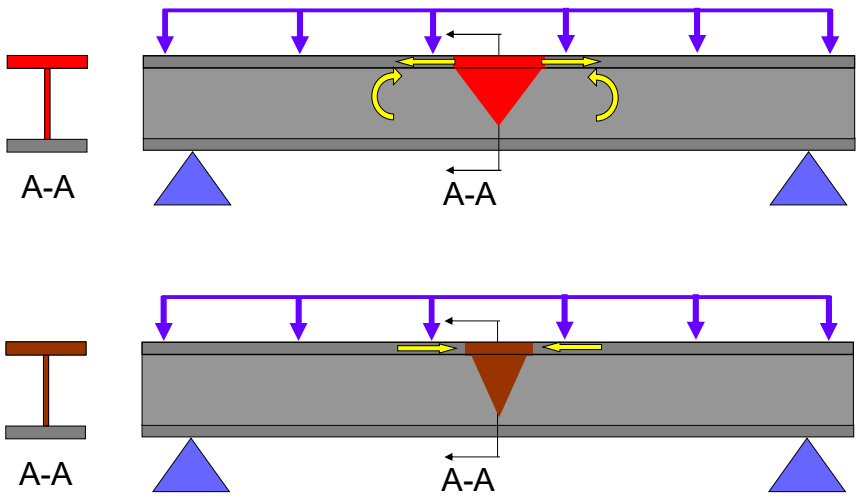
SPECIAL WELDING APPLICATIONS



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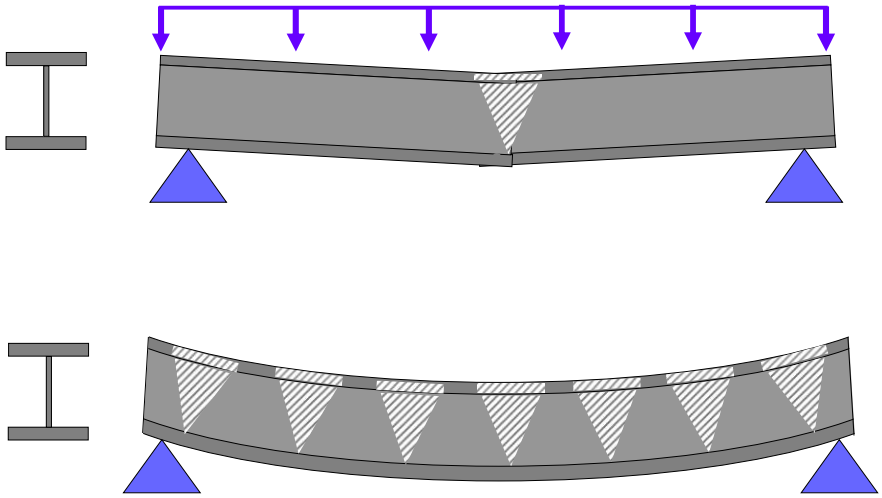
SPECIAL WELDING APPLICATIONS



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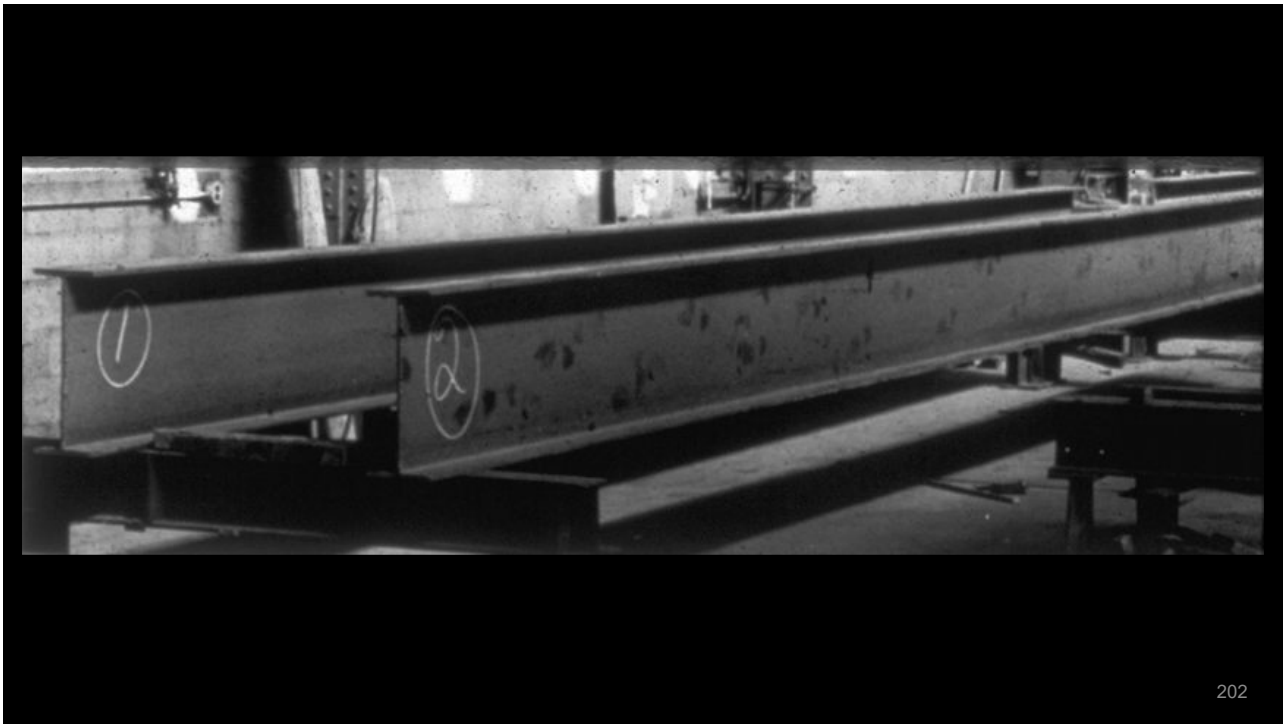

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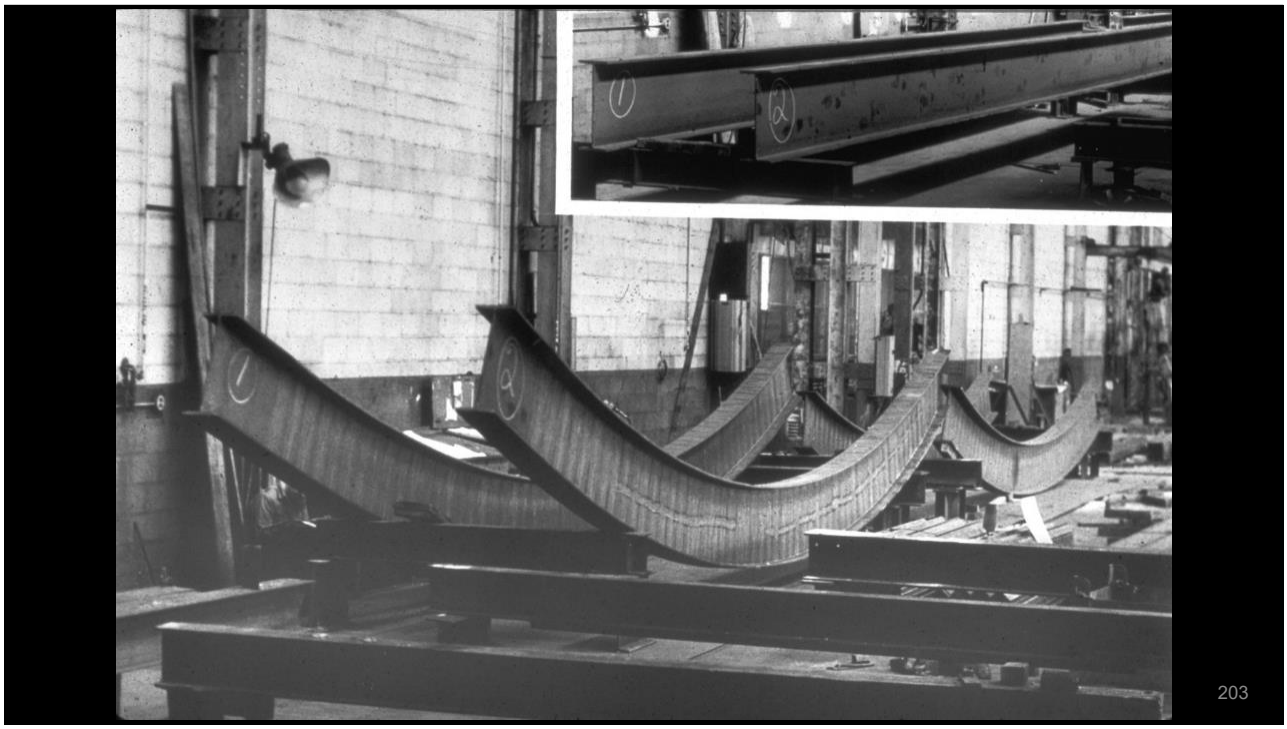


SPECIAL WELDING APPLICATIONS

Heat Shrinking

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

205

AWS D1.1:2020 STRUCTURAL WELDING CODE

7.25.2 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.

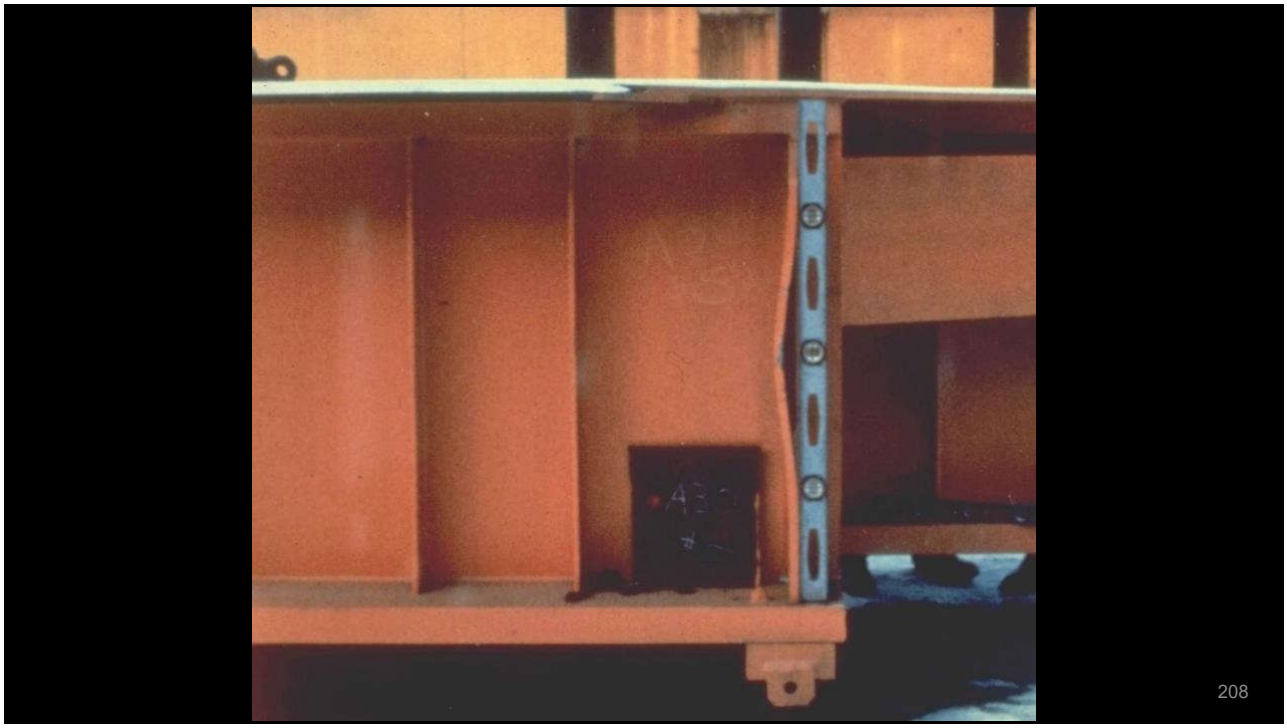
206

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%

207



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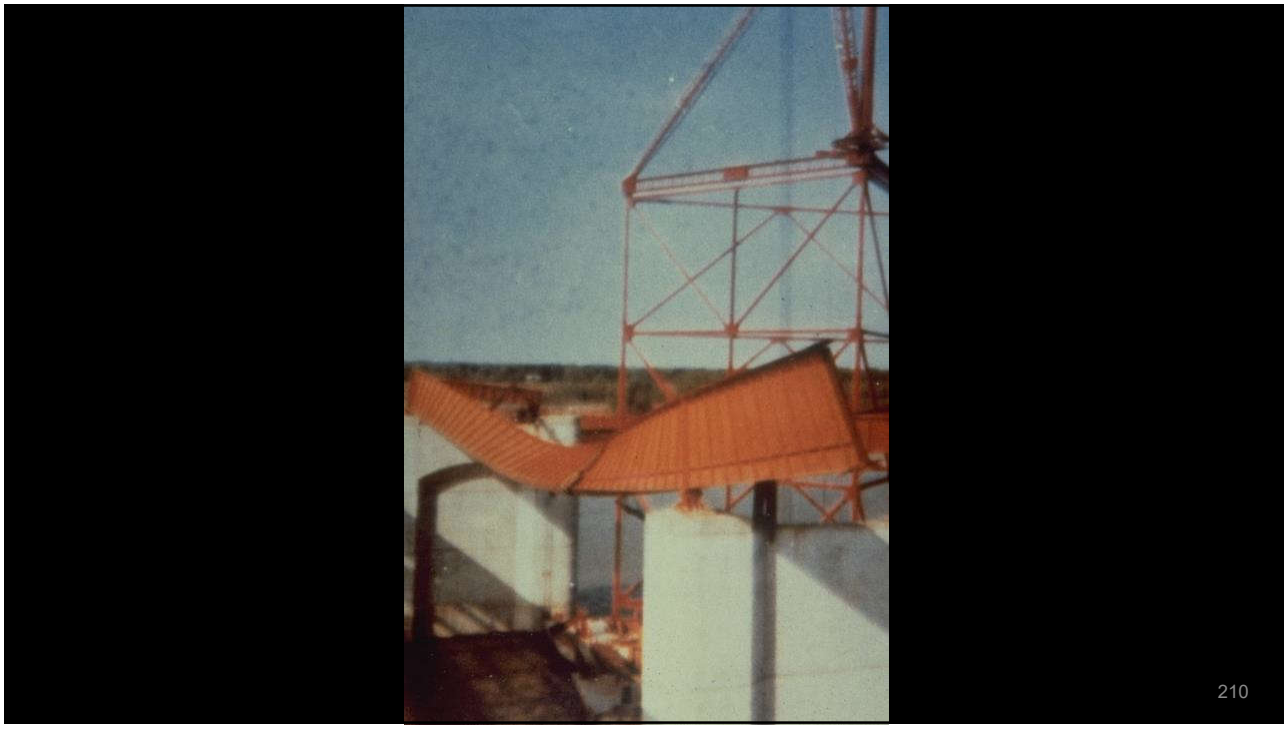

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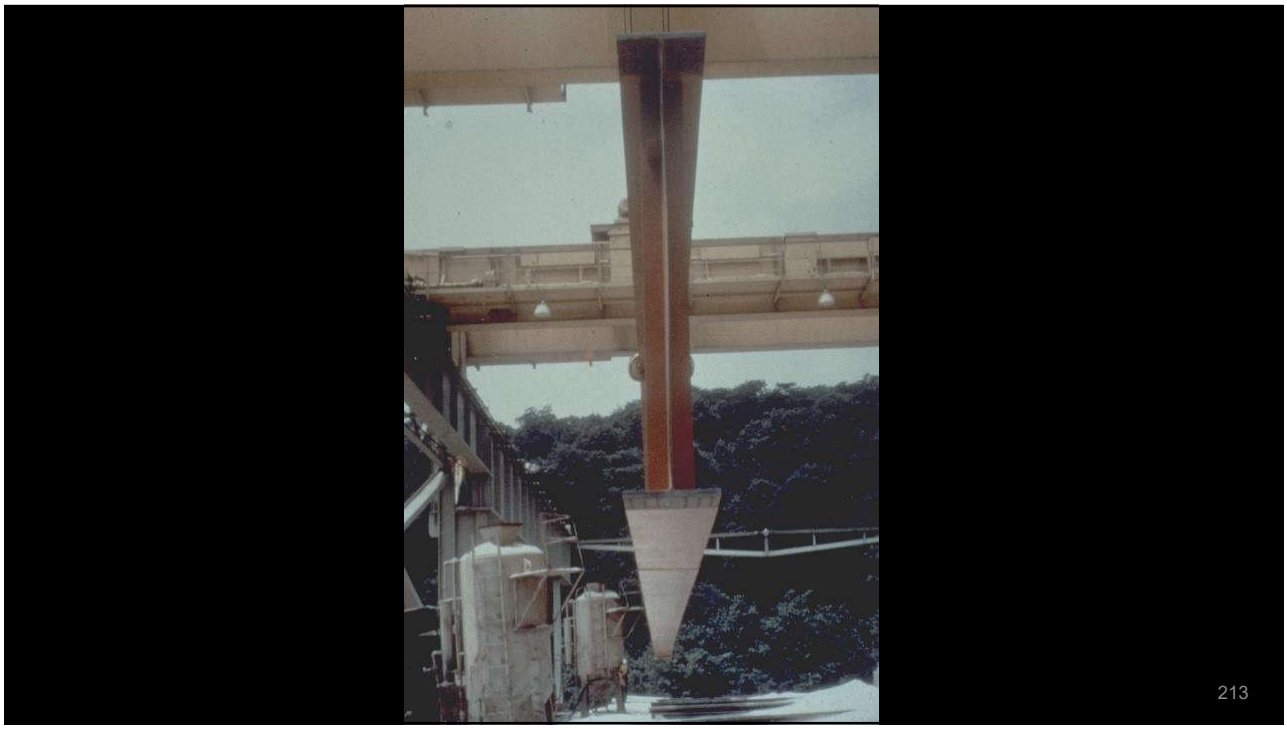
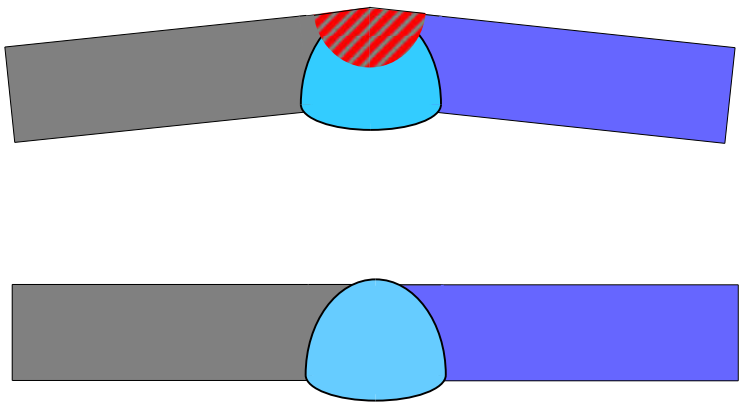


Correcting Angular Distortion



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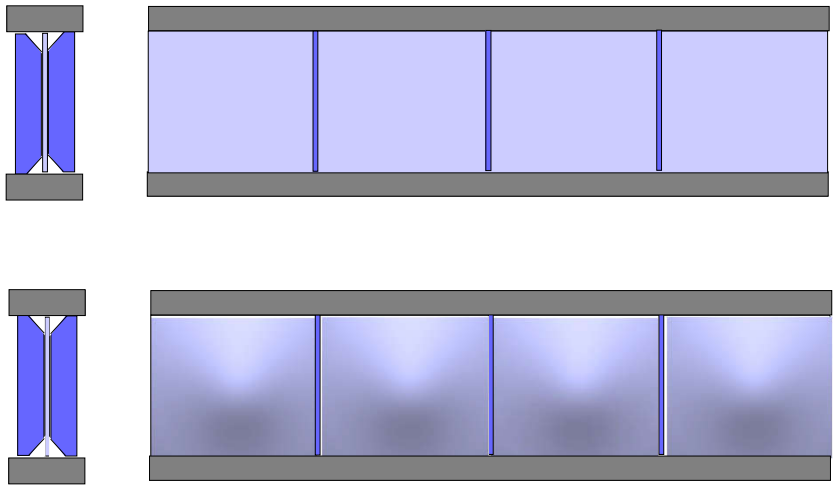
Correcting Panel Distortion



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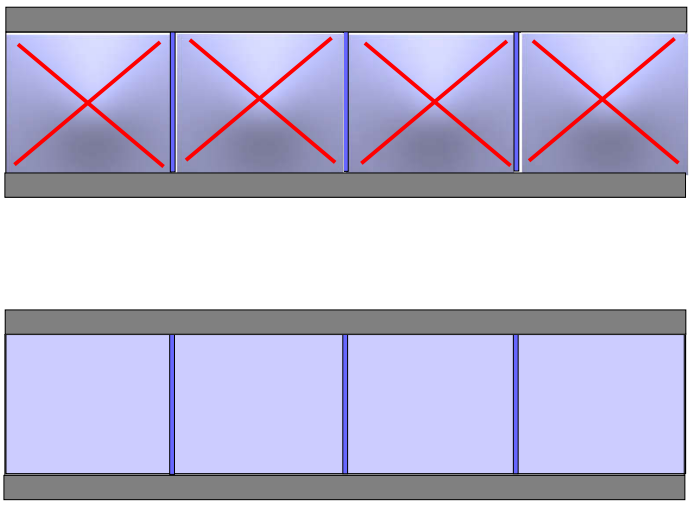
Correcting Panel Distortion



216

SPECIAL WELDING APPLICATIONS

Heat Shrinking: Summary

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

217

SPECIAL WELDING APPLICATIONS

Today's Webinar

14.4 Welding on Heavy Shapes
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14.15 Heat Shrinking
→ 14.16 Buttering

218

SPECIAL WELDING APPLICATIONS

BUTTERING

219

AWS STANDARD WELDING TERMS & DEFINITIONS (A3.0:2020)

buttering

A surfacing variation primarily use to provide metallurgically compatible weld metal for the subsequent completion of the weld.

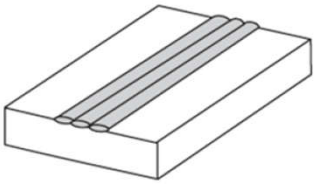
See also buildup, cladding, and hardfacing.

220

AWS STANDARD WELDING TERMS & DEFINITIONS (A3.0:2020)

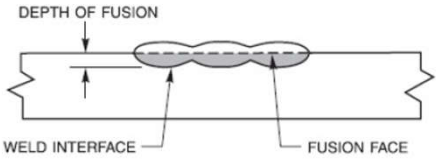
surfacing weld

A weld applied to a surface, as opposed to making a joint, to obtain desired properties or dimensions. See Figures B15(C) and B30(C).



(C) SURFACING WELD

Figure B15(C)



(C) SURFACING WELD

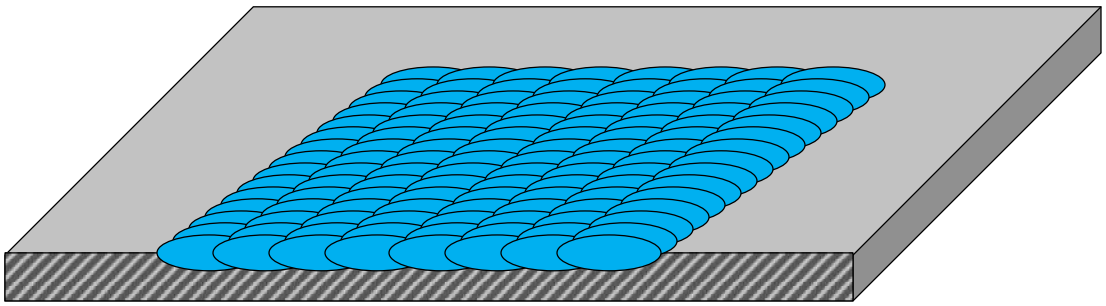
Figure B30(C)

SPECIAL WELDING APPLICATIONS

Buttering is used to:

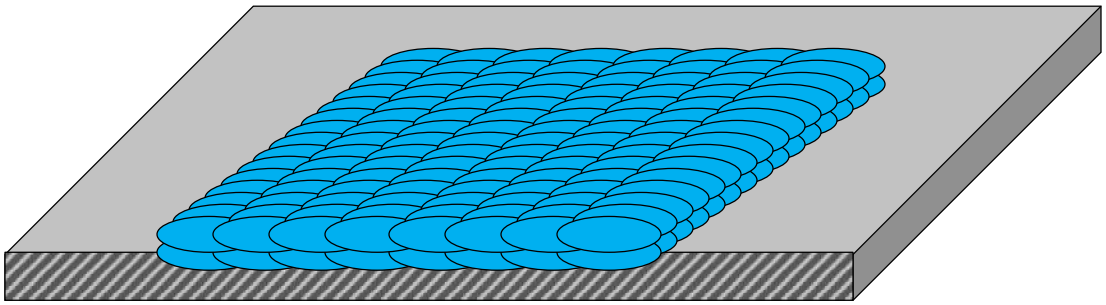
- Mitigate lamellar tearing tendencies
- Build up the faces of groove weld joint cavities where root openings are excessive
- Restore material from steel that was damaged by corrosion
- Enable welding on “hard to weld” steels

SPECIAL WELDING APPLICATIONS



223

SPECIAL WELDING APPLICATIONS



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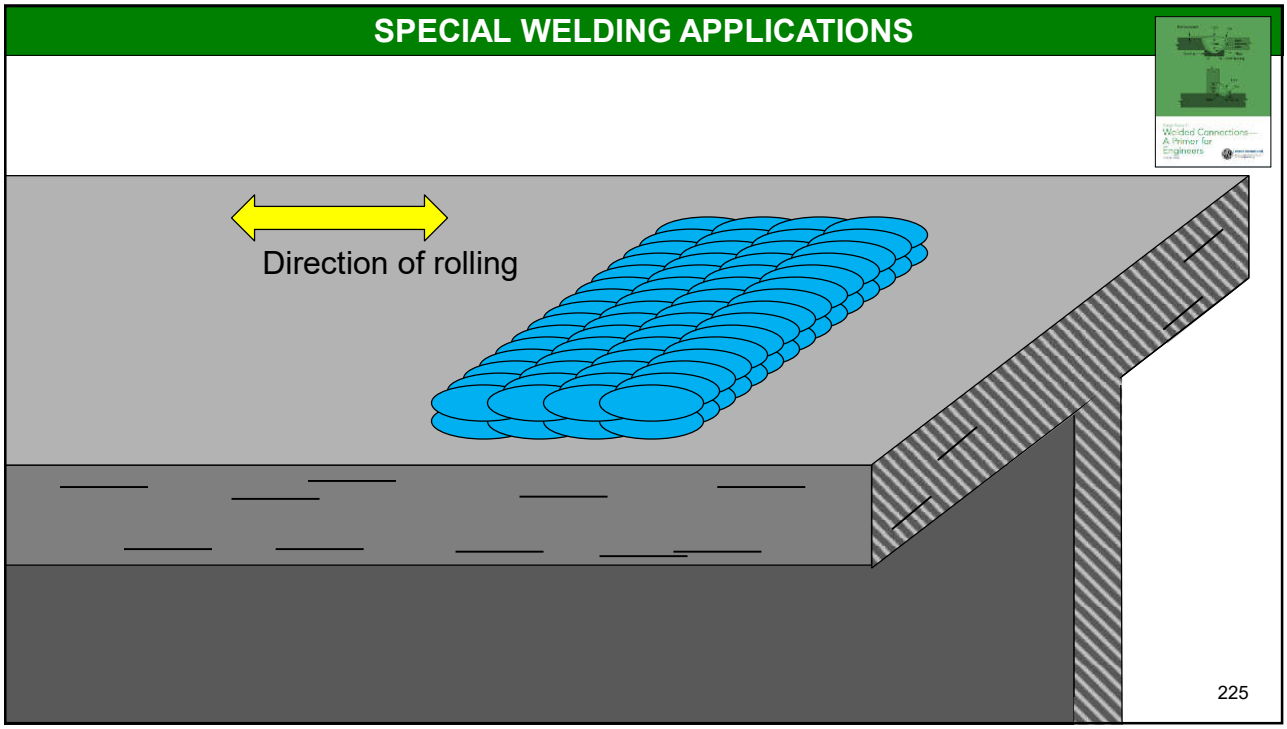
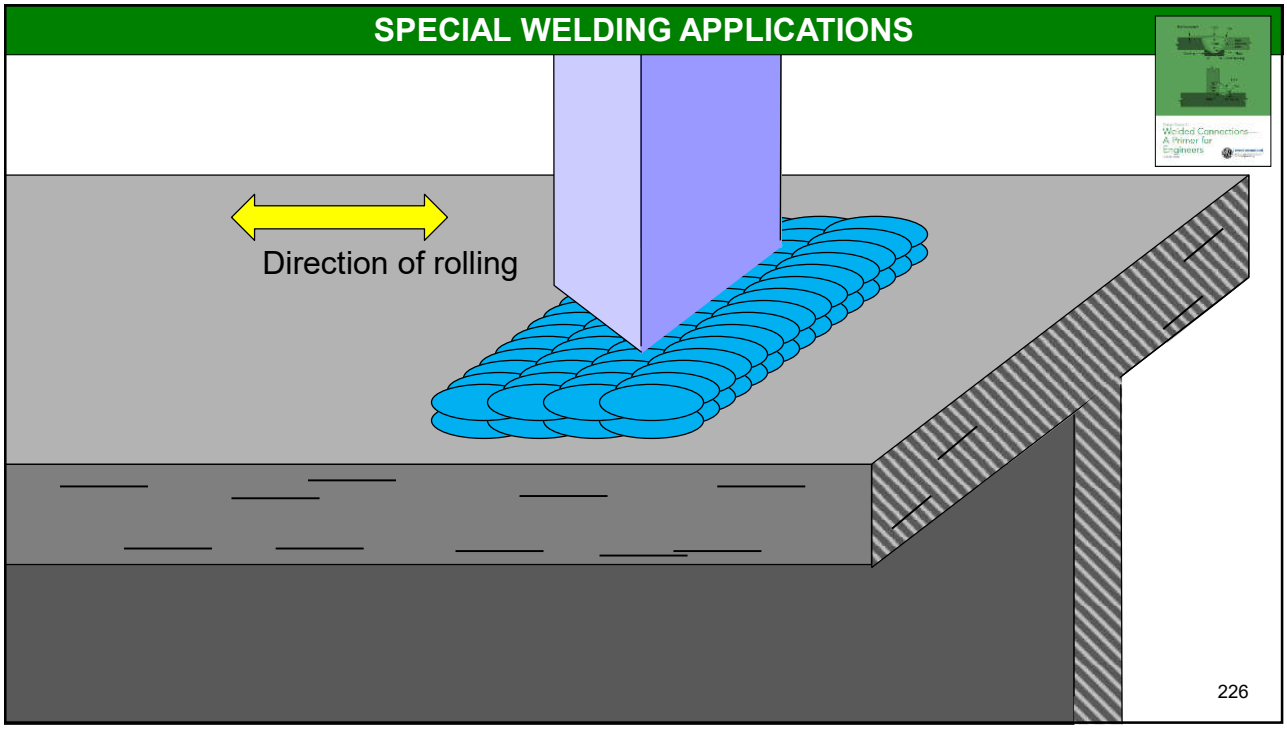
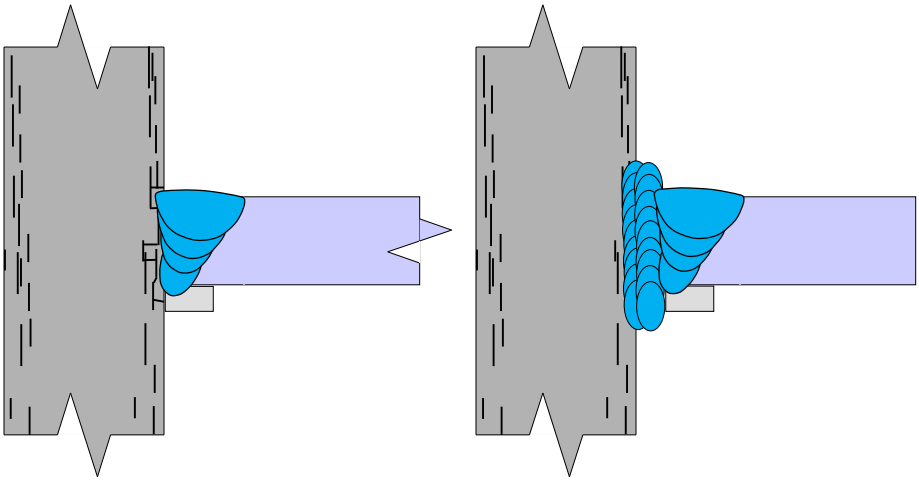




SPECIAL WELDING APPLICATIONS

Buttering Solution



Sensitive Detail

Buttered Detail

227

SPECIAL WELDING APPLICATIONS

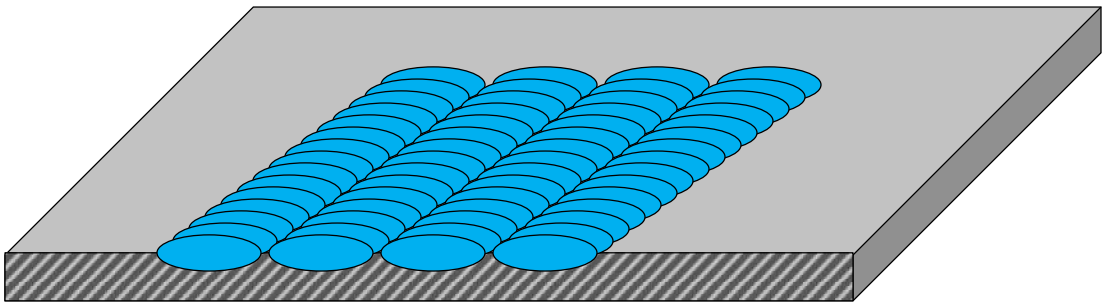
Buttering Guidelines

- 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%

228

SPECIAL WELDING APPLICATIONS

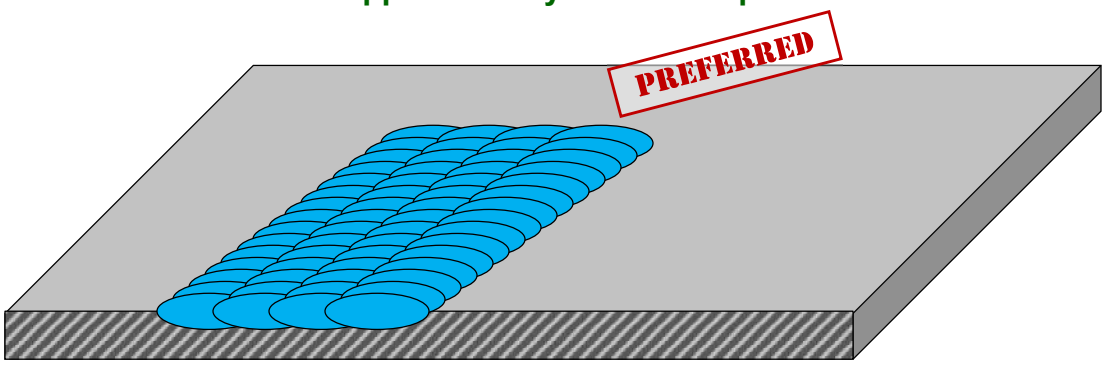
Non-preferred: no overlap



229

SPECIAL WELDING APPLICATIONS

Approximately 50% overlap



230

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.

231

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

232

SPECIAL WELDING APPLICATIONS

Today's Webinar

14.4 Welding on Heavy Shapes

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14.12 Cold Temperature Applications

14.15 Heat Shrinking

14.16 Buttering

233

SPECIAL WELDING APPLICATIONS

234

Thank you!

AISC | Questions

Smarter. Stronger. Steel.

Individual Session Registrants

PDH Certificates

- All WFH individuals associated with a group registration will be issued a certificate.
- All individuals attending at your connection: you will receive an email on how to report their 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!

8-Session Registrants

PDH Certificates

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

8-Session Registrants

Access to the quiz

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

Quiz and attendance records

Posted Friday 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

8-Session Registrants

Access to the recording

Information for accessing the recording will be emailed to you by Wednesday. 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.

8-Session Registrants

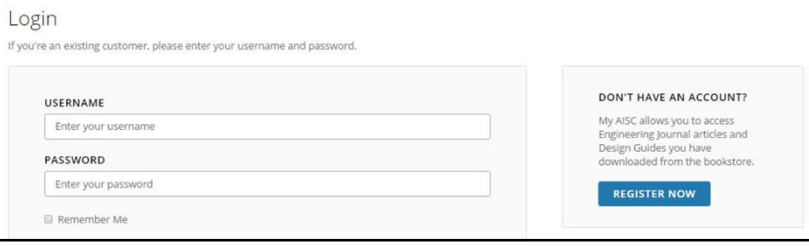
Night School Resources

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

8-Session Registrants

Night School Resources

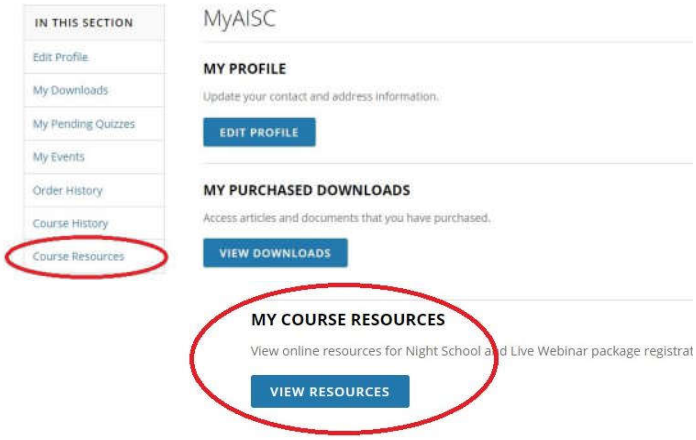
Go to www.aisc.org and sign in.



8-Session Registrants

Night School Resources

Go to www.aisc.org and sign in.



8-Session Registrants

Night School 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

8-Session Registrants

Night School Resources

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
NS13 - Building Envelope and Bracing Design	4/3/2017 7:00:00 PM	Handouts	Available 04/05/2017 5pm EST	Available 04/05/2017 5pm EST	Pending

8-Session Registrants

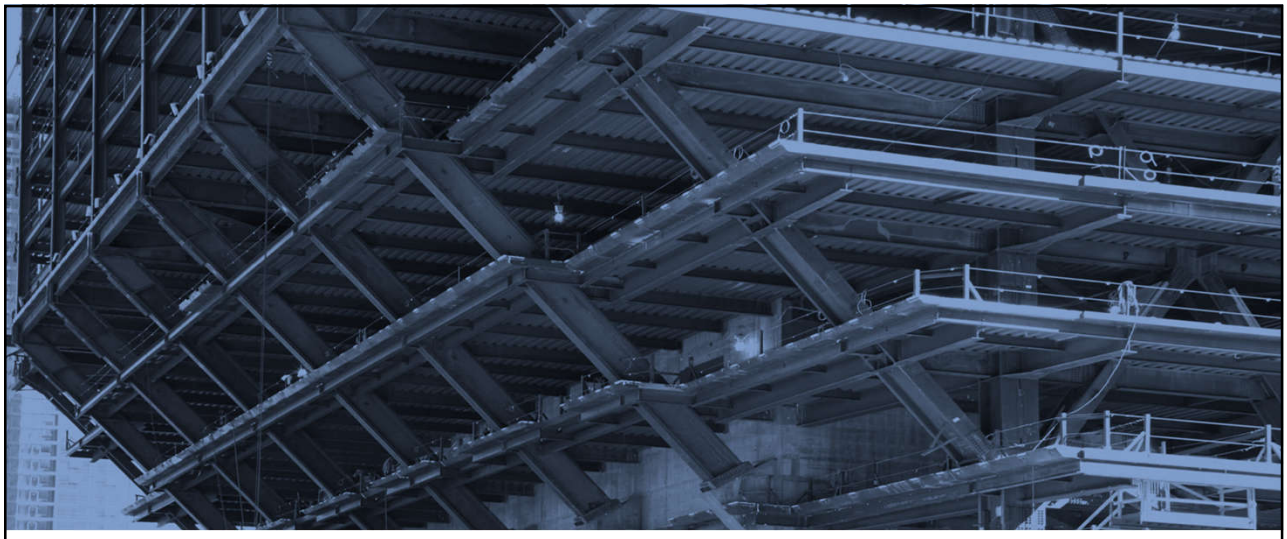
Night School Resources

- Weekly “quiz and recording” email.
- Weekly updates of the master quiz and attendance record, found at www.aisc.org/nightschool27. Scroll down to Quiz and Attendance records.
    - Updated on Friday mornings.

8-Session Registrants

Night School Resources

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



AISC | Thank you

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